SEASONAL PARASITE CARRIAGE OF VILLAGE CHICKEN IN MBEERE SUBCOUNTY, ANTIPARASITIC TREATMENTS USED AND EFFECTIVENESS OF SELECTED ANTHELMINTICS

DR. HANNAH WAMBUI CHEGE (BVM, UoN)

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DEPARTMENT OF VETERINARY PATHOLOGY, MICROBIOLOGY AND PARASITOLOGY

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DECLARATION

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

Signed _____ Date 15/4/2014

DR. HANNAH WAMBUI CHEGE (BVM)

This thesis has been submitted for examination with our approval as University supervisors.

1. PROF. LILLY .C. BEBORA (BVM, MSc, PhD)
   DEPARTMENT OF VETERINARY PATHOLOGY, MICROBIOLOGY AND PARASITOLOGY
   UNIVERSITY OF NAIROBI

Signed _____ Date 15/4/2014

2. PROF. NDICHU. MAINGI (BVM, MSc, PhD)
DEPARTMENT OF VETERINARY PATHOLOGY, MICROBIOLOGY AND PARASITOLOGY
UNIVERSITY OF NAIROBI

Signed _____ Date 15/4/2014

3. PROF. PAUL .G. MBUTHIA (BVM, MSc, PhD, FRVCS)
DEPARTMENT OF VETERINARY PATHOLOGY, MICROBIOLOGY AND PARASITOLOGY
UNIVERSITY OF NAIROBI

Signed _____ Date 15/04/2014

DEDICATION

To my loving husband Elijackson Machua, my son Austin, parents; Mr. Joseph Chege Ng'ang'a and Mrs. Jane Wacheke Chege, my sisters; Rehab, Damaris and Rachael and my brother Paul.

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LIST OF ABBREVIATIONS AND ACRONYMS

MAFF	Ministry of Agriculture, Fisheries and Food
NPLD	Nairobi Province Livestock Division
WAAVP	World Association for the Advancement of Veterinary Parasitology
KOH	Potassium hydroxide
mls	Milliliters
EDTA	Ethylenediaminetetraacetic acid
KBS	Kenya Bureau of Statistics
WFP	World food programme

ABSTRACT

Endo- and ecto- parasites are common among village chicken; as they scavenge and forage for food they tend to pick up infective stages of the parasites. These parasites are a major cause of stress to birds where they compete for nutrients, some suck blood causing anaemia, interfere with feed consumption, while others cause anorexia or death. High parasite burden leads to severe parasitism.

Poultry is the most kept livestock and almost every household in villages has about 5-20 indigenous chicken reared under free range management system. Compared to commercially kept exotic breeds, production of these indigenous chicken is poor; one of the reasons for poor performance being stress. It is, therefore, important to control these parasites so as to improve the birds' productivity; this will translate to improved financial status of the poultry keepers. In order to be able to come up with control strategies for these parasites, it was found important to establish the current parasite situation, even though two other researchers have worked on this aspect in Mbeere chicken before (between years 2005 and 2009) - one worked on ecto- and haemo-parasites only while the other worked on endoparasites; theirs was also a one-time study. The current study covered all the three parasite groups and also established their prevalences in wet and dry seasons. It also assessed the effectiveness of selected anthelmintics against endoparasites and documented information on knowledge of chicken parasites and local treatments used in the area, through use of questionnaires.

The questionnaires were administered to 17 farmers in the study area. The main constraints were found to be: diseases (88%) and parasites (70.6%). Ectoparasites commonly encountered were ticks and fleas, at prevalence rate of 47.06% each; and mites and lice at 17.65% each.

Endoparasites occurred at a rate of 29.1%. Majority (71%) of the farmers treated against endoparasites, using mainly piperazine citrate (35.3%). Others (82.4%) controlled ectoparasites using cabaryl (53%), cooking oil (11.6%), ectomin (11.6%), while 23.5% did not know the type of treatment they had given. Sixty five percent (65%) of the respondents used herbal medicine to control endoparasites such as Aloe species (29.4%), pepper (17.7%), ‘’*mikau*’’ (11.7%) and‘’*githongu*’’ (*Solanum incanum*) (11.7%). Other treatments used were, milk (5.88%), improved hygiene (11.76%), used engine oil (5.88%) and liquid paraffin (38.29%).

A total of 48 chicken were randomly selected and purchased from farms in the study area (24 in wet season and 24 in dry season). The chickens were of different ages (16 chicks, 16 growers and 16 adults) and sexes (19 males and 29 females). Post-mortem examination, worm counts and identification were done; two thin blood smears were made from each bird, for haemoparasites examination. All chicken in the 2 seasons had endoparasites, while ecto-parasites were found in all chicken in wet season and 95.8% of the chicken in dry season. In both wet and dry seasons the prevalences were: nematodes 95.8% and 87.5%, cestodes 87.5% and 83.3%, coccidia 20.8% and 0% and haemoparasites 79.2% and 62.5%, respectively. *Heterakis* species were the most prevalent nematodes (wet season 95.8%; dry season 87.5%). Other isolated nematodes were *Tetrameres americana* and *Gongylonema ingluvicola*. *Raillietina echinobothrida* was the most prevalent cestode (wet season 79.2%; dry season 54.2%). Other cestodes were; *Raillietina tetragona, Davaenea proglottina, Hymenolepis cantaniana* and *Choanotaenia infundibulum.* Among the recovered haemoparasites, *Plasmodium gallinaceum* was the most common (wet season 79.2%; dry season 62.5%). Ectoparasites observed in both seasons were mites, lice, ticks and fleas. Lice were the most prevalent (wet season 100%; dry season 70.4%). The difference in

occurrence of lice was statistically significant between the two seasons, among the age groups and between the sexes ($p<0.05$).

The effectiveness of piperazine citrate, albendazole and levamisole hydrochloride (HCL) was tested at the University of Nairobi, using 37 adult chicken purchased from individual farmers in the study area. Before the start of the experiment, post-mortem examination was done on 7 birds to determine the type of endoparasites the birds were carrying. This is the first study to be done in chicken, in Kenya. The birds were transported to the University and after 3 days of stabilization, separated into 4 groups. Chicken in groups 1, 2, and 3 were treated with piperazine citrate, levamisole HCL and albendazole, respectively, while group 4 chicken served as untreated controls. Albendazole at 20 mg/kg was administered orally as a single dose, while piperazine citrate and levamisole HCL were given for 24 hours in drinking water at dosages of 3 mg/kg and 25 mg/kg, respectively. Post -mortem examination for parasites was done 7 days post- treatment. Throughout the experimental period, each chicken was kept separately in cages where faecal samples were collected 3 times per day; morning (8pm), noon (12pm) and evening (5pm) and screened for parasite eggs. Albendazole was 100% effective against caecal worms (*Heterakis* species, *Subulura brumpti*) *Tetrameres americana, Raillietina tetragona* and *Raillietina echinobothrida*. Levamisole HCL was 100% effective against the caecal worms but had little effect on *Raillietina echinobothrida* (25.6%), *R. tetragona (*17.6%) and *Tetrameres americana* 62.8%. Piperazine citrate was effective against ascarids (which were found only in one bird) but had no effect on other worms.

