A COMPARATIVE STUDY OF GASTROINTESTINAL NEMATODE INFECTIONS IN TRADITIONAL AND COMMERCIAL CHICKENS AND EFFECTS OF ANTHELMINTHIC TREATMENT ON PRODUCTION.

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A dissertation submitted to the University of Zambia in fulfillment of the award of the Degree of Master of Science in Veterinary Parasitology.

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DEDICATION

This thesis is dedicated to my wife Maimbo, my two daughters Danielle and Dominique, and to my parents, Mr. and Mrs. Dominic Ziela

APPROVAL

This dissertation of **MOSES ZIELA** is approved as fulfilling the requirements for the award of the Degree of Master of Science in Veterinary Parasitology of the University of Zambia.

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ABSTRACT

Helminthosis is a very important disease condition affecting the poultry industry, especially the traditionally reared free ranging chickens. The traditionally reared poultry farming system constitutes over 50% of the poultry industry in Zambia (Hameenda, 1985), however, very little work has been done to establish the extent of helminth infection in the Zambian free-range poultry industry. The aim of this research therefore was to investigate various aspects of helminth infections in poultry with the hope of collecting base line data and suggesting control measures that will ultimately help reduce the suspected high prevalence of helminths and thus increase the productivity of the poultry industry in general.

The prevalence of the gastrointestinal nematode parasites was evaluated in poultry in three management systems in and around Lusaka and in Shibuyunji area, Mumbwa District, Zambia. A low prevalence (2.5%) with only two nematode species (*Ascaridia galli* and *Heterakis gallinarum*) was observed in the commercially reared chickens. A level of 12.5% was observed in the semi-intensively reared chickens with *Ascaridia galli, Gongylonema ingluvicola, Heterakis gallinarum* and *Tetrameres americana.* Finally, a prevalence of 100% was obtained in the traditionally reared free-ranging chickens. This included the above six mentioned nematodes plus *Acuaria hamulosa* and *Allodapa suctoria*. The prevalence in the latter management system was significantly ($p < 0.01$) higher than in the commercial and the semi-intensive management systems.

These observations do suggest that the type of management system practiced greatly influence the prevalence and incidence of helminth infections.

The effects of helminthosis on the weight gain in the traditionally reared chickens was observed with one group treated with Levamisole (25% m/v) and the other group a non-treated control. The mean weight of the two groups at the end of the 15 weeks study were, 623±574 g in the untreated control group and 812.8±51.4g in the treated group. There was a strong negative correlation ($r = -0.780$, $r^2 = 0.61$) between the weight gain and the worm burden in the untreated control group and a weak negative correlation ($r = -0.261$, $r^2 = 0.07$) between the weight gain and the worm burden in the treated experimental group. It was noted that anthelmintic treatment of young birds would improve the weight gain capacity of the flock of a traditional farmer.

An evaluation study was carried out on the efficacy of a commonly used anthelmintic in Zambia, piperazine (1000mg P.HCl) in comparison with two other anthelmintics i.e. albendazole (75% m/v) and levamisole (25% m/v). Percentage efficacy against *Ascaridia galli* was 100%, 100% and 52.4%, for albendazole, levamisole and piperazine respectively. Against *Heterakis gallinarum* was 96.2%, 89.3% and 27.9%, and for *Allodapa suctoria* was 95.1%, 89.6% and 28.6% for albendazole, levamisole and piperazine respectively. The mean worm counts for the groups were, control (70.59), albendazole group (3.55), levamisole group (9.67) and piperazine group (58.6). This indicates that Piperazine is not the best anthelmintic to use any more in the poultry industry in the country.

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CHAPTER ONE (1)

GENERAL INTRODUCTION

GENERAL INTRODUCTION

Poultry farming in the world has gone through a lot of development in the past few years. It is now one of the most important and intensive branches of the livestock industry (Boersema, 1985). This is because the industrialisation of poultry production is easier as compared to that of other livestock species. The total number of poultry in the world in 1996 was estimated to be 12.02 billion (Anon., 1996). However, only 954 million were found in Africa (Anon., 1992). This includes the domestic fowl (*Gallus gallus*), ducks (*Carina moschata*), geese (*Anser anser*) and turkeys (*Meleagris galopavo*).

In Zambia, the chicken population is estimated at 12 million (Anon., 1997). Over 50% are rural (free ranging) and kept traditionally for household consumption. These are left to scavenge for their food, are not given any feed supplementation and are housed at night to prevent thefts or losses from predators. The rest falls under semi-intensive management with partial feed supplementation, housed on earth floors and sometimes enclosed in a wire mesh and the commercial management systems where the chickens are completely housed in chicken houses, are exclusively fed commercial feeds and have disease prophylactic programmes carried out (Hameenda, 1996).

Boersema (1985) reported that despite the use of modern methods of poultry management, many domestic fowl are still kept under the free-range system and therefore likely to be infected with nematodes. This is true for most African countries including Zambia. Under this production system, chickens have permanent contact with the soil and many insects and these harbour a wide range of nematode and cestode species especially during the rainy

season (Pandey, Demey and Verhulst, 1992). Abebe, Asfaw, Genete, Kassa and Dorchies (1997) reported that parasites, both internal and external are common in the tropics where the standard of husbandry is poor and climatic conditions are favourable for their development. Graber (1973) and Gordon (1977) reported that intensive rearing once appropriately practised would exclude helminth parasites, especially those that require an intermediate host.

Shamul-Islam (1985) carried out a survey of the helminth fauna in domestic fowl in Zambia and reported that out of 825 domestic fowl examined, 809 were infected (98.1%). This included both nematodes and cestodes. This poses a very significant problem, as poultry have become an important substitute for the relatively expensive beef in the diet of Zambians (Chilonda, 1994). Despite the fact that beef production still ranks highest in the Zambian livestock sector, the poultry industry is the fastest growing small scale animal production industry in Zambia today (Chilonda, 1994). It is now the quickest source of additional income and one of the cheapest sources of animal protein supplementation.

There is however, a lack of knowledge on the helminths that are affecting poultry in the fast growing poultry industry in Zambia. This study is therefore designed to provide more information on gastrointestinal nematodes in the different poultry production systems in Zambia. Although the presence of cestodes has been reported (Shamul-Islam, 1985), they fall beyond the scope of this study. As nematodes constitute the most important group of helminth parasites in poultry (Ruff, 1991), the focus in the study is on the gastrointestinal nematodes.

The objectives of the study were as follows:

1. To determine the prevalence of helminth species in commercial, semi-intensive and traditionally reared chickens.
2. To study the effects of deworming on weight gain in the traditionally reared chickens.
3. To evaluate the efficacy of piperazine, albendazole and levamisole against mixed helminth infections in poultry.

CHAPTER TWO (2)

LITERATURE REVIEW

LITERATURE REVIEW

2.1 Common gastrointestinal nematodes of poultry

Studies on the gastrointestinal helminths of poultry have been carried out in various parts of the African continent. This chapter reviews some of these studies and also discusses several aspects of poultry gastrointestinal nematodes.

In Nigeria, Umeche and Eno (1987) identified two nematode species in their survey of parasites of chickens from three different semi-intensive poultry farms. They found that *Ascaridia galli* (prevalence, 61.3%) was the most common with ranges of 2-17 worms per chicken, and *Heterakis gallinarum* (20.0%) with ranges of 1-6. Oyeka (1989) in a separate study in some small-scale poultry farms in Anambra State in Nigeria observed again that among the roundworms, *A. galli* was the most frequent parasite species (31%). The others were *H. gallinarum* (3.9%), *Subulura brumpti* (3.9%) and *Strongyloides avium* (3.9%). In Uganda, Ssenyonga (1982) observed the following prevalence in local birds on free-range management; *A. galli* (32.7%), *Heterakis* spp. (83.6%), *Capillaria* spp. (10.9%), *Syngamus trachea* (11.8%) and *Gongylonema ingluvicola* (3.6%). He however, in the same study observed *A. galli* (8%) and *Heterakis* spp. (10%) only in the broilers reared under commercial management system. Negesse (1991) in his survey study on the internal parasites of local chickens small-scale farmers of Southern Ethiopia identified eight nematode species. He further observed that there was no significant difference in prevalence between the dry and the wet seasons of the year. *Subulura brumpti* had the highest prevalence (40%). The others were *A. galli* (29.0%), *H. gallinarum* (24.0%),

Capillaria anatis (5.0%) and *Hartertia gallinarum* (3.0%). In addition, Graber (1973, 1975 and 1981), focusing mainly on wild life in Ethiopia, also reports on the helminths in domestic and wild poultry. In Tanzania, Permin, Magwisha, Kassuku, Nansen, Bisgaard, Frandsen and Gibbons (1997), reported 29 different helminth species with at least 18 nematode species in rural scavenging poultry. Some of the most common were, *A. galli* (28.3% wet season, 32.3% dry season), *H. gallinarum* (74.0%, 78.7%), *Allodapa suctoria* (40.0%, 52.0%), *Tetrameres americana* (54.3%, 60.3%), *Acuaria hamulosa* (8.3%, 19.3%), *Capillaria obsignata* (8.7%, 25.0%) and *Capillaria anulata* (4.0%, 9.0%).

A summary of the gastrointestinal nematodes in poultry is given in Tables 2.1 and 2.2 below. The two tables show the gastrointestinal nematodes with a direct life cycle (Table 2.1) and those having an indirect life cycle with one or more intermediate hosts (Table 2.2).

Table 2.1: The commonly reported gastrointestinal nematode species of poultry that have a direct life cycle. Also shown are their preferred sites in the gastrointestinal tract.

NEMATODE SPECIES	PREFERRED SITE	REFERENCES
Strongyloides (*S. avium, S. oswaldoi)*	Tunnels in the walls of the intestines	Hall, 1985; Anon., 1989; Ruff, 1991;
Amidostomum anseris and related species.	Gizzard and proventriculus	Anon., 1989; Ruff, 1991
Heterakis *(H. gallinarum, H. dispar).*	Caecum	Hall, 1985; Urquhart, Armour, Duncan, Dunn, Jennings, 1987;Anon., 1989
Ascaridia *(A. galli, A. numidae).*	Small intestines	Hall, 1985; Urquhart et al., 1987; Anon., 1989; Ruff, 1991
Syngamus trachea.	Trachea, bronchi and bronchioles	Hall, 1985; Urquhart et al., 1987
Trichostrongylus tenuis.	The caecum, sometimes small intestines	Urquhart et al, 1987; Ruff, 1991
Cyathostoma bronchialis.	Larynx, trachea, bronchi and sometimes abdominal air sacs	Ruff, 1991
Ornithostrongylus quadriradiatus.	In the lumen of small intestines	Ruff, 1991
Eponidostomum incinatum.	Under horny lining of gizzard	Ruff, 1991

Table 2.2: The commonly reported gastrointestinal nematode species of poultry that have one or more intermediate hosts. Also shown are their preferred sites in the gastrointestinal tract.

NEMATODE SPECIES	PREFERRED SITE	REFERENCES
Hartertia gallinarum	Jejunum, anterior part of digestive tract	Hall, 1985; Urquhart et al., 1987;
Cheilospirura hamulosa	Gizzard wall	Hall, 1985Anon., 1989
Synhimantus (Dyspharynx) spiralis and related species.	Attached to proventricular mucosa sometimes gizzard, oesophagus, intestines	Hall, 1985; Ruff, 1991
Echinuria uncinata and related spp.	Nodules on the walls of oesophagus, proventriculus, and gizzard	Hall, 1985; Urquhart et al., 1987;
Streptocara pectinifera and related spp.	Gizzard mucosa	Urquhart et al, 1987; Anon., 1989
Tetrameres spp.	Gastric glands of the proventriculus	Urquhart et al., 1987; Ruff, 1991
Subulura strongylina.	Caecum	Hall, 1985; Ruff, 1991;
Allodapa suctoria	Caecum	Anon., 1989
Hystrichis spp. (several spp.).	Proventriculus	Anon., 1989
Eustrongylides spp. (several spp.)	Oesophagus, proventriculus and intestines	Anon., 1989

Table 2.2 continued

Capillaria (*C. caudinflata, C. contorta, C. obsignata*).	Oesophagus, crop, small intestines and caecum	Hall, 1985; Ruff, 1991
Oxyspirura mansoni	Beneath the nictitating membrane, conjunctival sacs and nasolacrimal ducts	Hall, 1985; Urquhart et al., 1987; Ruff, 1991
Gongylonema ingluvicola.	Mucosa of crop, oesophagus and proventriculus	Urquhart et al., 1987; Ruff, 1991
Cynea colini.	Wall of proventriculus, at junction with gizzard	Ruff, 1991

2.2 Characteristics of some gastrointestinal nematodes of poultry

Most nematodes in poultry are organ specific. The following gastrointestinal nematodes have been discussed in order of occurrence in the gastrointestinal tract, from the crop and oesophagus to the caecum and cloaca. These are the most likely nematodes to be observed in these organs.

2.2.1 *Gongylonema ingluvicola* (Ransom, 1904)

This helminth parasite is found in the mucosa of the crop. The anterior end of the body of *G. ingluvicola* has a zone of shield-like markings. They are few and scattered near the head end and numerous and arranged in longitudinal rows further down the length of the worm. The male is 17-20 mm long and has cervical papillae. The tail has two narrow asymmetrical bursal membranes. The genital papillae vary in number and are also asymmetrical. The left spicule is nearly as long as the body, while the right spicule is 100-120 μm long. The female on the other hand is 32-55 mm long. The vulva is 2.5-3.5 mm from the tip of the tail (Soulsby, 1984; Urquart et al., 1987; Ruff, 1991). See Figure 2.1.

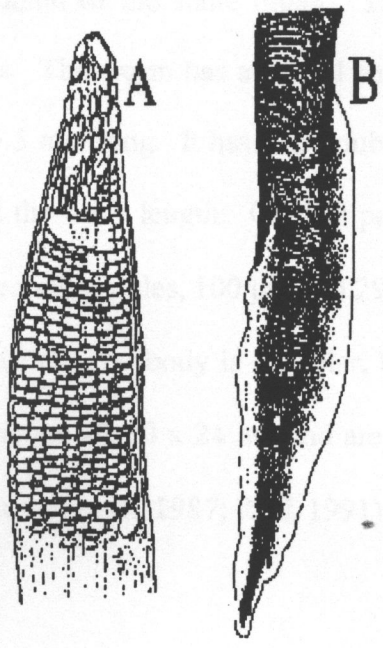


Figure 2.1: Head of *Gongylonema ingluvicola* (A) and tail of male *G. ingluvicola* (B) according to Permin and Hansen (1998)

2.2.2 *Tetrameres americana* (Cram, 1927)

The female parasite is found embedded in the gastric glands of the proventriculus while the male may be found in the lumen of the same organ. The mouth of *T. americana* is surrounded by three small lips. The worm has a buccal cavity and shows marked sexual dimorphism. The male is 5-5.5 mm long. It has two double rows of posteriorly directed spines, extending through out the body length. Conical papillae are present. The tail is long and slender, with two unequal spicules, 100 μm and 290-312 μm long. The female is 3.5-4.5 mm long and 3 mm wide. The body is globular, blood red in colour and has 4 longitudinal furrows. The eggs are 42-50 x 24 μm and are embryonated when deposited (Soulsby, 1984; Hall, 1985, Urquart et al., 1987; Ruff, 1991). See Figure 2.2.