In this study, done in Mbeere, heavy ecto- and endo-parasite carriage was demonstrated in chicken during both dry and wet seasons. Control of these parasites is recommended and use of albendazole would ensure total control of the worms.

CHAPTER ONE

1.0 INTRODUCTION

The livestock sub sector contributes 7.9% of the Kenyan economy. Out of the agricultural Gross Domestic Product (GDP), which makes-up 25% of the national GDP, the poultry industry contributes about 1.7% (MoLD 2008). Poultry production is a growing and economically important industry for Kenya's rural families and it contributes to the livelihood of an estimated 21 million people. The rapidly increasing human population in Kenya has led to shortage of land for agriculture and many people in rural areas have opted for poultry production which requires less land and its products are readily preferred by consumers (Kiptarus, 2005). Over the years the poultry industry has grown tremendously due to demand for meat and eggs especially in the urban areas (EPZ, 2005). The population stands at approximately 34 million, of which 6 million are commercial hybrids and the rest are indigenous chickens (KBS, 2009). The population of poultry increased from 21 million in 1993 (Mukisira, 2000) to 29 million in 2001and 34 million birds in 2006 (NPLD, 2007).

Many poultry owners have marginal incomes and poultry is therefore kept as a source of income, food and manure. The flock sizes range between 5-20 birds, which are mainly owned by women and children. The major poultry species kept include chicken, ducks, geese, and turkeys, guinea fowls, turkeys, pigeons, quails and ostriches (Mbugua, 1990). The most kept poultry are chicken (Perry *et al*., 2002; Moreki *et al*., 2010). Previous research has shown that about 90% of small-scale farmers in Kenya rear indigenous chicken (Ndegwa *et al*., 1998; Kaudia and Kitalyi, 2002). In contrast to the other livestock sectors, chicken production has an advantage of having quick returns to the investment and relatively simple management practices with numerous market

outlets. Indigenous chicken are usually hardy and they adapt well to the rural environments (Bebora *et al*., 2002). The major hindrances to enhanced poultry production are diseases like Newcastle disease, gumboro disease, fowl pox and helminthosis, poor management, poor nutrition, predation and theft. Diseases and parasites are common among indigenous chicken although they are not well documented (Nzioka, 2000). Past investigations have shown that gastrointestinal tract (GIT) worms are a problem to the chicken in feed scarce rural/scavenging production systems (Abebe *et al*., 1997; Permin *et al.*, 1997; Terregino *et al*., 1997; Eshetu *et al.*, 2001; Mukaratirwa *et al*., 2001; Irungu *et al.*, 2004; Maina, 2005; Sabuni, 2009).

Endo- and ecto- parasites are common among indigenous chicken since they are kept outdoors; as they scavenge and forage for food they pick up infective stages of the parasites. These parasites compete with the birds for nutrients; some suck blood causing anaemia, while others cause anorexia or death. Some ecto-parasites are important in transmission of certain pathogens, while others may cause disease such as scaly leg and depluming mange (Soulsby, 1982).

Anthelmintic interventions often involve medication with piperazine, tetramisole and oxfendazole. However these anthelmintics generally exhibit low efficacy and are associated with undesirable effects (Verma *et al*., 1991). In previous studies done in Arkansas, USA to determine the efficacy of albendazole in the treatment of chicken that were naturally infected with gastrointestinal helminths, it was demonstrated that 20 mg/kg body weight of albendazole cleared larval and adult stages of *Ascaridia galli*, *Heterakis gallinarum, Capillaria obsignata* and *Raillietina cesticillus* (Tucker *et al*., 2007). Another study conducted in Kansas State University, USA, to evaluate the efficacy of levamisole in drinking water against some nematodes of chicken, demonstrated that a dose of 48 mg/kg body weight was 100% efficacious against

Heterakis gallinarum. It was also found that levamisole given in drinking water to chickens at dosages of 18 or 24 mg/kg body weight was 100% efficacious against *Ascaridia galli* (Cruthers *et al*., 1975). No such studies have been done in Kenya; this is the first one.

Heavy parasite burdens have been recorded in indigenous chicken in Eastern Province of Kenya. Sabuni (2009 and 2010) reported that most chicken from this area were infested with ectoparasites such as lice, mites, fleas and ticks as single or mixed infestations. The intensity of parasite infestation was also significantly different among different age groups but not between sexes of birds. A study carried out by Maina (2005) on indigenous chicken sold in markets in Nairobi reported high carriages of endoparasites. Tracing the birds to respective origins, Maina (2005) found that some of the birds were from Eastern Province, which encompasses Mbeere Subcounty. Previous research on seasonal parasite variation between March 2005 and August 2006 was conducted in Machakos in Eastern Kenya where endoparasites were found to be more prevalent during the wet season and the ectoparasites were more prevalent during the dry season (Mungube *et al*., 2008). The seasonal occurrence of parasite types and intensity of both ecto-and endo-parasites in these chicken in Mbeere subcounty have not yet been determined. Also, not previously documented were the various anti-parasitic treatments used in the area and their effectiveness.

1.1 HYPOTHESIS

Parasite carriage and intensity of infections varies with seasons and there are effective anthelmintic treatments used in village chicken in Mbeere subcounty.

1.2 OBJECTIVES

1.2.1 Overall objective

To determine the seasonal parasite types and intensity in village chicken of Mbeere Subcounty, types and methods of anti-parasitic treatments used, and effectiveness of selected anthelmintics.

1.2.2 Specific objectives

1. To collect data on chicken parasites and local treatments used against them in Mbeere subcounty.
2. To establish parasite types and intensity in village chicken of Mbeere subcounty, in dry and wet seasons.
3. To determine effectiveness of selected anthelmintics used on the village chicken.

1.3 JUSTIFICATION

Parasitism is a problem in village chicken and the parasites are likely to contribute significantly to low productivity. The infections are likely to vary with season, which is an important consideration in their control. Work on seasonal parasite variation has been done in Eastern Kenya (Mungube *et al.*, 2008); he worked on the prevalence of parasite loads of local scavenging chicken between March 2005 and August 2006. However, to date, no studies have been done to determine the seasonal variations in parasite types and intensity of infection for both endo and ecto-parasites of indigenous chicken in Mbeere subcounty, Kenya. No previous studies have been carried out to document the methods and types of anti-parasitic treatments the farmers are using and their effectiveness. Results of this study will help in planning effective parasite control in Mbeere subcounty.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Poultry industry in Kenya

The poultry industry in Kenya has over the years progressed to become an important livestock enterprise particularly in the rural households where over 70% of the country's population live and derive their livelihood (MoLD, 2008). Poultry, especially chicken are the most numerous species of farm animals in the world (Perry *et al*., 2002; Moreiki *et al*., 2010). About 90% of small-scale farmers in Kenya rear indigenous poultry, majority of which are indigenous chicken (Gichohi and Maina, 1992). In Kenya, the population of chicken is approximately 34 million of which 6 million are commercial hybrids and the rest indigenous chicken (KBS, 2009). Poultry keeping is attractive to poor households as it requires low capital to start.

2.2 Ectoparasites and endoparasites of poultry

Diseases, including parasitism are common among indigenous chicken but they are often neglected. The most common diseases are Newcastle disease, fowl pox, fowl typhoid, infectious bursal disease (Gumboro disease), infectious coryza, helminthosis and coccidiosis. Ecto- and endo- parasites lower the growth of their host and could also affect the blood composition and cause anorexia (Permin *et al*., 1997; Hørning *et al*., 2003). Endo-parasite infections in indigenous chicken are common because of the risks posed by free range system management (Ondwassy *et al*., 1999). A study conducted in Zimbabwe showed that all chickens harboured ecto- and endo-parasites (Permin *et al*., 2002).

2.2.1 Ectoparasites of poultry

Ectoparasites found on poultry are in the Phylum Arthropoda. This phylum is characterized by segmented bodies, jointed appendages and chitinous exoskeleton. It has two main classes Arachnida including the order Acarina (ticks and mites), and Insecta, which has the order Phthiraptera (Lice), Hemiptera (bugs), Siphonapetera and Diptera (flies and mosquitoes) (Soulsby, 1982; Permin and Hansen, 1998).

The Class Arachnida is characterized by fused body divisions, no antennae, three pairs of legs in larvae and four pairs of legs in adults. The class Insecta is characterized by possession of three body parts (head, thorax and abdomen), one pair of antennae attached to the head, three pairs of legs attached to the thorax and trachea for breathing. Some adult insects have wings (Arends, 2003). Ectoparasites transmit a number of infectious diseases to poultry such as *Pasteurella multocida*, *Aegyptinella* species, *Borrelia anserina*, *Plasmodium* species and *Leucocytozoon* species. They can also act as intermediate hosts of helminths like *Heterakis gallinarum.*

Various ectoparasites have been reported in local scavenging chicken. The most common are lice, fleas, ticks and mites (Gordon and Jordan, 1982; Soulsby, 1982; Permin *et al*., 2002; Mungube *et al*., 2008; Sabuni *et al*., 2010).

2.2.1.1 Poultry lice

Lice infecting chicken are in the order Mallophaga, chewing type (Soulsby, 1982). They are characterized by chewing mandibles located ventrally on the head, and short antennae with 3-5 segments. They also undergo incomplete metamorphosis.

Lice affecting chicken include the following:

Menacanthus stramineus (body louse/yellow body louse)

This louse occurs in chicken, turkeys, geese and other birds. It is relatively large; adults measuring 3.5mm in length. It has palps and four segmented antennae that are distinct. The abdomen has a dense covering of medium-length setae (Wall and shearer, 1997). It stays on the skin rather than on the feathers in areas of the body that do not have dense feathers. Each of the abdominal segments has two rows of bristles. The eggs have characteristic filaments on the anterior half of the shell and on the operculum and are laid in clusters on the feathers near the skin (Soulsby, 1982). This type of louse has been recorded in Zimbabwe (Permin *et al*., 2002), Dube *et al*., 2010), Kashmir valley (Salam *et al*., 2009) and in Machakos Kenya (Mungube *et al.*, 2008).

Menopon gallinae (Shaft louse)

This louse affects chicken, turkeys, ducks, geese and other birds. It is pale yellow in colour, found on body feather shafts. The males measure 1.71 mm and females 2.04 mm long (Soulsby, 1982). It has small palps and a pair of antennae, folded into grooves in the head. The antennae have four segments and the abdomen has sparse covering of small to medium-length setae (Walker, 1994; Fabiyi, 1996) in Africa. It has been reported in Zimbabwe (Permin *et al*., 2002), Zambia (Lumbwe, 2002), Nigeria (Sadiq *et al.,* 2003), in market birds in Kenya (Maina, 2005) and Eastern Kenya (Sabuni *et al*., 2010). The eggs are laid in clusters on feathers.

Cuclotogaster heterographus (head louse)

This is mainly found on the head but can also be found on other parts of the body. It affects chicken, turkeys, ducks and geese. The males measure 2.43 mm and females 2.6 mm long. The

abdomen is barrel shaped in females and more elongate in males (Wall and Shearer, 1997; Soulsby, 1982). It has been recorded in Nigeria (Sadiq *et al.*, 2003) and in Kenyan market birds (Maina, 2005).

Gonoides gigas

This is a large brown louse that is mainly found on body feathers. The head is concave posteriorly, producing marked angular corners at the posterior margins. It has two bristles that project from each side of its dorsal surface (Wall and Shearer, 1997). In Africa, it has been reported in Nigeria (Sadiq *et al*., 2003), Zimbabwe (Permin *et al*., 2002) and in Eastern Kenya (Sabuni *et al*., 2010).

Lipeurus caponis (wing louse)

This is a slender, elongated louse that occurs in fowls and pheasants. It is located on the under-side of the large wing feathers (Soulsby, 1982). It measures about 2.2 mm long and 0.3 mm wide. The legs are narrow and, characteristically, the hind legs are about twice as long as the front two pairs. This louse has characteristic small angular projections on the head in front of the antennae (Walker, 1994). It has been recorded in Nigeria (Sadiq *et a*l., 2003) and in Eastern Kenya (Sabuni *et al*., 2010).

2.2.1.2 Poultry Ticks

Argas persicus (fowl tick) is commonest in domestic poultry and affects chicken, turkeys, pigeons, ducks and geese in tropical and sub-tropical countries. It is mostly found on the skin but adult ticks spend most of the time in cracks or under the tree barks away from the host (Permin

and Hansen, 1998). This tick does not have a scutum except for the larval stage that feed intermittently. The edges of the body are sharp. Unfed ticks have a flat ovoid shape and are brown/reddish in colour. The engorged tick has a slaty-blue colour (Soulsby, 1982). This tick has been reported in Nigeria (Sadiq *et al*., 2003), Zimbabwe (Permin *et al*., 2002), in market chicken in Kenya (Maina, 2005) and in Eastern Kenya (Sabuni *et al.*, 2010).

2.2.1.3 Poultry mites

Poultry mites burrow into the skin or live on feathers. Poultry mites are differentiated on the shape of dorsal plate (Permin and Hansen, 1998). The most common poultry mites include the following;

Dermanyssus gallinae (red mite)

This mite belongs to the family Dermanyssidae that are blood sucking ectoparasites of birds and mammals. It is a cosmopolitan species that attacks chicken, pigeon, canary and other caged birds and many wild birds. It is occasionally found in humans if the usual host is unavailable. This mite lives in cracks and crevices of chicken houses and feeds mainly at night (Wall and Shearer, 1997; Soulsby, 1982). The engorged adult female mites measure up to 1 mm in length or larger the other stages are smaller. Its colour varies, being only red after taking a blood meal on its host and grayish white when unengorged. The dorsal shield tapers posteriorly but the posterior margin is truncated. Three anal setae are present. The chelicerae are long and whip-like (Wall and Shearer, 1997). This mite has been reported in Zimbabwe (Dube *et al.*, 2010), Zambia (Lubwe, 2002), Machakos in Kenya (Mungube *et al*., 2008) and Eastern Kenya (Sabuni *et al.*, 2010).