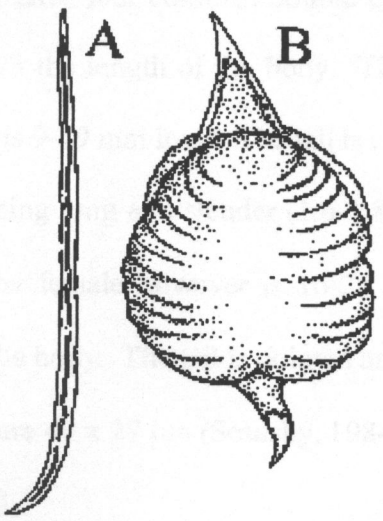


Figure 2.2: Male *Tetrameres americana* (A) and female *T. americana* (B) according to Permin and Hansen (1998)

2.2.3 *Acuaria hamulosa* (Diesing, 1851)

This helminth parasite is found under the horny layer of the gizzard. *A. hamulosa* has two large triangular lips. They have four cordons, double cuticular ridges that are irregularly wavy, extending at least 2/3 the length of the body. The cordons do not anastomose or recur anteriorly. The male is 9-19 mm long. The tail is coiled and its' spicules are unequal and dissimilar. The left being long and slender (1.6-1.8 mm) while the right is short and curved (180-200 μm). The female however is 16-25 mm long. The vulva is slightly posterior to the middle of the body. The tail is pointed and the eggs are embryonated when deposited. The eggs measure 40 x 27 μm (Soulsby, 1984; Hall, 1985, Urquart et al., 1987; Ruff, 1991). See Figure 2.3.

Figure 2.3: Head of *Acuaria hamulosa* (A) and tail of *A. hamulosa* (B) (Permin and Hansen, 1998)

2.2.4 *Ascaridia galli* (Schrank, 1788)

This is the common intestinal helminth parasite. *A. galli* is a large, thick, yellowish-white worm. The head has three large lips and the oesophagus has no posterior bulb. The male is 50-76 mm long. The preanal sucker is oval to circular with a strong chitinous wall. The tail has narrow caudal alae or membranes and has 10 pairs of papillae. The spicules are equal, narrow and blunt. The female is 60-116 mm long and its' vulva is in the anterior part of the body. The eggs are elliptical, thick-shelled and are not embryonated at the time of deposition. They measure 73-92 x 45-57 μm (Soulsby, 1984; Hall, 1985, Urquart et al., 1987; Ruff, 1991). See Figure 2.4.

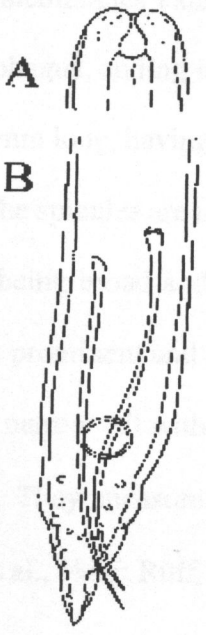


Figure 2.4: *Ascaridia galli*: Anterior end (A) and posterior end of male (B) according to Ruff (1991)

2.2.5 *Heterakis gallinarum* (Schrank, 1788)

H. gallinarum is a caecal worm. It is a small, white helminth, having 3 small equal sized lips on the mouth and has 2 lateral membranes extending almost the entire length of its body. The worm has a distinct oesophagus, ending in a well-developed bulb containing a valvular apparatus. The male is 7-13 mm long, having a well-developed preanal sucker and long alae with 12 pairs of papillae. The spicules are not equal, with the right spicule being slender and 2 mm long and the left being broad and measuring 0.37-1.9 mm long. The female is 10-15 mm long. Its vulva is prominent and is positioned slightly posterior to the middle of the body. It has a long and narrow tail with eggs that are thick-shelled, ellipsoid and unsegmented when deposited. They measure approximately 63-75 x 36-50 μm (Soulsby, 1984; Hall, 1985, Urquart et al., 1987; Ruff, 1991). See Fig. 2.5.

2.2.6 *Allodapa suctoria* (Molin, 1860)

This parasite is also found in the caecum. It is a small worm having a buccal cavity that is cuticularised forming 3 tooth-like structures. The oesophagus is dilated posteriorly, followed by a deep constriction and then a spherical bulb. The cephalic alae are present, extending only to the anterior portion of the small intestines. The male is 7-10 mm long and the tail is curved ventrally, ending in a prolongation. Its preanal sucker is like an elongate slit (170-220 μm) and its spicules are similar and equal both measuring 1.3-1.5 mm long. The female however is 9-18 mm long. Its tail is straight and conical, ending in a sharp point. The vulva position is anterior to the middle of the body. *A. suctoria* eggs are almost spherical, thin-shelled and measure approximately 82-86 x 66-76 μm. They are

fully embryonated when deposited (Soulsby, 1984; Ruff, 1991; Permin and Hansen, 1998). See Figure 2.5 below.

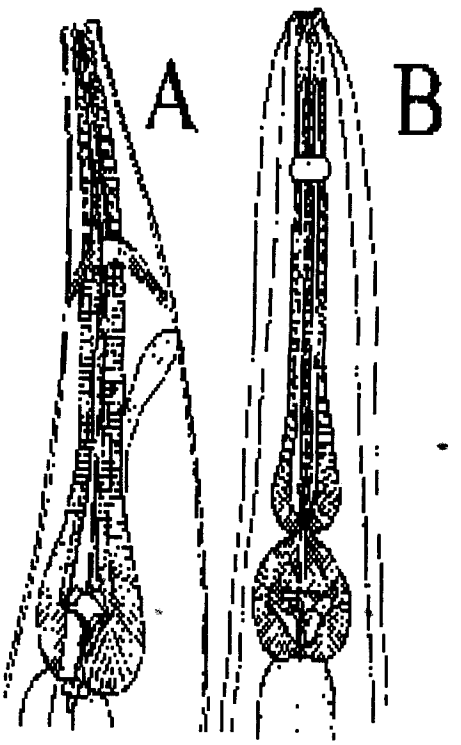


Figure 2.5: Anterior end of *Heterakis gallinarum* (A) and anterior end of *Allodapa suctoria* (B) according to Ruff (1991)

2.3 General life cycles of gastrointestinal nematodes of poultry

The life cycle of the gastrointestinal nematodes of poultry may have a direct, or an in-direct life cycle. An example of each of these is given below, and the helminth parasites *Ascaridia galli* and *Tetrameres americana*, have been used as examples respectively.

2.3.1 Direct life cycle

The nematodes of poultry that exhibit a direct life cycle do not require an intermediate host to complete their cycle of development. The infected birds pass the helminth eggs in their droppings, contaminating the litter, feed, and water. This then poses as the main way by which the infection is transmitted. Mechanical transmission by earthworms or cockroaches has been reported by Hall (1985) and it is clear that there is no development of the larval stage inside these carriers (Ruff, 1991). When the susceptible fowl ingest the infective eggs or carrier hosts, the larvae then penetrate the mucosa of the duodenum and develop to reach maturity and enter the intestinal lumen (approximately 28-30 days). See Fig. 2.6 below.

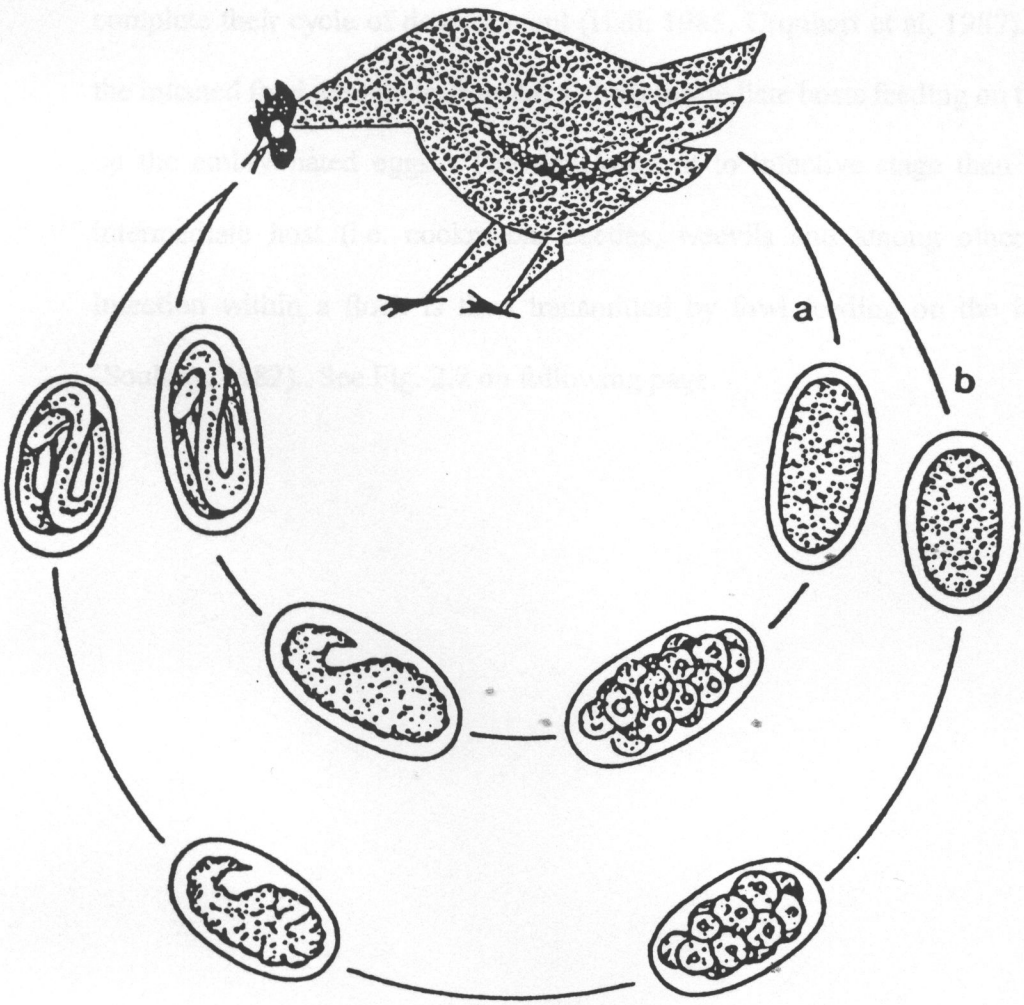


Figure 2.6: Direct Life cycle: The life cycle of *A. galli* (a) and *H. gallinarum* (b). Eggs are passed with the faeces and embryonation of the eggs takes place in the environment. Susceptible host then ingests infective eggs (with L_3 larvae). Occasionally earthworms can act as transport hosts

2.3.2 Indirect life cycle

The nematodes of poultry that exhibit an indirect life cycle, require an intermediate host to complete their cycle of development (Hall, 1985, Urquhart et al, 1987). Therefore when the infected fowl pass their droppings, the intermediate hosts feeding on the droppings pick up the embryonated eggs. The development to infective stage then occurs inside the intermediate host (i.e. cockroach, beetles, weevils and among others, grasshoppers.). Infection within a flock is then transmitted by fowl feeding on the intermediate hosts (Soulsby, 1982). See Fig. 2.7 on following page.

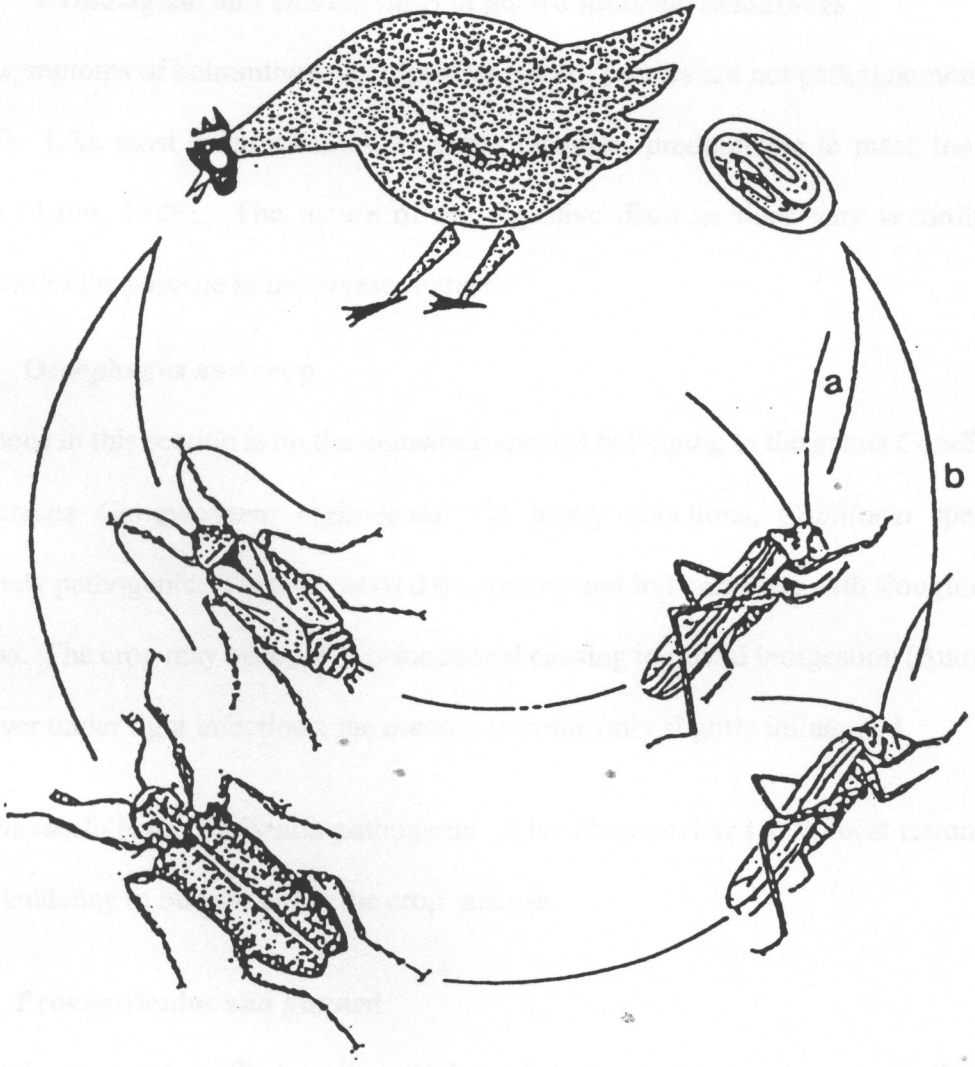


Figure 2.7: Indirect life cycle: The life cycle of *T. americana* (a) and *A. hamulosa* (b), with embryonated eggs passed in the faeces. The eggs are ingested by the intermediate host such as cockroach, beetles, weevils among others and within which the larvae undergoes development to the infective stage (L_3). When the final host ingests the intermediate hosts, the adult worms develop in the proventriculus of the host.

2.4 Pathological and clinical signs of gastrointestinal nematodes

The symptoms of helminthosis of digestive tract of poultry are not pathognomonic (Ralph, 1987). Like most avian diseases, systemic disorders predominate to mask the digestive signs (Anon, 1989). The nature of the digestive disorder does vary according to the location of the parasite in the digestive tract.

2.4.1 Oesophagus and crop

The focus in this section is on the nematode species belonging to the genus *Capillaria* and the parasite *Gongylonema ingluvicola*. In heavy infections, *Capillaria* species are extremely pathogenic. There is marked thickening and inflammation with sloughing of the mucosa. The crop may become non-functional causing ingluvial indigestion (Anon, 1989). However under light infections, the mucosa become only slightly inflammed.

G. ingluvicola is relatively non-pathogenic. It is only associated with local lesions related to the tendency to burrow under the crop mucosa.

2.4.2 Proventriculus and gizzard

The main nematodes affecting this section of the gastrointestinal tract are *Dyspharynx nasuta, Tetrameres americana* and *Acuaria hamulosa*. These three nematodes, do not cause clinical signs if the infection is light. However, under heavy infection *D. nasuta* will cause maceration of the proventricular wall. *T. americana* may cause emaciation and anaemia. They may also lead to a marked inflammation of the proventricular mucosa causing complete obliteration of its lumen. This will lead to diarrhoea and eventually may

lead to death (Ruff, 1991). Fatihu et al., (1992) reported that histopathologic sections of the proventricular wall showed cystic dilatations of the proventricular glands including some necrosis of the glandular epithelium.

The gizzard wall is seriously damaged due to *A. hamulosa* tunnelling into the submucosa. This causes ruptures in the submucosa with ultimate formation of a sac or pouch in the gizzard (Fatihu et al., 1992). Tissue degeneration of the mucosa layer thereby negatively affecting the ability of the chicken to digest its feed has also been reported. This leads to emaciation and in severe cases to death.

2.4.3 Intestines and caecum

These sections of the gastrointestinal tract are mainly infected by *Ascaridia galli*, *Heterakis gallinarum*, *Capillaria* spp, *Strongyloides* spp. and *Allodapa suctoria*

A. galli occurs in various domesticated and wild birds in most parts of the world. Fatihu et al. (1992) reported that *A. galli* does cause anaemia, decreases intestinal enzyme activity, and Ntekim (1983) observed that there was evidence of decreased egg production in laying chickens due to this nematode. Several cases of adult *A. galli* in the eggs of the domestic chickens have been reported (Akinyemi et al., 1980).

The most severe period of the infection with *A. galli* as reported by Boersema (1985) is during the second week of infection when the larvae spend part of their developing cycle in the intestinal mucosa.

Ruff (1991) reported that the caeca of chickens experimentally infected with *H. gallinarum* showed marked inflammation and some degree of enteritis. Riddell and Gajadhar (1988) discussed a possible causal relationship between *H. gallinarum* within caecal granulomas and development of hepatic granulomas in chicken. The parasite was observed to be present within the caecal granulomas in some flocks. Although the caecal nematodes are said to be non-pathogenic in light infections, they are known to be carriers of the 'Black head' organism, *Histomonas meleagridis*, a pathogenic protozoan affecting especially turkeys (Jordan, 1990).

2.5 Effects on Productivity

Reports of the effects helminth infections have on birds have been given in a number of papers. In Ethiopia, Negesse (1991) showed a negative correlation of dressed weight percentage among chickens infected with *H. gallinarum*, *A. galli* and *C. caudinflata* infection, demonstrating that the parasites reduce productivity. Haiba and Geneidy (1968) also reported that bacterial and helminth diseases lower both egg and meat production in chickens. Reports from Ntekim (1983) and Fatihu et al., (1992) also alluded to the fact that there are losses encountered when a flock is parasitised by Helminths. Walker and Farrel (1974) also found that *A. galli* infected chickens did not gain as much weight as the non-infected chickens. In a recent study on *A. galli* infections, effects on productivity in poultry were examined. For example Sanders and Schwartz (1994), Reid and Carmon, (1958), reported that the parasite causes reduced weight gain in chickens. It has also been reported that although infections by *A. galli* are more common in young chickens (Soulsby, 1982;

Ruff, 1984), it does cause economic losses in adult birds like laying hens (Kuhn, Buchwalder, Grafner and Hiepe, 1971; Sazikowa, 1975; Matta, 1981).

2.6 Treatment and Control

Treatment and control of helminthosis has long been practised in the commercial poultry sector, but less so in the traditional sector especially in Africa.

2.6.1 Anthelmintics

The choice of anthelmintics that can be used in domestic fowl is limited. However, it is important first to identify the nature of the parasitic problem in order to select the appropriate drug before use. Some anthelmintics that are being used in domestic fowl have a narrow spectrum, sometimes being only effective against a single helminth species (Boersema, 1985). Table 2.3 below reviews some of the anthelmintics used against gastrointestinal nematodes in domestic fowl.

Table 2.3: Some anthelmintics that have been used against gastrointestinal nematodes in domestic fowl (Boersema, 1985).

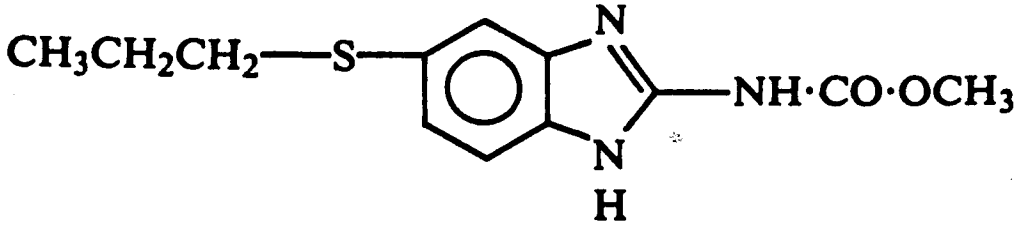
1. Phenothiazine	5. Haloxon	9. Fenbendazole
2. Piperazine	6. Thiabendazole	10. Pyrantel
3. Metyridine	7. Cambendazole	11. Levamisole
4. Coumafos	8. Mebendazole	12. Ivermectin

Use of an anthelmintic that has a broad-spectrum activity would help to reduce treatment costs. Ssenyonga (1982) reported that due to multiple infections of the domestic fowl, especially those under traditional free ranging management systems, use of some old

anthelmintic preparations (Piperazine, Phenothiazine and Thiabendazole) which are effective on particular groups of worms is no longer the best recommendation. Permin and Hansen (1998) in their manual on the epidermiology, diagnosis and control of poultry parasites reported that an ideal anthelmintic should have a broad spectrum activity against adult and larval helminth parasites. Also, that the drug should be rapidly metabolised, should have a low toxicity on the host and should not have unpleasant side effects to the birds, the operator or to the environment. Finally, they stated that it should be competitively priced and ready to use in an easy way.

2.6.1.1 Albendazole

This is a broad spectrum anthelmintic and it belongs to the group of anthelmintics known as the benzimidazoles. It therefore falls under the Class I anthelmintics (Permin and Hansen, 1998). It is a pale green powder, is insoluble in water but can be dissolved in suitable alcoholic solvents. Its basic structure is shown below:



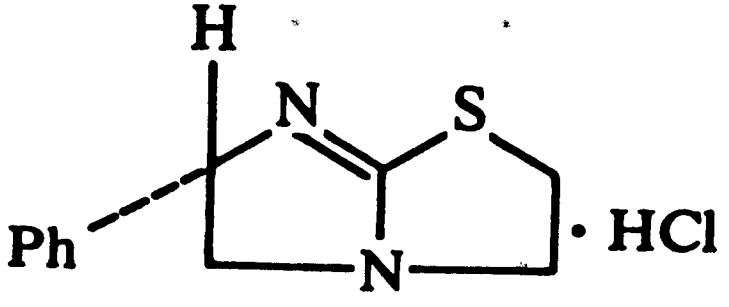
Albendazole

Figure 2.8: Basic molecular structure of albendazole (Brander, Pugh and Bywater, 1982)

Its mode of action is like most benzimidazoles, it affects the uptake of glucose, and this affects glycogen metabolism in the parasite. The parasite is unable to absorb nutrients and eventually they starve because of lack of glycogen (Brander et al., 1982).

2.6.1.2 Levamisole

This is a broad spectrum anthelmintic and it belongs to the group of anthelmintics known as the imidazothiazoles. It thus falls under the Class II anthelmintics (Permin and Hansen, 1998). Levamisole is an *l*-isomer of tetramisole. It's a white crystalline powder, highly soluble in water. Its structure is shown below:



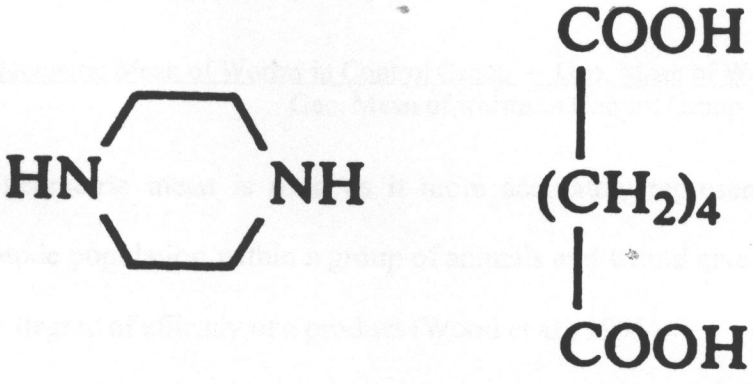
Levamisole hydrochloride

Figure 2.9: The basic molecular structure of levamisole (Alexander, 1985)

Low levels of the drug act as ganglion stimulants and give rise to muscular paralysis in the parasites. Higher levels however, interfere with the carbohydrate metabolism, with the blockage occurring at the site of fumarate reduction and succinate oxidation (Brander et al., 1982 and Alexander, 1985).

2.6.1.3 Piperazine

This drug has been categorised as a Class III anthelmintic (Permin and Hansen, 1998) with the avermectins and the milbymicins. Its very unstable and very deliquescent and thus consequently it is used in the form of the more stable salts i.e. adipate, citrate, phosphate, sulphate and hydrochloride. All are white crystalline powders, except for adipate and are soluble in water. See structure below:



Piperazine adipate

Figure 2.10: Basic molecular structure of piperazine (Alexander, 1985)

Piperazine is known to depress the motility of the worm by its γ-aminobutyric acid (GABA) mimic action. Hence the parasite can not maintain its position in the intestines and is then expelled by the peristaltic movements of the gut.

2.6.1.4 Drug Efficacy

The World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines published in 1982 (Powers, Wood, Eckert, Gibson and Smith, 1982), gave the opinion that 90% efficacy of an anthelmintic was very good and 80-90% moderately effective. However since then anthelmintics have been developed which archive over 98% efficacy (Wood, Amaral, Bairden, Duncan, Kassai, Malone, Pankavich, Reinecke, Slacombe, Taylor and Vercruysse, 1995) against the common parasitic Helminths when used at their effective dose (E.D.). According to these authors the drug efficacy is determined by using the following formula:

$$\frac{\text{Geometric Mean of Worms in Control Group} - \text{Geo. Mean of Worms in Treatment Group}}{\text{Geo. Mean of worms in Control Group}}$$

The geometric mean is used as it more accurately represents the distribution of the nematode population within a group of animals and would give a more accurate indication of the degree of efficacy of a product (Wood et al., 1995).

Reinecke, Snijders and Horak (1962) gave a similar formula however they used the arithmetic mean and not the geometric mean.

$$\frac{\text{Mean of Worms in Control Group} - \text{Mean of Worms in Treated Group}}{\text{Mean of Worms in Control Group}}$$

Wood et al (1995) further made three recommendations concerning the selection and use of anthelmintics.

The first one was that claims for efficacy of a product should be expressed against each genus / species (larvae / adults) as highly effective (over 98%), effective (90-98%), moderately effective (80-89%) or insufficiently active (less than 80%).

The second recommendation said that dose rates on the product label should be based upon body weights. Knowledge on the mode of action of the product should not be a requirement for registration. However, it may be useful to establish whether the product will be effective against resistant strains of parasites.

The third and final recommendation stated that for a new product to be economically successful, it should have a broad spectrum with high activity against all major nematodes. It should also have an effect on both adult and larval stages (Ssenyonga, 1982; Wood et al, 1995) and have a wide margin of safety (Tiefenbach, 1977).

2.6.2 Control of Helminths in Poultry

The aim of control strategies is mainly to keep the parasitic challenge in the host at its lowest possible level and to avoid clinical symptoms and production losses. This is so because complete eradication is not practically possible with the available drugs, especially in the free-range chickens (Permin and Hansen, 1998). Improved management and hygiene of the flock has proven to be the most efficient way to control poultry parasites. Proper sanitation and breaking the life cycles of the parasitic worms rather than chemotherapy is

reported to be the best control measure for most nematodes (Ruff, 1991). Total enclosure principles and improvements in cleaning the chicken houses have apparently decreased the significance of parasitic infections in some commercial in-door production systems. Also, intensive rearing on litter, largely prevents infection of chickens using outdoor-intermediate hosts (e.g. earthworms, grasshoppers).

The contamination of litter, however, is one important aspect to note when considering control strategies. Davis and Joyner (1965), in their study on the observations on the parasitology of deep litter poultry houses, reported that *A. galli* has a high biotic potential and large numbers of eggs will accumulate in deep-litter houses. Ghosh and Singh (1994) in a report on acute ascariasis in chickens also observed that due to a large number of infective eggs in old litter, cases with mortality of 11.7% were observed in a flock of 9-week pullets. Frequent removal of contaminated litter and a thorough cleaning of the floors, therefore would be advisable. The floor must also be kept as dry as possible, as the humidity levels play a significant role in the development of the eggs to the infective stages. The "all in-all out" principle would also prove an important management practice in order to keep the environment free of contamination and at the same time ensure that there is no mixing of different flock age groups. Davis and Joyner (1965) made a similar observation and suggested that adequate control could be maintained if breeders were treated at regular intervals in order to suppress egg output and hence reduce environmental contamination. This unfortunately would increase the risk of development of anthelmintic resistance (Permin and Hansen, 1998). McGregor, Kingscote and Remmler (1961) in their

study on pheasants suggested the treatment of soil and litter as alternative methods for reducing the contamination.

Other aspects of control that may be considered include the stocking rate. Overstocking will lead to birds having a higher chance of being in contact with feed contaminated with faeces resulting in consumption of high numbers of infective parasitic eggs. A low stocking rate would therefore be advisable as a helminthosis control measure. It has been known also that an adequate nutritional level may reduce the overall effects of helminth infection. Supplementation of the free-ranging chickens may therefore help improve on the overall productivity of the flock. Recently, Permin and Hansen (1998) suggested the possibility of identifying genetic resistant breeds of chickens as a means to control poultry helminthosis.

CHAPTER THREE (3)

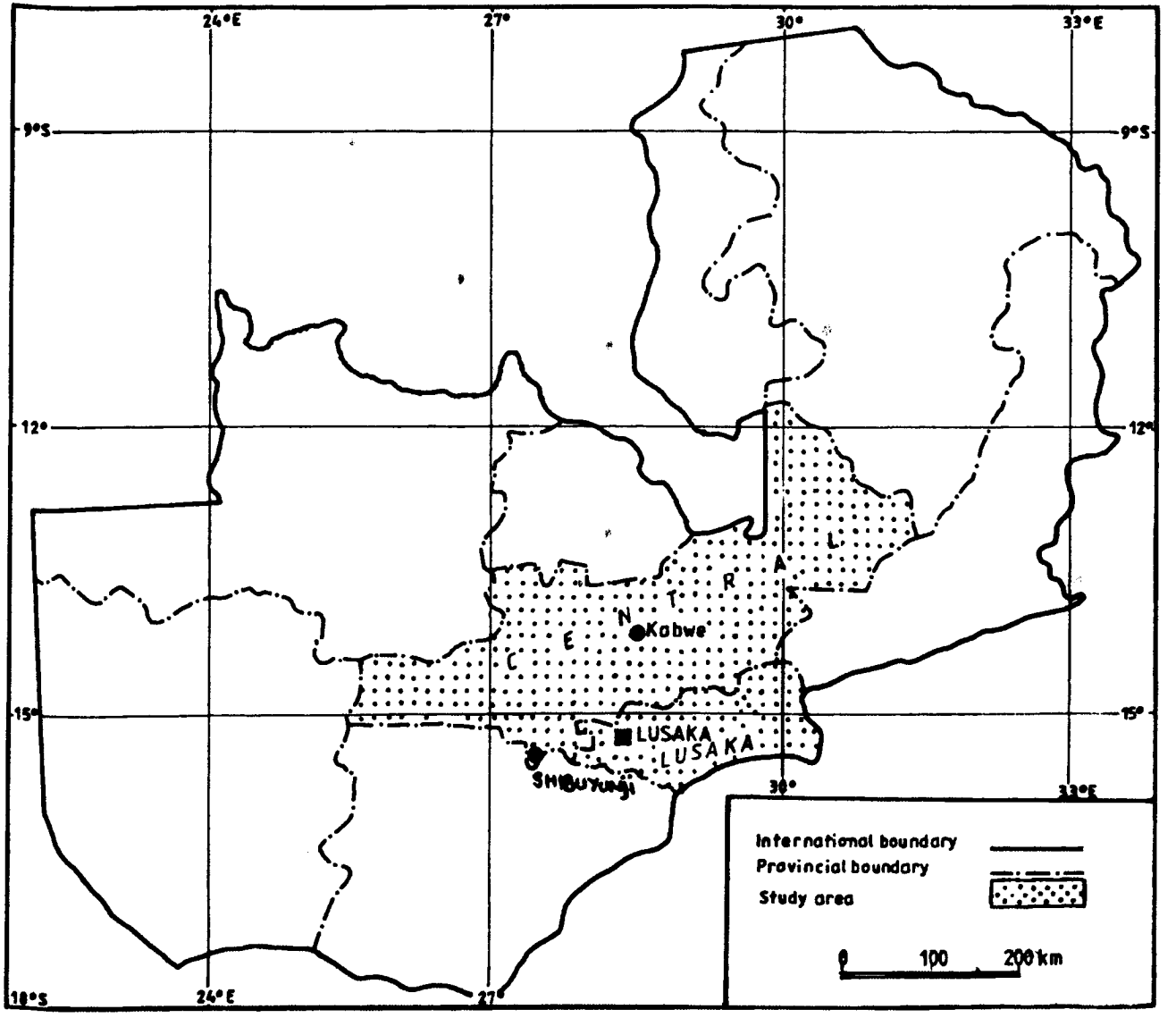
GENERAL MATERIALS AND METHODS

3.1 Study Area

The studies were carried out in two areas involving three production systems. The first study focused on the commercially reared chickens acquired from various commercial and small holder farms in and around Lusaka, the capital city of Zambia. The second and third studies were on the traditionally reared chickens and were carried out in the area known as Shibuyunji. This is a rural area, situated in the Central Province of Zambia, Mumbwa District, lying approximately 70km Southwest of Lusaka.