Ornithonyssus sylvarium (Northern fowl mite)

This mite occurs in chicken and other birds in temperate climates and it has been found in Britain and in New Zealand. It stays on the chicken all the time. It is differentiated from other species by the shape of the dorsal plate which is wide for two-thirds of its length and later tapers to form a tongue-like continuation about half as wide for the remainder of its length (Soulsby, 1982).

Ornithonyssus bursa (tropical fowl mite)

It is found in sub-tropical and tropical areas and affects chicken, pigeon, sparrow and other birds in warmer parts of the world, but can also affect man. It closely resembles the Northern fowl mite but it can be differentiated by the shape of the dorsal plate which gradually tapers to a posterior blunt end (Wall and Shearer, 1997). This mite has been reported in Zambia (Lumbwe, 2002).

Cnemidocoptes mutans (scaly leg, burrowing mite).

It is mainly found under the scales of legs but occasionally found on the comb, wattles and neck. Chicken and turkeys are the most important hosts. Birds get infected from the ground and infection spreads upwards. This mite is spherical in shape and is characterized by short legs that are stubby and anus that is terminal. The dorsal surface is covered by striations. Adult females measure 0.5 mm. The body has no spines or scales (Permin and Hansen, 1998; Wall and shearer, 1997; Soulsby, 1982). This mite has been reported in Zimbabwe (Dube *et al.,* 2010; Permin *et al.,* 2002), Tanzania (Msanga and Tungaraza, 1985), Zambia (Lubwe, 2002), Machakos, Kenya (Mungube *et al.,* 2008) and Eastern Kenya (Sabuni *et a*l., 2010).

Cnemidocoptes gallinae (depluming mite)

It inhabits the skin at the bases of feathers especially around the head and neck. This is a small mite that morphologically resembles *Cnemidocoptes mutans* but the dorsal striations are unbroken (Permin and Hansen, 1998). Females are rounded and about 400µ long.

2.2.1.4 Poultry Fleas

Echidnophaga gallinacea (stick tight flea) is a burrowing flea that affects chicken and other birds. It infects the skin of the head and survives for a long time in chicken houses (Soulsby, 1982). The adult flea is brown to black measuring about 1 mm. The head is sharply angled at the front. There are no genal and pronotal ctenidia. There are two setae behind the head and females have a well developed occipital lobe (Wall and Shearer, 1997). This flea has been reported in Nigeria (Sadiq *et al*., 2003), Zimbabwe (Permin *et al*., 2002), in market chicken in Kenya (Maina, 2005) and in Eastern Kenya (Sabuni *et al*., 2010).

2.2.2 Endoparasites of poultry

Endo-parasites of poultry include nematodes, cestodes, trematodes and protozoan species. Gastro-intestinal worms have been shown to be a problem to chicken in feed-scarce rural scavenging production systems (Maina, 2005). Owing to the free-range and scavenging habits, traditional village poultry is in permanent contact with soil and insects. Soil especially when humid acts as an important reservoir and transmission site for external larval stages of helminths (Permin *et al.*, 1997; Hørning *et al*., 2003). An earlier study, carried out in Kenya, Machakos county, showed that 93.35% of the chicken had helminths (Mungube *et al*., 2008); however, this has not been evaluated in Mbeere, subcounty.

2.2.2.1 Nematodes

Nematodes belong to the Phylum Nematohelminthes and Class Nematoda (roundworms). They are unsegmented and elongated in shape (Permin and Hansen, 1998; Norton and Ruff, 2003; Soulsby, 1982). All roundworms have an alimentary canal and have a direct or indirect life cycle. Those infecting poultry include *Ascaridia, Capillaria, Heterakis, Subulura, Dispharnyx, Gongylonema, Trichostrongylus Allodapa, Acuaria, Syngamus, Oxyspirura* and *Strongyloides* species (Soulsby, 1982).

Ascaridia galli

This worm is found in chicken, turkeys, geese, guinea fowl and a number of wild birds (Permin and Hansen, 1998). It occurs in the small intestines and occasionally in the oviduct. It is semitransparent and the oesophagus has no posterior bulb. The female is 72-116 mm and the male 51-76 mm long. It has three prominent lips at the mouth opening. The males have pre-anal sucker and two equal spicules measuring 1-2.4 mm in length. The female vulva opens in the middle of the body. This parasite has a direct life cycle where eggs are passed out in faeces onto damp or warm soil and become infective after 8 days. The eggs are smooth and oval in shape measuring 73-92 by 45-57 µm (Soulsby, 1982). *Ascaridia galli* has been recorded in Zimbabwe (Permin *et al*., 2002; Dube *et al*., 2010), in Kenya (Maina, 2005; Mungube *et al*., 2008; Kaingu *et al*., 2010).

Capillaria species

There are six species that are commonly found in poultry; *C. annulata, C. contorta, C. caudinflata, C. bursata, C. obsignata* and *C. anatis* (Permin and Hansen, 1998). The worms are

hair-like and are located along the entire intestinal tract. These parasites are difficult to detect in the intestinal content. *Capillaria annulata* and *C. contorta* are found in the crop and oesophagus while *C. caudinflata, C. bursata* and *C. obsignata* are found in the small intestines and *C. anatis* in the caeca. Females of *C. annulata* are 37-80 mm long and males are 15-22 mm long. Their eggs have a characteristic bipolar plugs and measure 60 by 25 µm. *Capillaria caudinflata, C. bursata, C. obsignata* and *C. anatis* are smaller, measuring 6-35 µm and their eggs measures 45 by 25 µm (Norton and Ruff, 2003). *Capillaria annulata* has been recorded in Zimbabwe (Dube *et al*., 2010) and in Kenya (Maina, 2005; Kaingu *et al*., 2010).

Heterakis species

Three species of *Heterakis* are important in poultry. These are *H. gallinarum*; *H. isolonche* and *H. dispar* (Permin and Hansen, 1998). These species are cosmopolitan. They are all found in the lumen of the caecum but the larvae of *H. isolonche* live in the mucosa of the caecum; it is only when they become adults that they live in the lumen of the caecum. The three species have a similar appearance but *H. dispar* is slightly larger than *H. gallinarum* and *H. isolonche*. The three species are differentiated based on the shape of the oesophagus and the length and shape of spicules. Their females measure 10-15 mm and males 7-13 mm long. The eggs have a smooth shell and measure 65-80 by 35-46 µm. *Heterakis species* have a direct life cycle. Eggs are passed out in faeces of the bird and take 2 weeks to become infective. The eggs are ingested by the bird; hatch into larvae and the worms mature in the caecum (Soulsby, 1982). *Heterakis gallinarum* has been reported in Zimbabwe (Dube *et al*., 2010; Permin *et al*., 2002) and in Kenya (Maina, 2005; Kaingu *et al*., 2010). *Heterakis gallinae* has been reported in Kenya (Maina, 2005).