Both areas are at an altitude of approximately 1150-1300m above sea level, have a typical tropical climate that is characterized by rainfall of 800-1000 mm per annum during the summer months (late October to late March). They both have a mean monthly temperature that varies from 18°C (June/July) to approximately 33°C (October /March) and the vegetation is of the savanna type having a mixture of deciduous and evergreen trees and shrubs (Anon., 1998). See figure 3.1 on next page.

Figure 3.1: The Map of Zambia showing Lusaka and Central Provinces, the two provinces in which the study was carried out.


24°E
27°
30°
33°E
9°S
12°
15°
18°S
CENTRAL
Kabwe
LUSAKA
LUSAKA
SHIBUYUNJI
International boundary
Provincial boundary
Study area
0 100 200 km

3.2 Study Animals

Throughout the whole period of study, chickens in three different production systems were examined. The majority of them however, were the local breeds. See Figure 3.2.

The chickens collected from Shibuyunji were indigenous breeds reared traditionally. Approximately 300 chickens were selected for the study. Traditional chicken rearing in Zambia consists of free ranging during the day and housing at night to avoid losses through predators. None of these chickens had received any vaccinations or any anthelmintic treatment prior to the studies. On collection, they were all vaccinated as described in section 3.3.

The semi-intensively managed chickens receive partial feed supplementation and are housed on earth floors (sometimes are enclosed in a wire mesh). Finally, the commercially managed chickens are completely housed in chicken houses and are exclusively fed commercial feeds with disease prophylactic programs carried out.

The study focusing on commercially reared chickens included the following: Point of lay pullets and spent-hens, approximately 200 chickens were used in the study. All these were reared on deep-litter systems. These were not given any prophylactic treatment of any kind as slaughter of the chickens was within 48 hours of purchase.

Figure 3.2: Some of the growing chickens (local breeds) confined in an enclosure before slaughter at the School of Veterinary Medicine. Age ranging from 4-12 weeks.

3.3 Prophylactic Treatment

The chickens acquired from Shibuyunji were vaccinated and given prophylactic treatment against New Castle Disease, Gumboro Disease, Fowl Pox and bacterial diseases as follows:

3.3.1 Vaccinations

Prophylactic treatment against some common viral diseases was given. This was to ensure that no out break would occur as the birds were acquired from different households. All the chickens received oral single dose treatments, except for the Pox-vaccine that was administered subcutaneously.

Table 3.1: Showing the three vaccines administered to the chickens reared in the Free-range system

Vaccine	Manufacturer	Batch #	Expiry date
New Castle Disease Vaccine (TAD ND vac La Sota®)	TAD Pharmazeutisches Werk GmbH	975585	09 /1999
Gumboro Disease Vaccine (TAD Gumboro vac®)	TAD Pharmazeutisches Werk GmbH	975760	10 /1999
Fowl Pox Vaccine (TAD Pox vac®)	TAD Pharmazeutisches Werk GmbH	975591	07 /1999

3.3.2 Antibiotic Treatment

Doxycycline (Doxycycline hydrate 50% W.S.P.) was chosen and administered as a broad-spectrum antibiotic. The dosage was at 1g per 5 liters of drinking water for 5 days. This was administered to ensure that no other bacterial disease would affect the chickens during the experiment.

3.4 Methods

3.4.1 Tagging of the chickens

The chickens were selected and they were tagged by using different coloured insulation tape to wrap around one of the chickens' legs. An identification number was then placed on the tag. The tags were checked once a week to ensure that they were still intact and the numbers still clearly visible.

3.4.2 Weighing of chickens

The same person performed the weighing of all chickens involved in the experiment. The weight was read from an electric scale (Mettle-BasBal), showing digital figures of up to two decimal places.

3.4.3 Post-mortem and worm collection

All the chickens were slaughtered by bleeding them through the neck. They were then placed on a tray in dorsal recumbence and a longitudinal incision along the mid-line was done. This facilitated the removal of the whole gastrointestinal tract. The different gastrointestinal tract segments i.e. the crop and oesophagus, the proventriculus, the gizzard, the intestines and the caecum (Fig. 3.3), were then detached and placed into individual

dishes. Worms were collected following visual examination using fine forceps. All the collected worms were stored in small plastic bottles containing 70% ethanol (Permin and Hansen, 1998).

Figure 3.3: The gastrointestinal tract of fowl, with the different segments of the tract i.e. the crop and oesophagus (A), the proventriculus and gizzard (B), the intestine (C) and the caeca (D).

3.4.3.1 The crop and oesophagus

By use of a pair of scissors, this was longitudinally cut open and the contents were then washed into a petri dish. The crop was then stretched lightly and raised up to the light for further examination and worm collection.

3.4.3.2 The proventriculus

This was cut open by use of a pair of scissors and the contents washed into a petri dish. The proventriculus was then firmly pressed and more samples were collected of the nematode parasites found in the proventriculus glands.

3.4.3.3 The gizzard

This was also placed in a separate petri dish. The individual gizzards were cut open and the contents washed and discarded. The keratinized layer of the gizzard was then peeled off and the inner surface was examined for any nodules or swellings. These were then pressed and the worms were collected and stored as above.

3.4.3.4 The intestines

These were opened along their entire length and thoroughly washed with their contents placed into a petri dish. Examination was then carried out under an inverted microscope and all the worms collected were treated as above.

3.4.3.5 The caecum

This was also opened and its contents placed into a petri dish. Due to the faecal material that some worms were lodged into, the washings were then placed in a sieve (210μm) then under pressure, water was used to clear the washing for the collection of the individual worms.

3.4.4 Worm counting and identification

The counting of the worms was done under a stereomicroscope. The identification and differentiation of the adult Helminths was carried out using the morphological characters as described by Soulsby (1965), Chabaud (1978) and Ruff (1991).

3.5 Statistical Methods Used

All the numerical data collected was stored in computer spread sheets in Microsoft® Excel 97, and this was the statistical software used for the analysis of the data and formation of graphs. Minitab® statistical package was also used in the analysis and evaluation of significant difference in the three studies. The statistical methods employed included descriptive statistics, two-sample t-test, Mann-Whitney and the correlation.

CHAPTER FOUR (4)

A Comparative Study of Gastrointestinal nematode Infections in Commercial, Semi Intensive and Village Free-Range Reared Chickens.

4.1 INTRODUCTION

The literature on helminth parasites of domestic fowl in Zambia is limited to a report by Shamul-Islam (1985) and a few unpublished records from hatcheries. There have been however, a number of reports in other African countries that do apply to the Zambian situation. Negesse (1991) reported that helminthosis is an important disease condition in poultry in the tropics. He further reported that poor nutrition and disease conditions in the tropics are major constraints to poultry production in the tropics. Abebe, et al. (1997) however stated that if confinement rearing were promptly practised, these parasitic infections would be markedly controlled. They however, did not consider the semi-intensive production system in their study.

Chapter 4 was set up to study the prevalence of gastrointestinal nematodes in the commercial, semi-intensive and traditionally reared chickens in and around Lusaka and Shibuyunji, Mumbwa District. Layers were chosen from commercial and semi-intensive sector for this study, as they are kept much longer than the broilers and this facilitates the complete development of the life cycle of the helminths. The traditional sector does not have the above distinction therefore a mixed group of chickens were used for this study.

4.2 MATERIALS AND METHODS

Commercially and semi-intensively reared chickens were bought from various farms and housing locations around Lusaka. An average of 20% was purchased from each holding and these were all layers (Table 4.1). A total of 80 free-ranging traditionally reared

chickens were also bought from around Shibuyunji field station, Mumbwa District for this study.

Table 4.1: The number of chickens sampled in the three farming management systems, the age, breeds and type of chickens used.

Rearing systems	**No. of chickens**	**Breed**	**Age**	**Layer/ Broilers**
Commercial	80	Lowman red	> 18 weeks	Layers
Semi-intensive	120	Lowman red/ white	> 18 weeks	Layers
Traditional	80	Local	Adult	mixed

All the chickens were brought to the school of Veterinary Medicine and were slaughtered 48 hours later. During the two days of confinement, feed and water was provided *ad lib*. The post-mortem procedure was done as explained in section 3.4.3. The results were recorded and subsequently analysed using appropriate software as stated in section 3.5.

4.3 RESULTS

The following sections give the results on the gastrointestinal nematode species identified in the three management systems and show the nematode prevalence in the respective management systems.

4.3.1. Nematode species counted and identified

There were 3818 worms recovered from the free-range reared chickens compared to only 114 and 18 worms in semi-intensive and commercially reared chickens respectively (Figure

4.1). Although the free-range chickens had a high worm count per chicken, out of the 3818 worms recovered, 2054 were *Heterakis gallinarum* and 1518 were *Allodapa suctoria*, thus 3572 (93.6%) of all the worms recovered in this group were parasites of the caecum (see Table 4.2).

Ascaridia galli and *Heterakis gallinarum* were found in all the three management systems. *H. gallinarum* contributed the most to the worm burden. The worm species *Allodapa suctoria* and *Acuaria hamulosa* were only found in the free-range management system (see Table 4.2). These two nematode species require an intermediate host for the completion of there life cycles.

Table 4.2: The gastrointestinal nematode species identified and the total worm counts for each group in the three poultry farming systems

Helminth parasites	**Commercial system (n=80)**	**Semi-intensive system (n=120)**	**Traditional system (n=80)**
G. ingluvicola	0	12	15
T. americana	0	19	135
A. hamulosa	0	0	1
A. galli	6	8	95
H. gallinarum	12	75	2054
A. suctoria	0	0	1518
Total	18	114	3818

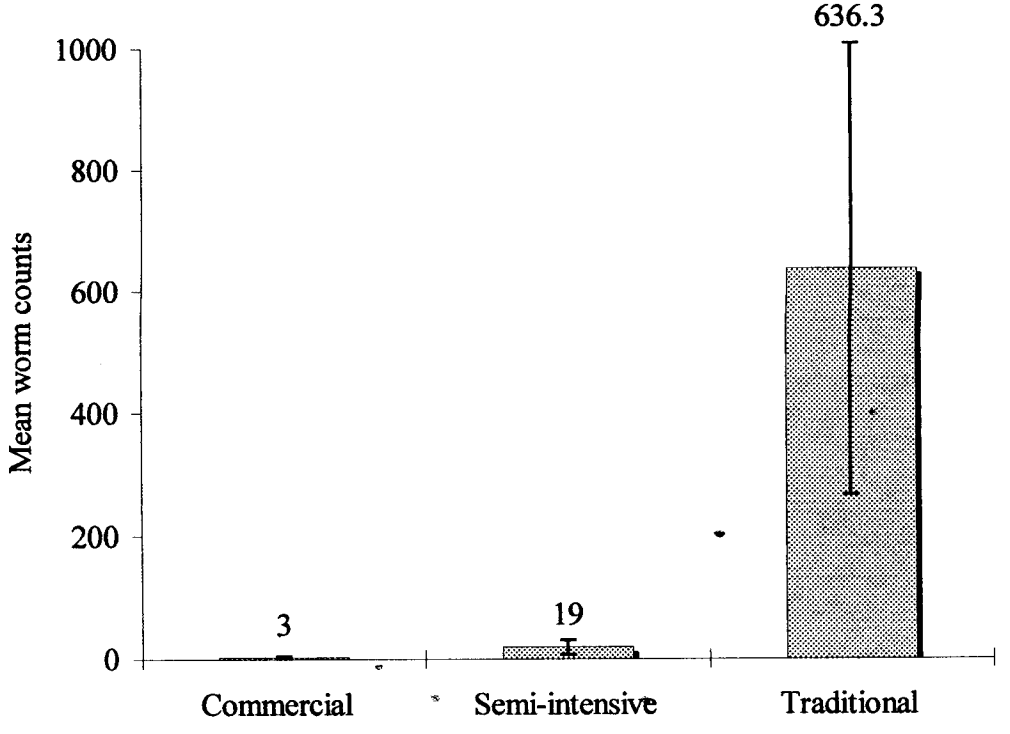


Figure 4.1: The mean (± SEM) worm count per chicken in the three poultry management systems (commercial (n=80), semi-intensive (n=120) and traditional (n=80) systems) observed in the study.

4.3.2. Prevalence of gastrointestinal nematodes in the commercial, semi-intensive and traditionally reared chickens

The results have shown that there is a very low prevalence of gastrointestinal nematodes in the commercial (2.5%) and the semi-intensive chickens (12.5%). However, there is a very high prevalence in the free-range, traditionally reared chicken (100%) as shown in Figure 4.3. Mann-Whitney test confirmed that there was a significantly higher worm burden (U = 23.0, $p < 0.01$) in the free ranging chickens than in the commercial birds. There was also a significantly higher worm burden (U = 27.0, $p < 0.01$) in the free ranging birds than in the semi-intensively reared chickens. There was, however, no significant difference (U = 30.5, $p > 0.1$) between the semi-intensive and the commercial flock. All the worms recovered in the commercially reared chickens were from very old birds, where as the worms in semi-intensive system were from young producing layers (see Table 4.1).

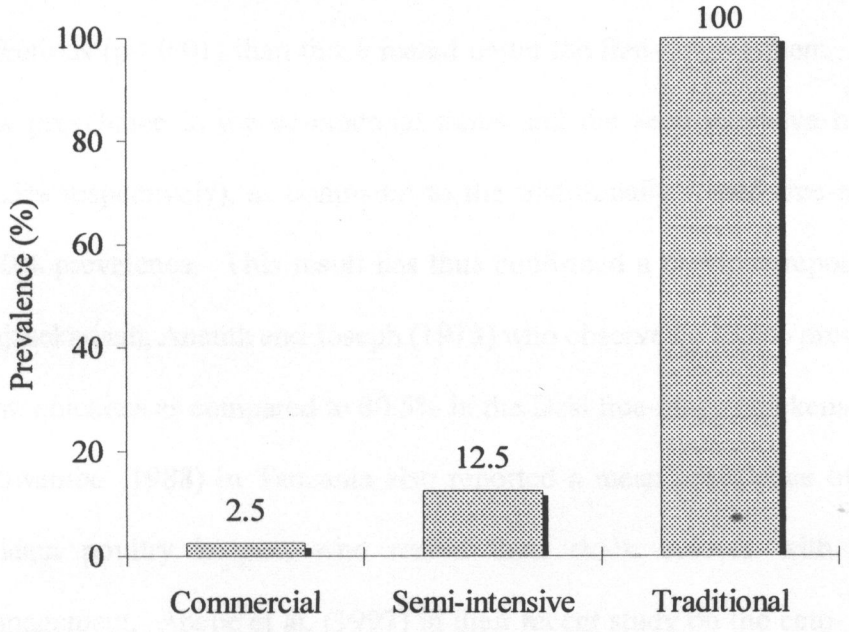


Figure 4.2: The prevalence rates (%) in the three poultry management systems (Commercial, Semi-intensive and Traditional systems) observed in the study.

4.4 DISCUSSION

The results in this study have shown that domestic fowl reared in small holder semi-intensive farms and commercial farms have significantly lower gastrointestinal nematode infections ($p < 0.01$) than those reared under the free-range system. This is shown by the low prevalence in the commercial farms and the semi-intensive households (2.5% and 12.5% respectively), as compared to the traditionally reared free-range chickens with a 100% prevalence. This result has thus confirmed a previous report by Hedge, Rahman, Rajasekariaah, Ananth and Joseph (1973) who observed a 13.5% prevalence in commercial farm chickens as compared to 80.5% in the Desi free-range chickens in India. Msangi and Mbwambo (1988) in Tanzania also reported a mean prevalence of 0.7% among Dar es Salaam poultry keepers who reared their stock indoors with satisfactory hygienic management. Abebe et al. (1997) in their recent study on the ecto- and endo-parasites of chickens in and around Addis Ababa, found no helminths in commercial industrial flock. They also further reported that there was a significant difference ($p < 0.05$) in the prevalence rate of endo-parasites in the commercial industrial flock and the rural free-ranging flock.

This study has also shown that there are more multiple nematode species infections in the free-range traditionally reared chickens, while the commercially reared chickens will predominantly have single or at most double nematode species infection. This suggests that management practices greatly influence the number and type of parasites harboured by the domestic fowl. *Gongylonema ingluvicola* and *Tetrameres americana* occurred only in the free ranging traditionally reared chickens and almost insignificantly in the small holder farms. This is because the parasites need intermediate hosts for their life cycles and these

are more accessible to the free-ranging chickens. This is in agreement with Ssenyonga (1982) who reported that certain helminths, due to their life cycles, would be more accessible to fowl reared under free-range systems than fowl reared under commercial farming systems and gave the example of *Tetrameres americana.* Fakae et al. (1991) in their study on the gastrointestinal helminth infection of the domestic fowl also reconfirmed this by their findings that under intensive management systems, the principle intermediate hosts for a number of helminths are very limited. During feeding (scavenging) of the traditionally reared chickens, the intermediate host i.e. cockroaches, beetles and among others grasshoppers, form a considerable part of their diet. Abebe, et al. (1997) observed in their study that the species and mean worm burdens of parasites in the local chickens were significantly higher ($p<0.01$) than in the commercially reared chickens.

Also shown in this study is the fact that the chickens raised under the semi-intensive farming systems had a higher infection rate than those reared under big commercial farming systems. This may be explained by the fact that all the semi-intensive farmers reared their chickens on earth floor houses, while the commercial farmers reared their chickens in houses with concrete floors and deep litter, and the houses were thoroughly cleaned before restocking. It therefore, can be concluded that infection of the earth floor is possible, and it gives the opportunity for the development and survival of infective eggs in the soil. The wet conditions of the earth in some small holder farms may have also contributed to the development of *Ascaridia galli* and *Heterakis gallinarum.* This is similar to the report by Oyeka (1989) who observed that the prevalence of *A. galli* in broiler houses in Britain was attributed to the use of earth floors in the poultry houses. This factor was

earlier on noted by Long (1977) when he stated that there was a high opportunity of survival of infective eggs in the soils in earth floor poultry houses.

The study has therefore shown that there is a significant difference in nematode infections between the free-ranging traditionally reared chickens and the commercially reared flock. Also shown is that within the commercial flock, there may be variations in prevalence depending on the degree of cleanliness of the various poultry farm environments. It is finally important to note that the nematodes requiring an intermediate host are unlikely to be found in the commercially reared chickens due to their lack of contact with the intermediate hosts.

CHAPTER FIVE (5)

The Effects of gastrointestinal nematodes on Production in Rural Chickens in Mumbwa District in Zambia.

5.1 INTRODUCTION

Viral, bacterial and protozoan diseases may appear to be more economically important to the farmer because they cause obvious losses in form of deaths of many birds at a time. However, the less obvious, but ubiquitous losses due to reduced productivity, caused by helminthosis, are economically, also very important to the poultry industry (Ssenyonga, 1982). These losses may be in the form of poor egg production, poor weight gain, especially in young growing chickens and other diseases caused by the helminths being carriers of other pathogenic agents. There is currently no information in Zambia to highlight the impact of helminthosis on the weight gain especially in the traditional free-range production system.

Chapter 5 therefore will evaluate quantitatively the effects of the worm burden on the weight gain of the infected birds in the rural area. This will help assess and advise the rural poultry keepers on the effects of nematode infections on the productivity of the birds.

5.2 MATERIALS AND METHODS

Over 100 chickens were bought from villages around, the Shibuyunji Veterinary Field Station, in Mumbwa District, which is run by the Department of Clinical Studies, School of Veterinary Medicine, University of Zambia. The chickens were then kept at the field station under the traditional free-range management system. Prophylactic treatment for all the chickens was then provided as described in Table 3.1. The birds were also provided with antibiotic prophylactic treatment with Doxycycline (Doxycycline hydrate 50% W.S.P.) at a dose of 1g/ 5l for 5 days, in the drinking water. The flock was then divided

into two groups of 25 chickens each within the whole population, and were tagged with two different colour insulation bands respectively. An identification number was then marked on the tags of each chicken for individual identification.

One group was drenched with the anthelmintic, levamisole 25%m/v (0.12 ml/100mg), while the other group was left as the untreated control. The chickens were kept in a wire fence enclosure at night, and let free during the day to freely roam about the entire village area. The birds were minimally supplemented with commercial growers' marsh, however, water was provided *ad lib.*

The chickens in both the groups were weighed weekly on an electric scale (Mettle-BasBal) for 15 weeks starting from two weeks pre-treatment to twelve weeks post-treatment. The chickens were slaughtered and worm collection, counting and identification was done as described in sections 3.4.3 to section 3.4.4. The results obtained were analysed as stated in section 3.5.

5.3 RESULTS

The results obtained are shown in the sections below.

5.3.1 Nematode species counted and identified

The study has revealed a high prevalence of nematodes (100%, n=25) as is shown in Table 5.1. *Heterakis gallinarum* was the dominant parasite followed by *Ascaridia galli*, however all four identified nematode species in the experiment had a 100% prevalence and all the segments of the digestive tract examined, except for the gizzard, were parasitized (Table 5.1).

Table 5.1: The nematode species, prevalence and worm burden (range and mean) of chickens in Shibuyunji area (n=25).

Site	Species	Prevalence	Worm burden	
			Range	Mean
Crop	*Gongylonema ingluvicola*	100%	1-8	5.05
Proventriculus	*Tetrameres americana*	100%	8-24	14.50
Gizzard	Nil	0	0	0
Intestines	*Ascaridia galli*	100%	8-28	17.40
Caecum	*Heterakis gallinarum*	100%	19-97	60.35

5.3.2 Weight gain

The mean weight gain (± SEM) of the untreated control and the treated experimental groups at the end of the 15 weeks period showed very clearly that treatment was effective against a number of Helminths species. There was a significant difference ($t = 2.4$, $p<$

0.01) in the mean (± SEM) weight gain between the treated group (812.8±51.4 g) and the untreated control group (623±57.4 g) (see Figure 5.1).

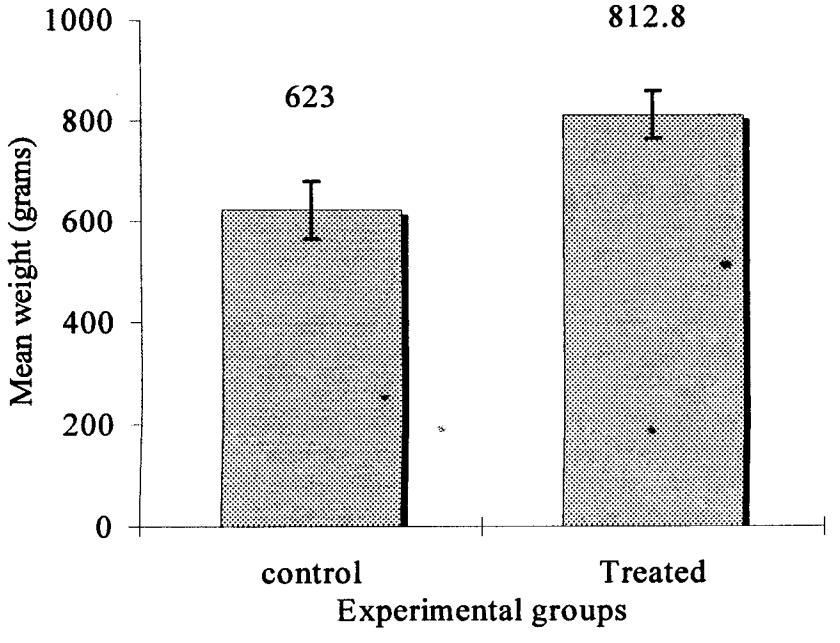


Figure 5.1: The mean (± SEM) weight gain for the experimental group treated with Levamisole 25% m/v,(n=25) and the untreated control group (n=25).

5.3.3 Worm counts

A total of 2139 Helminths were recovered from 25 chickens of the untreated control group, while 495 nematodes were recovered from 25 chickens of the treated group. The mean (± SEM) worm counts revealed that the untreated group harboured significantly higher worm burden ($t = 12.08$, $p < 0.001$) than the treated group. This is further elaborated in Figure 5.3 as it shows how the two groups compare in the individual gastrointestinal segments.

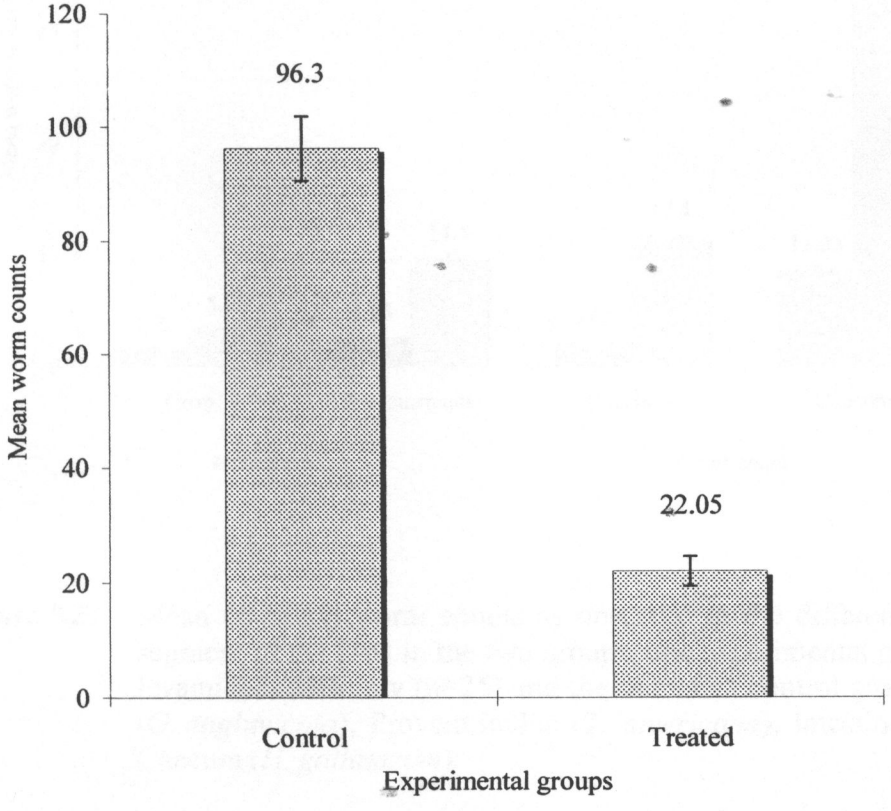


Figure 5.2: The mean (± SEM) worm counts in the experimental group treated with levamisole 25% m/v, (n=25) and the untreated control group (n=25)

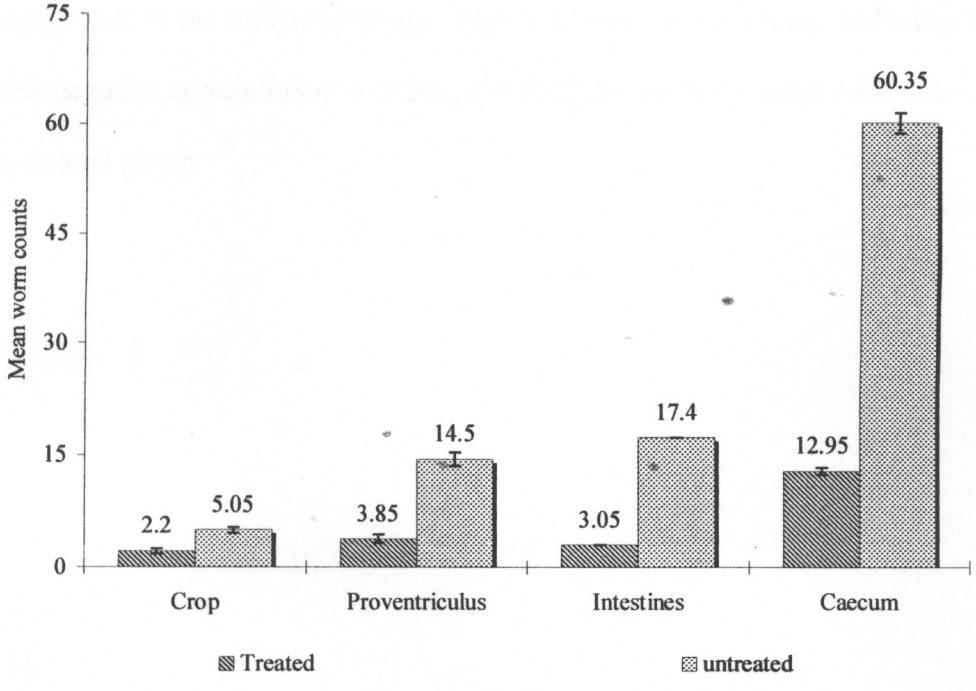


Figure 5.3: Mean (± SEM) worm counts as observed in the different gastrointestinal segment of the fowl in the two groups, one experimental group treated with levamisole 25% m/v (n=25) and the untreated control group (n=25). Crop (*G. ingluvicola*), Proventriculus (*T. americana*), Intestines (*A. galli*) and Caecum (*H. gallinarum*).

5.3.4 Correlation of weight gain and total worm counts

After comparing the total worm count with the weight gain of the treated and the untreated groups, the results indicate that the treated group had a higher mean (± SEM) weight gain and a less mean (± SEM) worm count than the untreated group. As shown in Figure 5.6 there is a strong negative correlation ($r = -0.780$, $r^2 = 0.61$) between the weight gain and the worm count in the untreated group. Figure 5.7 on the other hand, indicates that there is a weak negative correlation ($r = -0.261$, $r^2 = 0.07$) between the weight and the worm count in the treated group.

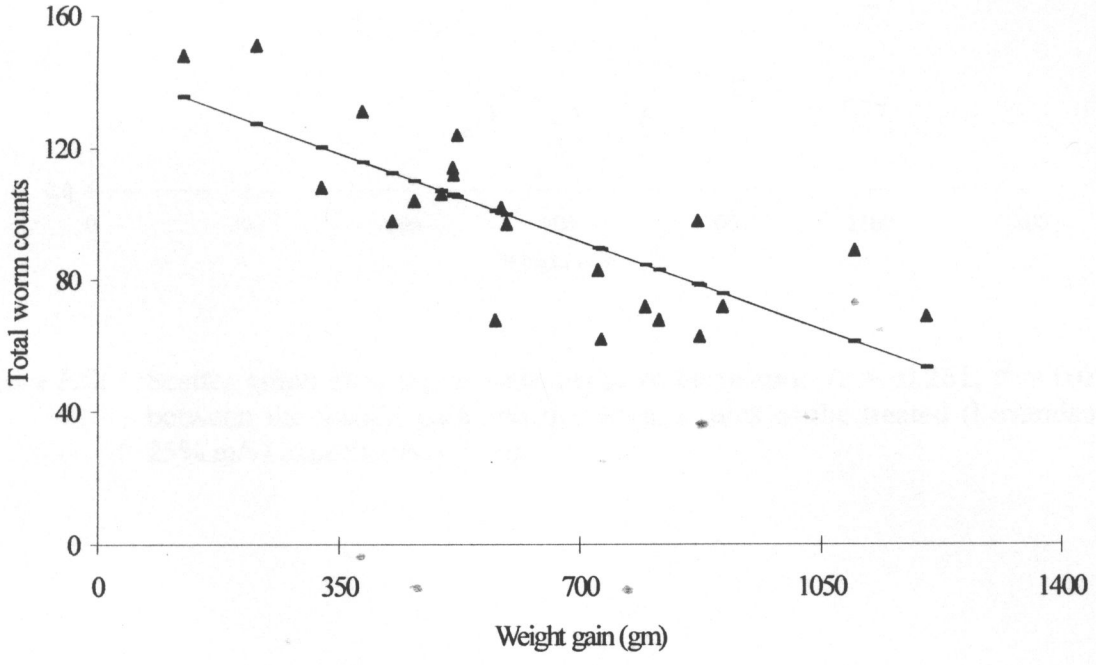


Figure 5.4: Scatter graph showing a strong negative correlation ($r = -0.780$, $r^2 = 0.61$) between the weight gain and the total worm counts of the untreated control experimental group.