Subulura brumpti (Syn *Allodapa suctoria*)

This parasite occurs in chicken, turkeys, guinea fowls, ducks, pheasants, grouse and quails in North and South America, Africa and Asia (Permin and Hansen, 1998). It is found in the caecum. Females measure 9-18 mm and males 7-10 mm long. This parasite is small, white in colour, with a dorsally curved anterior end. Its oesophagus has a small posterior swelling followed by a constriction and an oesophageal bulb. The tail is curved ventrally in male worms and has large lateral alae. The spicules are equal in size. The worm has an elongated pre-cloacal sucker that is surrounded by radiating muscle fibers (Soulsby, 1982). *Subulura brumpti* has been reported in Kenya (Maina, 2005).

Tetrameres species

Tetrameres species are found in the proventriculus. *Tetrameres americana* occurs in chicken, turkeys, ducks, geese, grouse and quails in North America and Africa (Hansen and Permin, 1998; Soulsby, 1982). Females measure 3.5-4.5 by 3mm while the males are 5-5.5 mm long. The female is sub-spherical and has four longitudinal furrows on the surfaces (Urquhart *et al*., 1996). Their eggs are thick shelled and measure 42-50 by 24 µm. These parasites have an indirect life cycle where grasshoppers or cockroaches act as intermediate hosts. *Tetrameres americana* have been recorded in Zimbabwe (Permin *et al*., 2002) and in Kenya (Maina, 2005; Mungube *et al*., 2008).

Gongylonema ingluvicola

These worms are found in the crop, oesophagus and proventriculus in chicken, turkeys, partridges, pheasants and quails. Females measure 32-55 mm and male 17-20 mm long. Their

anterior end of the body has varying number of characteristic round or oval thickenings called cuticular plaques. It has indirect life cycle that utilizes beetles or cockroaches as intermediate hosts (Permin and Hansen, 1998, Msoffe and Cardona, 2009). This parasite has been documented in Zimbabwe (Permin *et al*., 2002) and in Kenyan chicken (Maina, 2005) and ducks (Mavuti, 2010).

Acuaria humulosa (Sny.Cheilospirura humulosa)

It occurs in chicken and turkeys in North and South America, Europe, Africa and Asia (Permin and Hansen, 1998; Norton and Ruff, 2003; Soulsby, 1982). Its predilection site is the gizzard. The females measure 16-29 mm and males 10-14 mm long. It has four long circular cordons which are irregular and wavy in shape that extend two thirds down the body (Soulsby, 1982; Permin and Hansen, 1998; Norton and Ruff, 2003). The tail is pointed and the eggs are embryonated when deposited. The males have four pairs of pre-cloacal and six pairs of post-cloacal papillae. This parasite has indirect life cycle, the grasshoppers, beetles sand hoppers and weevils act as intermediate hosts (Soulsby, 1982; Permin and Hansen, 1998). *Acuaria hamulosa* has been recorded in Zimbabwe (Dube *et al*., 2010) and in Kenya (Maina, 2005).

Dispharnyx nasuta

It has been reported in chicken, turkeys, grouse, guinea fowls, partridges, pheasants, pigeons, quails in North and South America, Africa and Asia. It is located in the proventriculus and oesophagus. It has four cuticular cordons which recurve but do not anastomose or fuse. This parasite has a wavy pattern to the anterior end. The females measure 9-10.2 mm and males 7-8.3 mm in length. The left male spicule is long and measures 0.4 mm and the right spicule is 0.15-

0.2 mm. The eggs are embryonated and measure 33-40 by 18-25 µm. This parasite has an indirect life cycle where pill bugs and sow bugs serve as intermediate hosts (Permin and Hansen, 1998; Soulsby, 1982).

Nematodes found in tissues

Oxyspirura mansomi

It occurs in the nictitating membrane in the naso-lacrimal ducts or conjuctival sacs. The worm is slender and has a smooth cuticle. The female worm is 12-19 mm and the male is 10-16 mm long. The vulva of the female is located on the posterior end (Soulsby, 1982).

Syngamus trachea

It occurs in the trachea of chicken, turkeys, pheasants, guinea fowls, geese and various wild birds (Soulsby, 1982; Permin and Hansen, 1998; Norton and Ruff, 2003). The parasite is bright red in colour and the two sexes are found in permanent copulation. The females are 5-20 mm and the males are 2-6 mm long. The mouth opening is wide without leaf-crowns. The buccal capsule is cup-shaped with six to ten small teeth at its base. The male possesses two spicules that measure 53-82 µm. Their eggs are operculated in both poles. It has an indirect life cycle -earthworms, snails and flies serve as intermediate hosts (Permin and Hansen, 1998). *Syngamus trachea* has been recorded in Kenya (Maina, 2005).

2.2.2.2 Cestodes of poultry

Tapeworms belong to the Phylum Platyhelminthes and Class Cestoda. They are endoparasitic, hermaphroditic worms. They have flat long segmented bodies without alimentary tract or body

cavity (Soulsby, 1982; Permin and Hansen, 1998). The following genera infect chicken: *Raillietina, Hymenolepis, Choanotaenia, Davainea* and *Amoebataenia* species. All tapeworms of chicken have indirect life cycle; earthworms, ants, flies or grasshoppers acting as intermediate hosts (Soulsby, 1982; Permin and Hansen, 1998).

Raillietina species

The most common *Raillietina* species in poultry are *R. tetragona*, *R. echinobothrida* and *R. cesticillus. Raillietina echinobothrida* occurs in the small intestine of chicken, turkey and other fowl while *R. tetragona* occurs in small intestine of chicken, guinea fowls, pigeons and other birds (Soulsby, 1982). *Raillietina tetragona* has a cosmopolitan distribution and it is one of the largest chicken tapeworm measuring upto 25 cm long. The rostellum is armed with one or two rows of hooks. It has along neck and the suckers are oval and armed. The shape of *R. echinobothrida* resembles *R. tetragona* but it is more heavily armed with two rows of hooks and the suckers are round (Permin and Hansen, 1998). It has been recorded in Zimbabwe (Permin *et al*., 2002; Dube *et al*., 2010) and Kenya (Maina, 2005; Mungube *et al*., 2008; Kaingu *et al*., 2010).

Raillietina cesticillus (Sny. *Skrjabinia cesticillus*) is a cosmopolitan parasite of the domestic poultry. It measures 4 cm and rarely 15 cm long. The parasite has no neck but the scolex has a wide rostellum armed with 400-500 small hooks. The suckers are not conspicuous and are unarmed. *Raillietina cesticillus* has been reported in Kenya (Maina, 2005).

Hymenolepis species

This genus contains two species which are pathogenic; *H. carioca* and *H. cantaniana* which are found in fowls (Permin and Hansen, 1998). They have a predilection site in the small intestine. *Hymenolepis carioca* is slender and threadlike and measures 8cm long. The parasite has indirect life cycle and the beetles act as intermediate hosts. *Hymenolepis cantaniana* is 2 cm long, has indirect life cycle and the crustaceans serve as intermediate hosts (Permin and Hansen, 1998). *Hymenolepis carioca* has been recorded in Kenya (Maina, 2005).