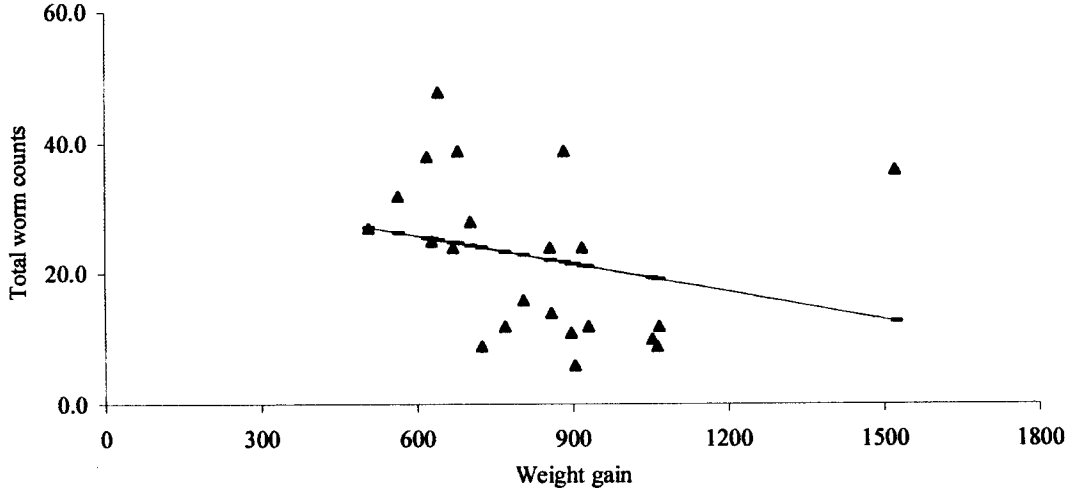


Figure 5.5: Scatter graph showing a weak negative correlation ($r = -0.261$, $r^2 = 0.07$) between the weight gain and the worm counts of the treated (Levamisole 25% m/v) experimental group.

5.3.5 Pathology

Some pathological lesions associated with gastrointestinal nematodes of chickens observed in the study have been described. These have been divided into gross and micro pathological (histology) lesions.

5.3.5.1 Gross pathology

Major pathological changes were observed in the proventriculus, the intestines and the caecum. In the proventriculus, evidence of catarrhal inflammation was observed and the parasites were seen as dark spots through the serosa. In some heavily infected chickens, areas of ecchymotic haemorrhages were visible from the serosa in the intestines and generalised catarrhal enteritis was also observed in the intestines and the caecum. See figure 5.6. and 5.7.

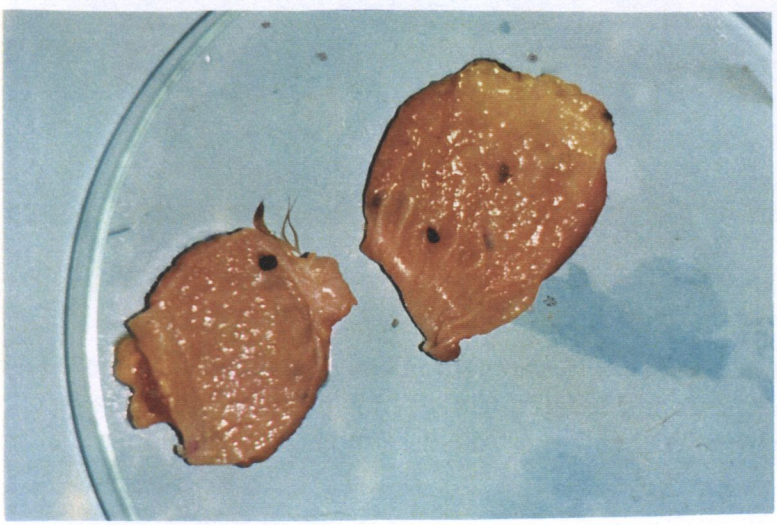


Figure 5.6: Catarrhal inflammation of the proventricular mucosa in the Zambian local chicken due to the parasite *Tetrameres americana* (black spots) in the proventricular glands.

A.

B.

Figure 5.7: (A) Marked inflammation and ecchymosis of the intestinal mucosa due to the presence of *Ascaridia galli* (immature) and some cestodes (B) Catarrhal inflammation and congestion of the caecum due to *Heterakis gallinarum* and *Allodapa suctoria*.

5.3.5.2 Histopathology

The gastrointestinal tract showed evidence of cellular infiltration and degeneration. In the proventriculus, there was glandular atrophy in the glands affected with the parasite *Tetrameres americana*. Finally, erosion of the mucosal lining in the intestines was also observed. See figures 5.7, 5.8 and 5.9.

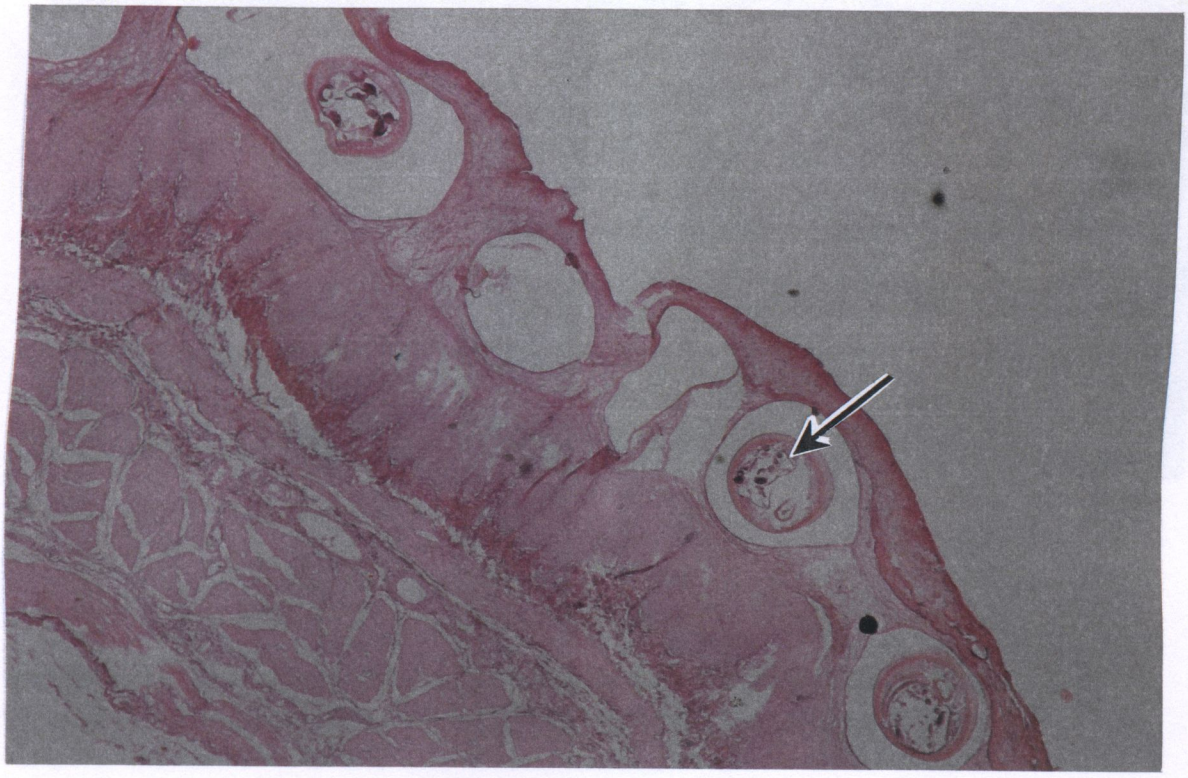


Figure 5.8 Microphotograph of a section of the crop of Zambian local chicken showing parasites (*Gongylonema ingluvicola*) imbedded in the mucosa (H and E stain, x 52 magnification).

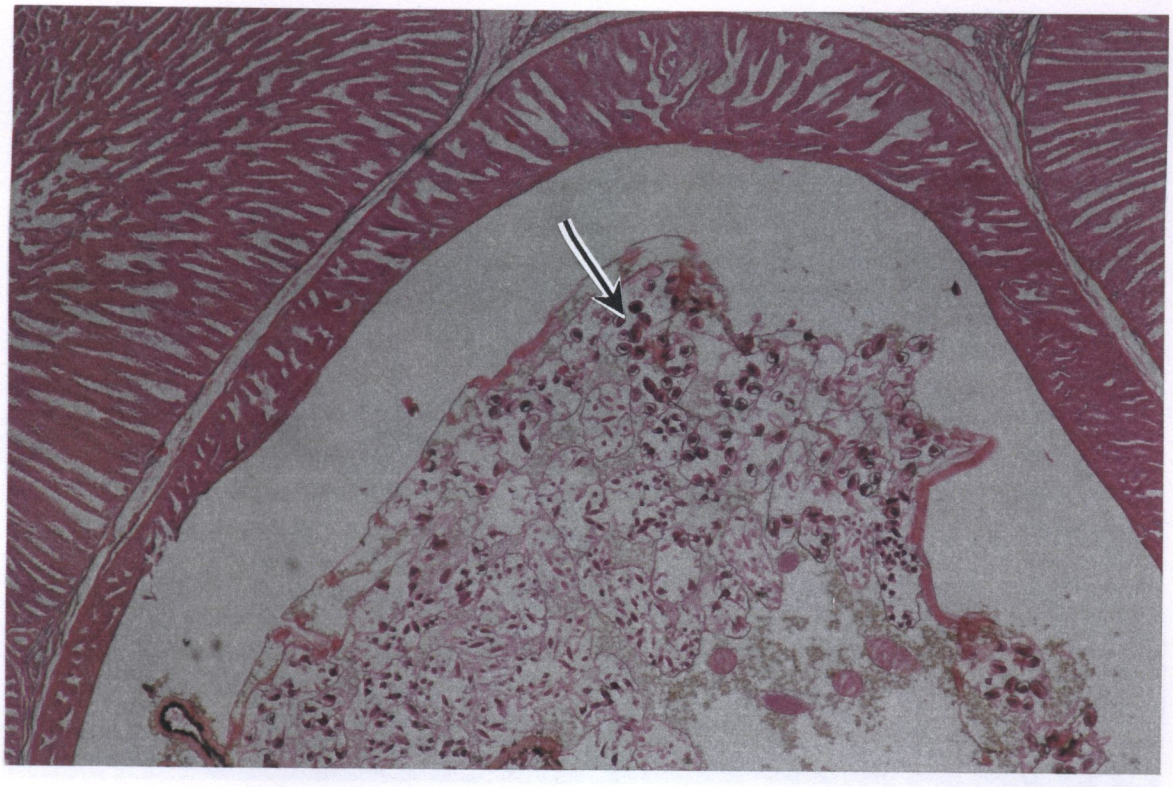


Figure 5.9 Microphotograph of a section of the proventricular glands of the Zambian local chicken showing *Tetrameres americana* (H and E stain, x 52 magnification).

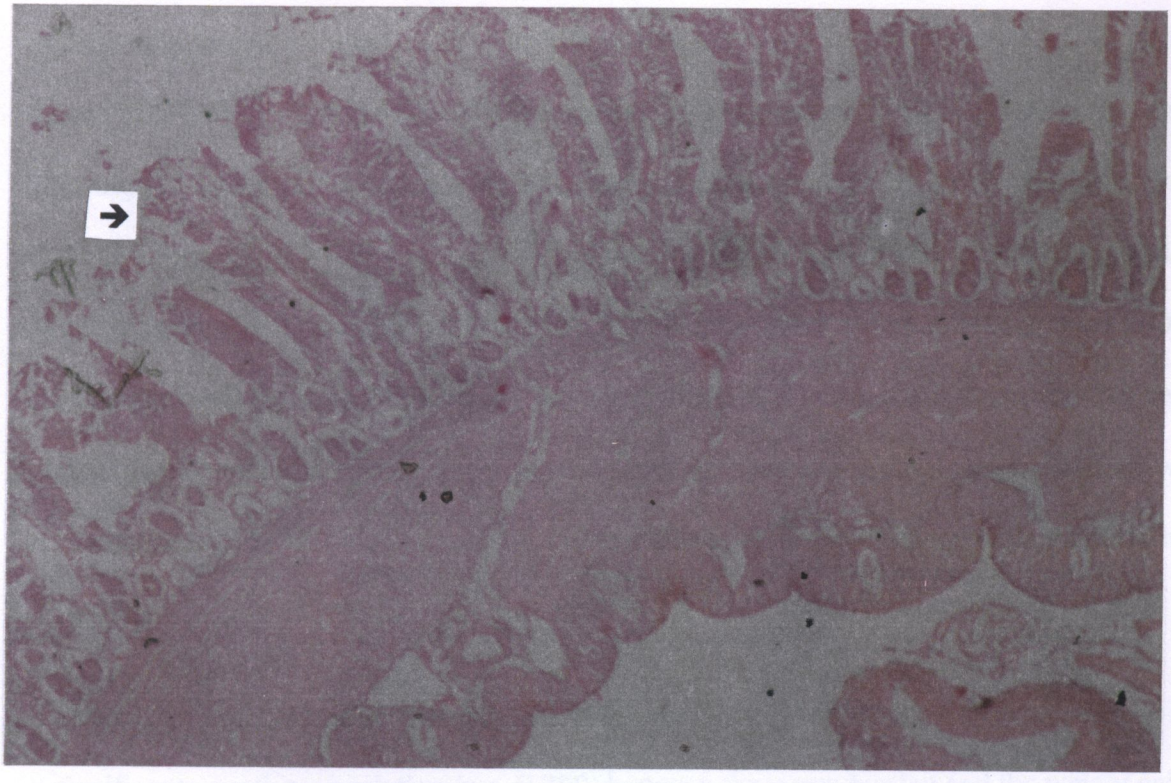


Figure 5.10 Microphotograph of a section of the small intestines of a heavily infested Zambian local chicken showing degeneration of the intestinal villi (arrow) (H and E stain, x 52 magnification).

5.4 DISCUSSION

This experiment has revealed a high prevalence (100%) of gastrointestinal nematodes in the traditionally reared sampled chickens. This is similar to the previous reports of Shamul-Islam (1985) who reported a 98.1% infection in 825 fowls examined in and around Lusaka. This high infection rate has also been reflected in reports given around the sub-region. For example, Msanga and Tungaraza (1985) reported a 95% infection rate in the chickens in Mwanza region in Tanzania. Permin, et al. (1997) reported a 100% infection rate in 600 chickens examined from villages in Morogoro district, Tanzania. Jansen and Pandey (1989) also observed a 100% infection in 30 chickens sampled in Zimbabwe. This shows the serious extent of helminthosis in the free-range traditionally kept chickens in the Eastern and Southern Africa.

The problem can not be over-emphasised as the results in the study have shown that there is a significant negative correlation ($r = -0.780$) between the worm burden and the weight gain in the untreated infected flock. The study, having excluded all factors that could have given a spurious result, has shown that proportionately smaller and lighter chickens have a higher worm burden in the local chickens in Zambia. This study has confirmed previous observations in reports by Malhotra (1983) who observed that the heavier and larger the host, the lower the degree of helminth infection. He further revealed that the ratios illustrating the interrelationship of host weight and size with worm burden established that proportionately higher worm burdens are found in smaller and lighter domestic fowl than in larger and heavier domestic fowl. Ojok (1993) and Sanders and Schwartz (1994) also alluded to the argument of having a relationship between helminth infection and weight

gain of domestic fowl, stating that infections with *A. galli* often led to host-weight depression and this was attributed to the relationship with the worm burden. This actually re-emphasised an observation much earlier by Reid and Carmon (1958) in a study on the effects of numbers of *A. galli* in depressing weight gain in chickens. Negesse (1989) in his study on the survey of internal parasites reported similar results when he observed that there was a negative correlation of dressing percentage with the prevalence of *H. gallinarum, A. galli, C. anatis* and *C. caudinflata* respectively. He pointed out that helminthosis reduced productivity of the chickens. This study in agreement with the previous authors has shown that *A. galli* and *H. gallinarum* significantly reduced after treatment with levamisole. It can be concluded therefore that the two parasites also played a major role in reducing the weight gain in the untreated flock, which is in agreement with Negesse (1989).

It also has shown that it is not necessary to completely clear a flock of infection, but once the infection is reduced in a flock by treatment, the negative effects on the weight gain are reduced. Figure 5.4 therefore shows the correlation graph of the treated group with a weak negative correlation coefficient ($r = -0.261$).

Damyanova, Teodorova and Gabrashanska (1993) in their study on the kinetic model of parasite development and of the host microelement content under combined drug treatment helped explain this relationship. They observed that due to reduced absorption of some microelements by the host, and pathological changes and subsequent gastrointestinal tissue damage, the chicken is unable to reach its full potential. Hence as described above, the

study has shown that by reducing the degree of infection in the flock, there may be an increase in the absorption of microelements and also a reduction in the amount of tissue damage to the gastrointestinal tract. Fakae, et al. (1991) reported that the gross pathological lesions like swelling and thickening of the gastrointestinal tract wall caused varying degrees of indigestion and malabsorption of nutrients leading to weight loss and possible unthriftness. Fabiyi (1972) and Malaki (1976) in their reports observed that the lesions caused by helminthosis contributed to the general debility of the fowls and ultimately to production losses.

In conclusion, this study has shown that helminthosis in domestic fowl exerts a negative effect on their weight gain in young chickens and treatment of the infected flock will help improve the growth and subsequently the mean weight gain of the flock. Finally, it may be necessary in future studies to quantify the difference in weight gain in terms of actual monetary losses for the small-scale traditional farmer and discuss a possible relationship between weight gain and laying of eggs.

CHAPTER SIX (6)

Evaluation of the Efficacy of Piperazine, Albendazole and Levamisole against Gastrointestinal Nematodes of Chickens.

6.1 INTRODUCTION

The importance of poultry rearing (domestic fowl) in Zambia cannot be over emphasized as this has become a ready source of much needed animal protein, and also serves as a flexible source of income to the rural community. Surveys have indicated that birds are heavily parasitized by nematodes and have in most cases multiple infections (Shamul-Islam, 1985). An anthelmintic with broad-spectrum activity is therefore needed to help in treating these infections, and also to minimize treatment costs.

Chapter 6 therefore was undertaken to evaluate the efficacy of piperazine (1000mg P. HCl) albendazole (75% m/v) and levamisole (25% m/v) against gastrointestinal nematodes of chickens.

Piperazine (1000mg P. HCl) was chosen because it has a wide market as an anthelmintic and it is popular among small-scale farmers in Zambia. The remaining two drugs, albendazole (75% m/v) and levamisole (25% m/v) were chosen due to their broad-spectrum and highly efficient anthelmintic activity (Abdelsalam and Nourellhuda, 1988; Xie and Zhang, 1989). It is however noted that only limited data on the applicability of albendazole in the treatment of gastrointestinal nematodes in fowl is available (Zhang, Jiang, Tao and Shi, 1984; Rong, Jiang and Shi, 1989) hence the interest to study its efficacy.

6.2 MATERIALS AND METHODS

One hundred and twenty (120) adult chickens were purchased from the villages around Shibuyunji veterinary field station. These chickens were then given prophylactic treatment against some viral and bacterial diseases as described in sections 3.3.1 and 3.3.2.

The chickens were then weighed and placed into four groups of 25 birds each, identified by different coloured insulation tape tags (Sect. 3.4.1).

Two weeks later, the chickens were moved to the School of Veterinary Medicine and placed on concrete floor. The three groups were then treated with the anthelmintics (Table 6.1), while the fourth group served as the control group.

Table 6.1: The three anthelmintics used in the study, their dosages used and the route of administration

Treatment	**Dosage**	**Route of Adminstration.**
Albendazole (75% m/v)	0.01ml/100mg	Per os (p.o.)
Levamisole (25% m/v)	0.12ml/100mg	p.o.
Piperazine (1000mg P. HCl)	0.10ml/100mg	p.o.

The slaughter of the chickens was carried out 10 days post-treatment. The collection, counting and identification of the worms was done as described in sections 3.4.3 and 3.4.4. The drug efficacy was determined by use of the formula (Wood et al., 1995)

$$\frac{\text{Geometric mean of worms (control group)} - \text{Geometric mean of worms (treated group)}}{\text{Geometric mean of worms (control group)}}$$

6.3 RESULTS

The following section gives the results of the total worm counts, the nematode species identified and the percentage efficacy of the drugs being evaluated.

6.3.1 Worm counts and identification

Six (6) nematode species were identified from the different gastrointestinal tract segments. *Heterakis gallinarum* (100%) and *Allodapa suctoria* (98.1%) were the most prevalent. *Acuaria hamulosa* (1.9%) was the least prevalent. The table below gives the results for the identified nematode species in the study.

Table 6.2: The nematode species of the gastrointestinal tract of fowl identified in the study with their prevalence (n = 52)

GIT segments	Nematode species	Prevalence (%)
Crop	*Gongylonema ingluvicola*	15.4
Proventriculus	*Tetrameres americana*	51.9
Gizzard	*Acuaria hamulosa*	1.9
Intestines	*Ascaridia galli*	34.6
Caecum	*Heterakis gallinarum*	100.0
	Allodapa suctoria	98.1

The control group had a mean worm count of 70.59, the group treated with albendazole had a mean worm count of only 3.55. The group treated with levamisole had a mean worm count of 9.67 and the piperazine treated group had a mean worm count of 58.6 (see fig. 6.1).

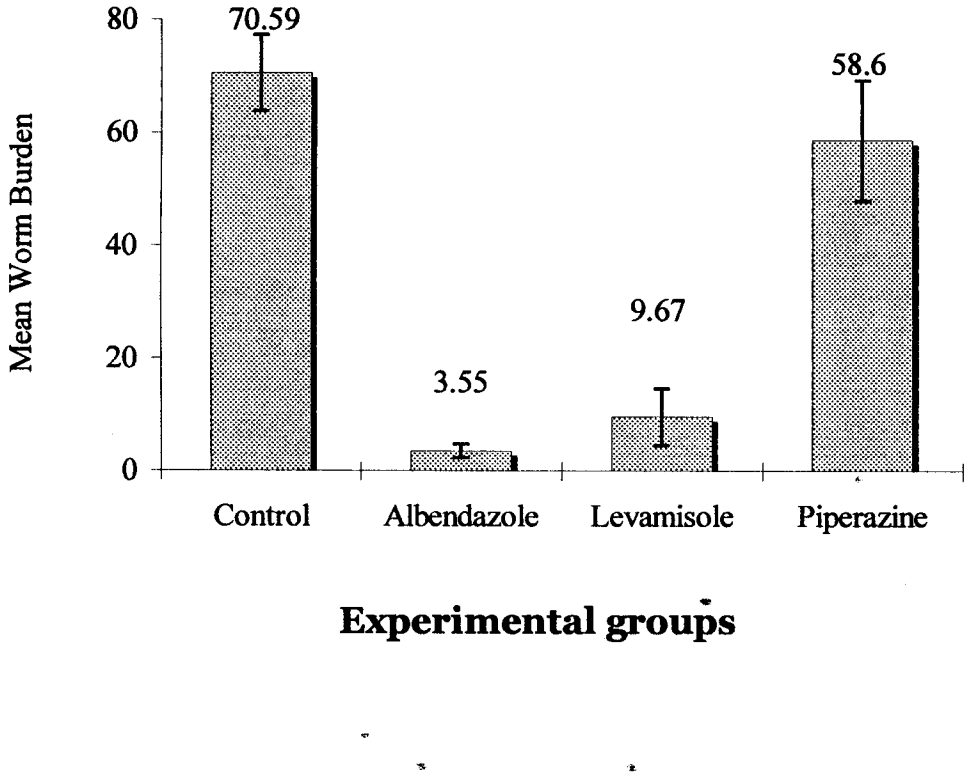


Figure 6.1: The mean (± SEM) worm counts of the four experimental groups, after treatment. The untreated control group (n=25), the albendazole (75% m/v) treated group (n=25), the levamisole (25% m/v) treated group (n=25) and the piperazine (1000mg P. HCl) treated group (n=25).

6.3.2 Percentage efficacy results

Albendazole (75% m/v) recorded the highest efficacy (95%). This was followed by levamisole (25% m/v), which recorded an 86.3% efficacy. Piperazine (1000mg P. HCl) had the lowest efficacy of 17%. Against specific nematode species, albendazole (75% m/v) proved to be the best i.e. against *Ascaridia galli*, the efficacy was 100%, against *Heterakis*

gallinarum, 96.2%, and against *Allodapa suctoria*, 95.1%. For levamisole (25% m/v), the efficacy against *A. galli* was 100%, against *H. gallinarum*, 89.3% and against *Allodapa suctoria,* 89.6%. The efficacy for piperazine against the three mentioned nematodes was insufficient (< 80%). See Tables 6.2 and 6.3, and figure 6.2 below.

Table 6.3: The general percentage efficacy of the anthelmintics, albendazole, levamisole and piperazine.

Anthelmintics	**Percentage Efficacy (%)**
Albendazole (75% m/v)	95.0
Levamisole (25% m/v)	86.3
Piperazine 1000mg P. HCl	17.0

Table 6.4: The percentage efficacy of the anthelmintics, albendazole (75% m/v), levamisole (25% m/v) and piperazine (1000mg P. HCl) against *Ascaridia galli*, *Heterakis gallinarum* and *Allodapa suctoria* (calculated according to Wood et al., 1995)

Helminth species	**Drug percentage efficacy (%)**		
	Albendazole	**Levamisole**	**Piperazine**
Ascaridia galli	100	100	52.4
Heterakis gallinarum	96.2	89.3	27.9
Allodapa suctoria	95.1	89.6	28.6

6.3.3 Worm Counts

The following section gives the results of the respective mean (± SEM) worm counts of the four experimental groups. The mean (± SEM) worm counts in the individual gastrointestinal tract segments of the experimental groups and the results of the mean (± SEM) worm counts of the caecal worms identified in the groups have been shown.

The results have shown that there is a significant difference ($t = 10.32$, $p < 0.01$) between the control group and the albendazole treated group. There is also a significant difference ($t = 7.47$, $p < 0.01$) between the control group and the levamisole treated group. Finally, there is however, no significant difference ($t = 1.41$, $P > 0.01$) between the control group and the piperazine treated group. It has also been noted that significant changes in the caecal and the intestinal worms accounted for these overall changes in significance. The caecal worms (*Heterakis gallinarum* and *Allodapa suctoria*) in the control group had a mean of 65.72±6.67 while in the albendazole, levamisole and piperazine groups had 3.54±1.28, 7.2±4.98 and 47.9±10.7 respectively, see figures 6.2 (A and B) and 6.3 (A and B). Finally, it has been shown that the two caecal Helminths identified had approximately equal numbers in each chicken and responded the same to treatment with the three anthelmintics, see figures 6.4 (A and B) and 6.5 (A and B).

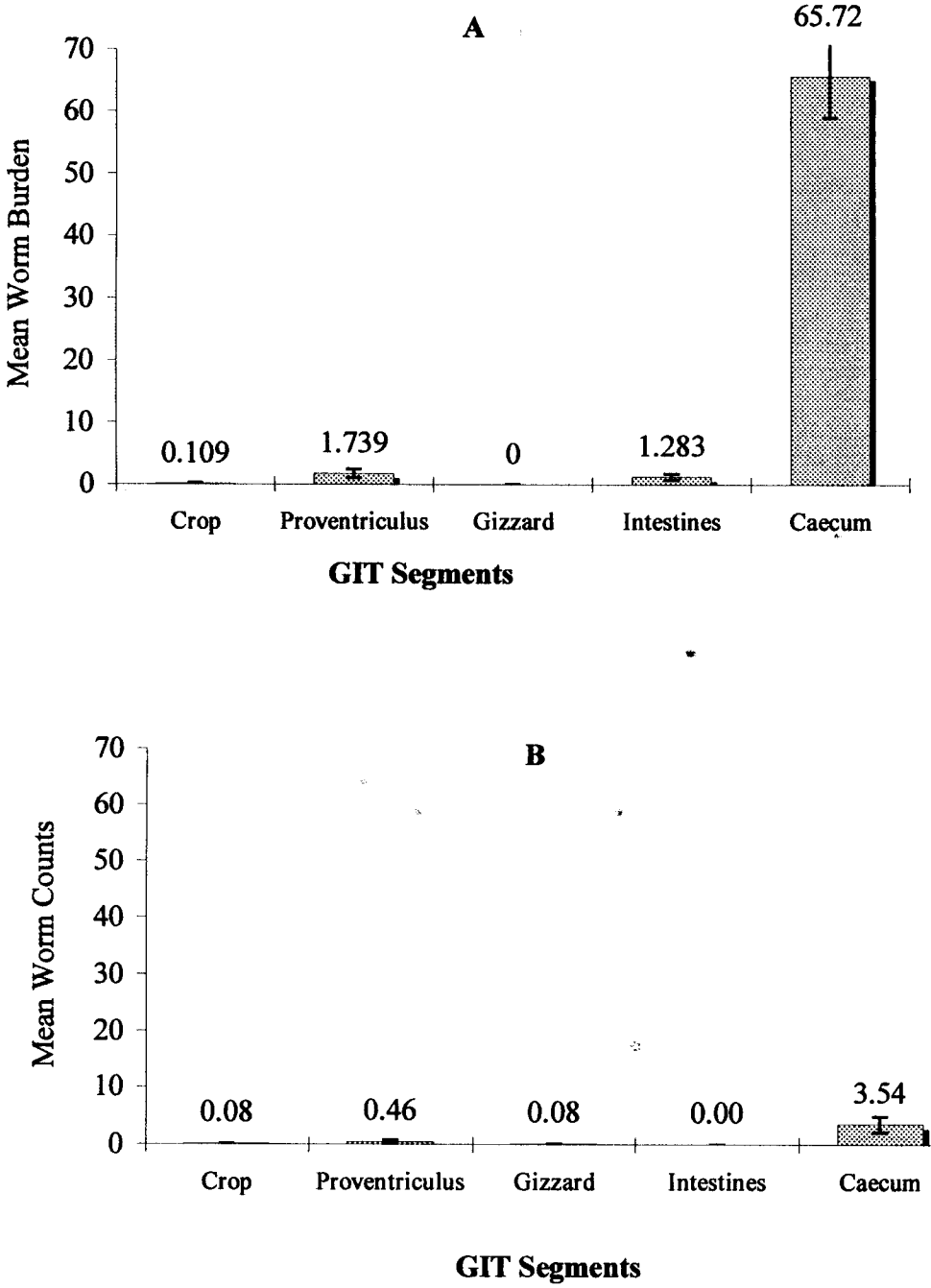


Figure 6.2: The mean (± SEM) worm counts of the different gastrointestinal segments in the untreated control experimental group (n=25) (A) and in the experimental group treated with albendazole (75% m/v) (n=25)(B).