Choanotaenia infundibulum

It occurs in the upper half of small intestine in chicken and turkeys in most parts of the world; it measures 23 cm long. The rostellum is armed with 16-22 slender hooks. The suckers are unarmed and the genital pores alternate irregularly. The proglottids are clearly wider at the posterior end of the parasite. The eggs have distinct elongate filaments and measure 47 by 54 µm (Soulsby, 1982; Permin and Hansen, 1998; Norton and Ruff, 2003).

Davainea proglottina

The parasite is found in duodenum of chicken, pigeons and other birds in most parts of the world. They measure 4 mm long with 4-9 proglottids. The rostellum and suckers are armed. The genital pores alternate regularly. It has indirect life cycle with snails acting as the intermediate hosts (Gibbons *et al*., 1996). *Davainea proglottina* has been recorded in Kenya (Maina, 2005; Mungube *et al*., 2008).

Amoebataenia cuneata (Sny.*Amoebotaenia sphenoides*)

It occurs in the duodenum of the chicken in most parts of the world. The parasite is small with a triangular shape that measures 4 mm long and 1 mm wide. The rostellum is armed with a single row of 12-14 distinctive hooks and the proglottids are about 20 (Gibbons *et al*., 1996). It has indirect life cycle and the earthworms act as intermediate hosts (Permin and Hansen, 1998).

2.2.2.3 Trematodes of poultry

Trematodes belong to the Phylum Platyhelminthes and Class Trematoda. They have two Sub-classes; Aspidogastrea and Digenia. All poultry trematodes belong to the Subclass Digenia (Soulsby, 1982). They have a digestive system and include the following:

Prosthogonimus species

The most common *Prosthogonimus species* are: (1) *Prosthogonimus pellucidus* that occurs worldwide in chicken and ducks. It occurs in the bursa of Fabricious, oviduct and posterior intestine. It is pale reddish yellow in colour. It measures 8-9 by 4-5 mm and it is usually broad posteriorly. It possesses oval testes that lie horizontally at the middle of the body. The ovary is much lobed and lies partly dorsal to the ventral sucker. The eggs are brown, operculated and bear a spine at the pole opposite to the operculum (Soulsby, 1982). The parasite requires two intermediate hosts, the first - a water snail and the second - the nymphal stage of various species of dragon flies. The birds become infected when they eat infected larvae or adult stages of the dragon fly. (2) *Prosthogonimus macrotchis* occurs in bursa of Fabricius and oviduct of chicken and ducks and wild birds in North America. It measures 5-7 mm in length (Soulsby, 1982).

Echinostoma revolutum

It occurs in the rectum and caecum of ducks and geese, pigeons and humans. This parasite is 10-22 mm long and up to 2.25 mm wide. *Echinostoma revolutum*'s head is usually armed with hooks (Soulsby, 1982). It has been reported in Kenya (Kyalo, 2012).

2.2.2.4 Haemoparasites of Poultry

Haemoparasites are found in poultry in the tropical and temperate areas; they include *Plasmodium, Leucocytozoon, Haemoproteus, Aegyptinella* and *Trypanosoma* species (Arends, 2003). These parasites require arthropod vectors in their life cycle. The vectors include poultry ticks, mosquitoes and other flies (Permin and Hansen, 1998). These parasites have been recorded in Zimbabwe (Permin *et al*., 2002). A study conducted in the Eastern Province of Kenya also showed that most birds were infected with haemoparasites (Sabuni *et al.*, 2011).

Plasmodium species

The two most common species that affect chicken are: *Plasmodium gallinaceum* that occurs in chicken in Asia and Africa and *Plasmodium juxtanucleare* that parasitizes chicken and turkeys in South America, Africa and Asia (Permin and Hansen, 1998). The gametocytes and schizonts can be round, oval or irregular in shape. The nucleus of the host cell is rarely expelled during infection, but may be displayed by the parasite. Each schizont produces 8-36 merozoites. On average, there are 16-20 merozoites in erythrocyte schizonts of *P. gallinaceum* (Permin and Hansen, 1998). *Plasmodium species* have been recorded in Zimbabwe (Permin *et al*., 2002) and in Kenya (Sabuni *et al*., 2011).

Leucocytozoon species

Leucocytozoon species are hemoprotozoan parasites that may infect erythrocytes or leucocytes (Weisman *et al*., 2007). The two most common *Leucocytozoon* species found in chicken are: *Leucocytozoon caulleryi* and *Leucocytozoon sabrazesi. Leucocytozoon* species are recognized by their large size and football-like distortion of infected cells with pointed ends (Permin and Hansen, 1998). *Leucocytozoon sabrazesi* has been reported in Zimbabwe (Permin *et al., 2002*) while Leucocytozoon *caulleryi* has been reported in Nigeria (Sadiq *et al*., 2003). *Leucocytozoon schoutedeni* has been reported in Kenya (Sabuni *et al*., 2011).

Leucocytozoon caulleryi affects only chicken and mature gametocytes are round or oval and found in young and mature red blood cells. Full-grown gametocytes push the nucleus of infected cells. It is transmitted by biting midges (Permin and Hansen, 1998).

Leucocytozoon sabrazesi is found in domestic chicken and wild galliformes especially pheasants. Merozoites enter erythroblasts and mononuclear leukocytes to develop into ovoid and elongated gametocytes. The host cells with elongated gametocytes become spindle shaped with the nuclei appearing as thin bands beside the parasite (Permin and Hansen, 1998).

Leucocytozoon schoutedeni affects only the chicken, the nuclei is usually distorted by mature gametocytes and may become elongated (Permin and Hansen, 1998).

Haemoproteus species

Haemoproteus species are intracellular, hemoprotozoan parasites that infect red blood cells of birds, turtles and lizards. It has a cosmopolitan distribution and it may infect a variety of birds like game birds (Galliformes), waterfowl (Anseriformes), raptors (accipitriformes, falconiformes, Strigiformes), pigeons, doves (Columbiformes), and perching birds or song birds (Passeriformes). This parasite may appear like *Plasmodium,* but the pigment within the intraerythrocytic gametocytes is more dispersed. The gametocytes partially encircle the erythrocyte nucleus forming a ‘’halter-shaped’’ appearance. *Haemoproteus* gametocytes often occupy over one-half of the erythrocyte cytoplasm with little displacement of the host cell nucleus. *Plasmodium* and *Haemoproteu*s produce an insoluble pigment called hemozin which is derived from digestion of haemoglobin found within the host’s erythrocytes and appears as refractile, yellow to brown granules within the host’s erythrocyte (Weisman *et al.,* 2007). *Haemoproteus* species have been recorded in Kenyan chicken (Sabuni *et al.,* 2011) and ducks (Mavuti, 2010).

Aegyptinella species

The two most common *Aegyptinella* species are: *Aegyptinella pullorum* and *Aegyptinella mushkovskii*. They affect chicken, turkeys, ducks, geese and other birds in Africa, Asia and Southern Europe. Initial bodies occur in the red blood cells as trophozoites. They appear as small round oval bodies in the red blood cells. They are transmitted by *Argas persicus (*Permin and Hansen, 1998). *Aegyptinella pullorum* has been recorded in Zimbabwe (Permin *et al.,* 2002). In Kenya, it has not been reported in chicken but has been observed in ducks (Mavuti, 2010).

Trypanosoma species

The most important *Trypanosoma* species is *Trypanosoma avium* that occurs in a wide range of birds. The most common vectors of the parasite are the arthropods that belong to *Hippoboscidae, Culicudae, Ceratopogonidae* and *Simuliidae.* Dermanyssid mites have also been identified as avian trypanosome vectors (Soulsby, 1982). *Trypanosoma avium* has been reported in Zimbabwe (Permin *et al*., 2002), Uganda and Cameroon (Sehgal *et al.*, 2006).

2.3 Sex and age influence on Parasite burdens

Host sex and age can affect parasitism in birds and mammals. Male-bias in the occurrence of nematode and arthropod parasites has been the most consistent finding (Poulin, 1996; Schalk and Forbes, 1997; Moore and Wilson, 2002). Certain avian blood parasites can be more common in females than in males (McCurdy *et al*. 1998; Moore and Wilson, 2002). Sexual biases in the prevalences of cestode and digenean parasites of birds and mammals have not been detected using metaanalysis (Poulin, 1996). Ectoparasites like *Cnemidocoptes mutans* affect mainly adults compared to growers and chicks (Soulsby, 1982).

2.4 Anthelmintics

A number of synthetic drugs in different formulations have been manufactured, in succession, for the treatment of parasitic infections in chicken. They include: albendazole which removes roundworms and tapeworms and levamisole, piperazine and ivermectin which remove roundworms (Permin and Hansen, 1998). Anthelmintics are divided into various classes based on their mode of action.

Class I anthelmintics are the benzimidazoles and pro-benzimidazoles. These drugs exert their action on the intracellular polymerization of the tubulin molecules to microtubules. When the cellular functions are disrupted, this results in death of the worm. Examples of drugs in Class I are: albendazole, thiabendazole, fenbendazole, parabendazole; flubendazole, febantel and thiophanate. These are broad spectrum anthelmintics that cater for nematodes, cestodes, and trematodes (Permin and Hansen, 1998). Up to date, there is no chicken formulation of any of these drugs in the market. Previous research in Arkansas, United States, showed that albendazole at 20 mg/kg body weight kills all types of helminths when given orally to chicken (Tucker *et al*., 2007). There has been no efficacy testing of albendazole against various worms done in Kenya, to date.

Class II anthelmintics are the imidazothiazoles and tetrahydropyrimidines. These drugs act on the acetylcholine receptors in the neuromuscular system causing paralysis of the worms which are later removed by gut motility. They are effective against roundworms such as *Heterakis* species and *Gongylonema* species. Examples of these are: levamisole, pyrantel and morantel. Levamisole formulation for chicken is available commercially (Permin and Hansen, 1998). The efficacy of levamisole against round worms in chicken in Kenya has not previously been reported.

Class III anthelmintics are the avermectins and milbymicins. These drugs act on the nervous system of the worms causing flaccid paralysis and removal by gut motility. Examples of these are: piperazine and avermectins. Piperazine has a different mode of action but has not been defined and documented; it is also a narrow spectrum anthelmintic that seems to cater for

Ascaridia galli only. Avermectins are effective against ectoparasites such as mites (Permin and Hansen, 1998). The efficacy of piperazine citrate against roundworms in chicken in Kenya has not previously been tested.

Class IV anthelmintics include salicylanids and substituted nitrophenols. The drugs are used against blood sucking parasites (Permin and Hansen, 1998).

Class V anthelmintics that include acetylcholine esterase antagonists include dichlorvos and neguvon. There is a chicken formulation of dichlorvos available in form of spray (Permin and Hansen, 1998).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Study area

The research was conducted in Mbeere sub-county (**Figure 1**), Kenya (WFP, 2006). The sub-county has a total area of 2093 km^2 and lies between 0^0 20^0 and 0^0 50^0 South and longitude 37^0 16^1 and 37^0 56^1 East. It has a bimodal pattern of rainfall with long rains falling between mid March and June while the short rains occur from October to December. Most parts of the subcounty receive less than 550 mm rainfall per year giving the area a marginal status. The temperature ranges between 20-30^o C (Onduru *et al*., 2002). The area has a high population of indigenous chicken, approximately 165,090 (KBS, 2009), and rearing of chicken is a major source of livelihood in the county. The study was conducted during wet season associated with short rains in the month of October to December 2011 and in the dry season in January to March 2012. **Figures 2 and 3** show the production status of the land during the two seasons, respectively.