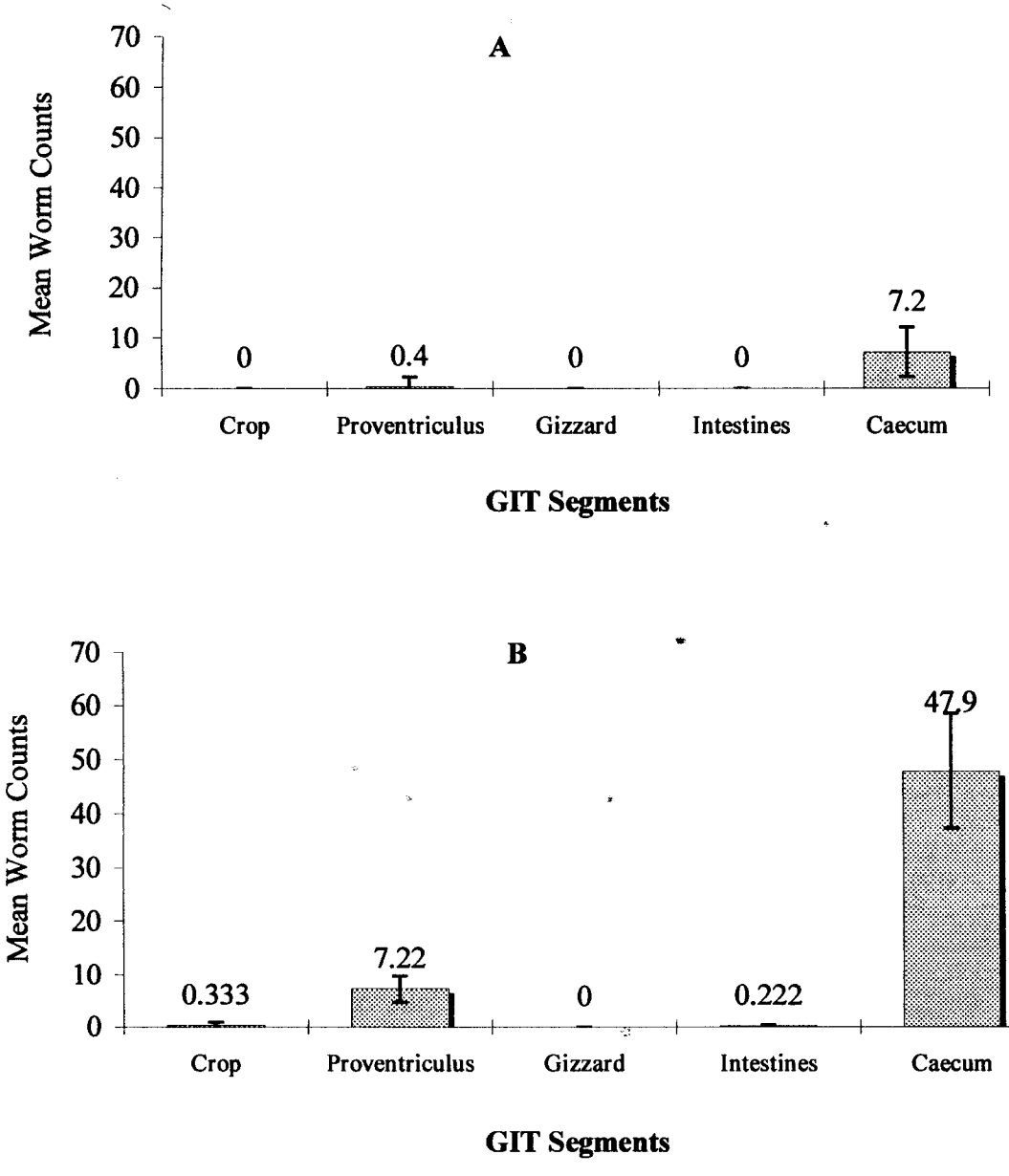


Figure 6.3: The mean (± SEM) worm counts of the different gastrointestinal segments in the experimental group treated with levamisole (25% m/v) (n=25) (A) and in the experimental group treated with piperazine (1000mg P.HCl) (n=25)(B).

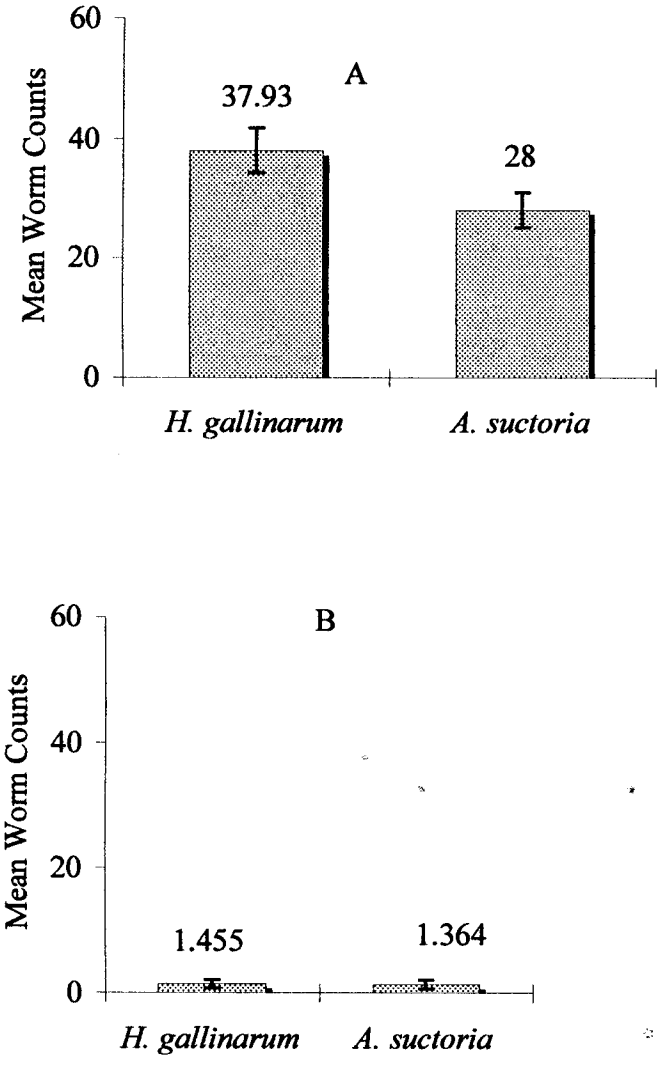


Figure 6.4: The mean (± SEM) worm counts of the caecal nematodes, *Heterakis gallinarum* and *Allodapa suctoria* in the untreated control experimental group (n=25) (A) and in the experimental group treated with albendazole (75%) m/v) (n=25) (B).

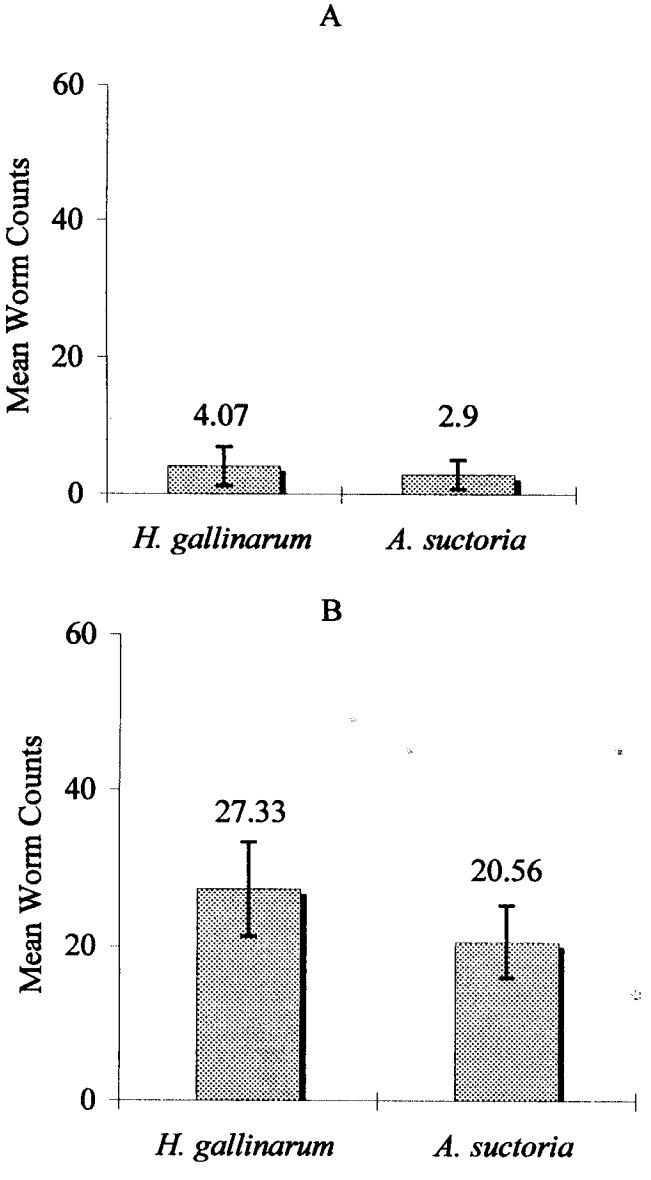


Figure 6.5: The mean (± SEM) worm counts of the caecal nematodes, *Heterakis gallinarum* and *Allodapa suctoria* in the experimental group treated with levamisole (25% m/v) (n=25) (A) and in the experimental group treated with piperazine (1000 mg P. HCl) (n=25) (B).

6.5 DISCUSSION

This study has shown a very high prevalence of gastrointestinal nematode infection in the free-ranging traditionally reared chickens. A 100% infectivity with multiple infections has also been characteristic. This emphasizes the importance of helminthosis (gastrointestinal nematodes in particular) in the domestic fowl and the need to control and prevent its occurrence.

In this study, albendazole and levamisole have each recorded a very high efficacy (95.0% and 86.3% respectively), while piperazine a commonly used dewormer in poultry has recorded a low efficacy (17.0%). This result is consistent for both the overall efficacy and the efficacy for specific Helminths species.

The high efficacy of albendazole does suggest that it would be one of the best drugs of choice for the treatment of gastrointestinal nematodes in domestic fowl. This is in agreement with Csiko, et al. (1996) who reported that there is a high plasma concentration of albendazole and metabolite albendazole-sulphoxide (ABL-SO) formed 1-24 hours after treatment of chickens. The albendazole-sulphoxide derivative is a known-marketed individual product because it also has a significant anthelmintic effect against chicken Helminths (Marriner and Bogan, 1980). McKellar and Scott (1991) in their study on the benzimidazole anthelmintic agents also reported the high efficacy albendazole-sulphoxide has as an anthelmintic. Benchaoui, Scott and McKellar, 1993, in their study in goats on the pharmacokinetics of Albendazole, albendazole-sulfoxide and netobimin, reported that the albendazole-sulphoxide had a high anthelmintic effect. The high percentage efficacy in the

study has been justified therefore, due to this high concentration of both albendazole and the Albendazole-sulphoxide derivative in the plasma. Benchaoui et al., 1993, further reported that albendazole is absorbed from the gastrointestinal tract of chickens more efficiently than in the ruminants justifying the high efficacy observed in the study.

The high percentage efficacy result obtained by levamisole is similar also to other previous reports (Abdelsalam, 1986; Abdelsalam and Nourelhuda, 1988; Verma, Bhatnagar and Banerjee, 1991). Abdelsalam (1986) reported that besides the drug's broad-spectrum anthelmintic activity, the drug also has a non-specific immunomodulatory effect. It has therefore been concluded that the routine use of levamisole in poultry management is highly beneficial in terms of its broad-spectrum anthelmintic activity and its non-specific immunomodulatory effect. Verma et al. (1991) reported a 95.8% efficacy at a dose of 20mg/ kg body weight which was also higher than piperazine in their study, as they compared the efficacy of levamisole, piperazine and pyrantel. This was also similar to an early report by Cruthers, Al-Khateeb and Hansen (1975) when they observed a 100% efficacy with levamisole against gastrointestinal helminths in fowl.

Piperazine on the other hand, has reported a very low, insufficiently active result. This is different from results given in other previous reports (Nilsson and Alderin, 1988; Verma et al., 1991). These all observed at least an 85-90% efficacy, especially against the helminth species, *Ascaridia galli*. Nilsson and Alderin (1988) however did make the drug availability much longer (6-8 hours) to the chickens, possibly leading to the higher percentage efficacy. Sanders and Schwartz (1994) in their study on the evaluation of three water-susceptible

formulations of fenbendazole against *Ascaridia galli* infection in Broiler chickens, gave an interesting observation that could explain this matter. They stated that piperazine eliminated parasites inadequately at the recommended dose (i.e.< 80% efficacy). This could therefore apply to the results in this study, as the dose was the recommended dose. There is need therefore to further investigate the efficacy at different dosages and also the efficacy of the drug administered with different dosing regimes.

In conclusion therefore, according to the study carried out, piperazine has a very low percentage efficacy (17.0%) when administered at the recommended dose as compared to albendazole (95.0%) and levamisole (86.3%). Albendazole has shown to have the highest percentage efficacy against the given helminth species, i.e. *Ascaridia galli* (100%), *Heterakis gallinarum* (96.2%) and *Allodapa suctoria* (95.1%).

CHAPTER SEVEN (7)

GENERAL DISCUSSION

7.0 GENERAL DISCUSSION

Poultry production is one of the fast growing and most viable livestock sectors in Zambia. It offers a unique opportunity for both the urban and rural small-scale farmers to take up as an income-generation venture. Increasingly, small-scale poultry production is playing an important role at household level in Zambia, especially because of the liberalisation of the economy and the high losses incurred in cattle production due to east coast fever, foot-and-mouth disease, and other infectious diseases.

The present study has demonstrated that the problem of helminthosis for the poultry population in Zambia is very serious. This is because of the very high prevalence observed in the traditionally reared flock, which covers more than 50% of the poultry population in Zambia (Hameenda, 1996). A positive aspect that has however been observed in this study is that by improving management practices, significant changes may be made on the existing prevalence and the incidences of new infections occurring. Similar to Ssenyonga (1982) findings, the study has shown that certain helminths due to their life cycles will be more prevalent in the free-ranging fowl than the fowl reared under the commercial farming systems. This is because the life cycles of the parasites cannot be completed, as the intermediate hosts are not present due to the better hygienic standard and the physical barrier created by the chicken housing units. As shown in the study, this problem is currently affecting the sub-region (Msanga and Tungaraza, 1985; Jansen and Pandey, 1989; Permin et al., 1997).

On the effects of helminthosis on the productivity of the flock, the study has shown that

helminth infection does reduce the weight gain potential of the affected flock. This was observed by the significant difference ($t= 2.4$, $p< 0.01$) in the weight gain between the treated and the untreated group. In addition, it was observed that there is a negative correlation between the worm burden and the weight gain in the infected flock ($r^2 =0.61$). This is mainly due to the reduced absorption of some microelements by the infected host, and also pathological changes and subsequently gastrointestinal tract tissue damage (Damyanova et al., 1993). It therefore becomes imperative that infection levels be lowered in flocks to ensure minimum gastrointestinal tract damage and hence optimize the feed efficiency and hence the weight gain potential of the individual chickens and the flock as a whole.

In the third and final study that focused on the efficacy of piperazine (1000mg P. HCl), it was observed that the anthelmintic was not effective. This was even against the *Ascaridia* species identified in the flock. On the other hand albendazole (75% m/v) and levamisole (25% m/v) proved to be more effective and ensured a broader spectrum of helminths were covered on treatment. It is thus important to develop strategic methods of anthelmintic use even in the village poultry-farming sector to reduce the productivity losses. The use of the right anthelmintic at the right time will certainly improve the productivity of the flock. Despite the limited resources, especially among the traditional and the semi-intensive poultry farmers, the need to focus more on developing improved management and production technologies and systems is cardinal for the control of these parasites. This may better the returns for the individuals and the communities as a whole.

In conclusion, I would suggest a systems approach to poultry development on a national as well as a regional level, as the way forward. The poultry development should not only focus on the parasites but also on all aspects of the inputs of productivity in the poultry industry. The inputs include raw material sourcing for feed resources, acquiring and sustaining both the imported and the local genetic pool and the most important aspect for the rural farmer, improving the technical and extension services. This will improve the standard of living of the individuals and the communities that are increasingly becoming dependent on this industry.

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