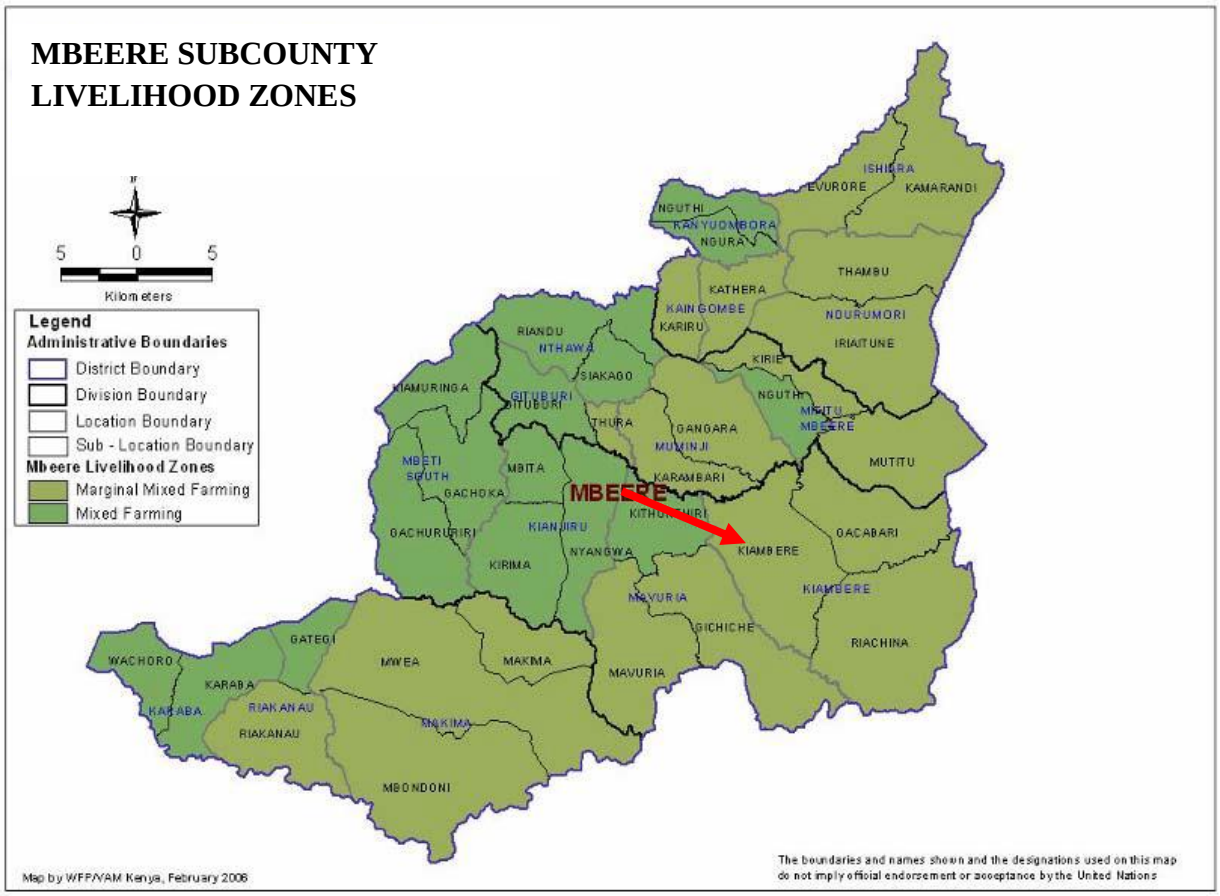

Figure 1: Map of Mbeere sub-county showing the study area (WFP, 2006)

Figure 2: Production status of the study area during the wet season

Figure 3: Production status of the study area during the dry season

3.2 Collection of data on chicken parasites and local antiparasitic treatments practiced in the area

Data was collected from individual farmers using a structured questionnaire (**Appendix 1**). The following type of data was collected; type of chicken kept, flock size, the major challenges they faced in poultry keeping (parasites, diseases, theft), type of treatments used to control ectoparasites and endoparasites, how often they dewormed their birds, presence of other species of birds, season in which parasites were common, age group mostly affected, type of housing, frequency of retarded growth, reduced weight gain, decreased egg production, emaciation and diarrhea.

3.3 Experimental birds

The target population was male and female indigenous chicken of three age groups, namely, chicks (less than 2 months), growers (2-8 months) and adults (over 8 months of age), which were aged according to Magwisha *et al.* (2002). The birds were obtained from individual farmers using purposive sampling where each homestead sampled had at least 10 birds, managed entirely by free-range manner. The sample size was determined using the method described by Martin *et al*. (1987), as follows:

$$N = \frac{4PQ}{L^2}$$

Where N = number of chicken to be used, P = prevalence estimated, Q = 1-P, L = precision error e.g. 5% at confidence interval of 95.0%. Therefore,

$$N = \frac{4 \times 0.5 \times 0.5}{(0.1)^2} = 100 \text{ chicken}$$

A total of 24 birds were purchased during each of the two seasons (dry and wet) to establish parasite carriage. In numbers, chicks were 7 and 9, growers 8 and 8, and adults 9 and 7 for the wet and dry seasons, respectively.

In addition 37 adult birds were purchased and used for the helminth control experiment on anthelmintic efficacy. All the birds were transported alive in cages to the Department of Veterinary Pathology, Microbiology and Parasitology, University of Nairobi's Kabete Campus, where laboratory examination and the control experiment were done.

Although the calculated sample size was 100 chicken, 85 chicken were used, since the animal welfare and management regulations does not allow sacrifice of many birds.

3.4 Aging of the chicken

The ages of the birds were determined based on the size of the crown, length of the spur, flexibility of xiphoid cartilage and information from the poultry farmers as previously done by Magwisha *et al.* (2002) and Sabuni (2009). The chicken were classified as adults, growers or chicks (Magwisha *et al*., 2002). For seasonal parasite carriage and controlled experiment, all ages of birds and adults were used respectively.

3.5 Clinical examination, blood smear preparation and post mortem examination of chicken

Before slaughter each chicken was thoroughly examined and observations including presence of ectoparasites recorded. A post-mortem examination of birds was carried out as described by Charlton *et al*. (2006). The chicken were killed by dislocation of the atlanto-occipital joint, followed by severing of the carotid arteries and jugular veins using a scalpel blade.

For each chicken, two thin blood smears were prepared using blood from the severed jugular veins. The smears were air dried within 5-10 seconds after the preparation. They were later fixed in methanol for 5 minutes, stained with 10% Giemsa for 15 minutes, washed with tap water, blot dried and examined under the microscope for haemoparasites as described by Nemi (1986) and Sabuni *et al.* (2010).

The gut was separated into different parts as follows: crop, proventriculus, gizzard, duodenum, small intestine, caecum and large intestine and later placed separately in 70% alcohol (Kyalo, 2012). The parts were later opened longitudinally and the contents examined under a stereoscope. The worms from each part were collected, counted and preserved in 70% alcohol (Maina, 2005; Kyalo, 2012) for subsequent processing and identification according to Soulsby (1982).

3.6 Processing of nematodes for identification

The nematodes from each section of the gut were identified and counted before processing as described by Gibbons *et al.* (1996). Nematodes were transferred from 70% alcohol to a drop of cold (room temperature) lactic acid placed on a slide and a cover slip mounted over. The preparation was then left to stand for 15 minutes before examination.

3.7 Processing of cestodes for identification

Processing of the cestodes for examination was done according to the method described by Gibbons *et al*. (1996). A sample was declared negative if no worm or its segment was detected

and positive if a segment with or without a head was found. The worms were put in 70% alcohol, then 50% and 30% descending concentrations of alcohol and then to distilled water for 10 minutes. The specimens were stained regressively using aceto alum camine until the required intensity of colour was reached. Differentiation was done in acid solution, 1% concentrated HCL in 70% alcohol until the body surface of the worm appeared pale pink. A 1% solution of sodium hydroxide or potassium hydroxide was put to stop the dehydration process. The specimens were washed in distilled water (several changes) to remove the differentiating agent. Dehydration was done in ascending series of graded alcohols (30-50-70-80-90% -industrial methylated spirits to absolute ethanol) for 10 minutes in each grade of alcohol. The specimens were later cleared with clove oil and mounted on a slide using DPX mountant (Destrene 80, dibutylphthalate and xylene). The specimens were left to dry for 3 days before examination.

3.8 Examination and identification of ectoparasites

The ectoparasites were collected from skin of the body, legs and head. The birds were skinned and the whole skin together with feathers, head, and legs removed and stored in 70% alcohol. The parasites were identified according to their morphological characteristics using entomological key as given by Soulsby (1982), MAFF (1986), Wall and Shearer (1997) and Arends (2003).

The degree of infestation was classified as follows: For *Echidnophaga gallinacea* (the stick tight flea) the number of adult fleas was categorized as none; 1-20; 21-100; and > 100 fleas, respectively. Infestation with *Cnemidocoptes mutans* was classified on a clinical evaluation, based on the presence of hypertrophic dermatitis on the legs, using the criteria as follows: (+) no

visible sign of mite infestation though mites were present on microscopic changes on laboratory examination; (++) minor scale formation on the distal parts of the legs and (+++) massive hypertrophic dermatitis where the whole leg was infested. The skin scrapings were digested with potassium hydroxide (KOH) to identify the adult parasites (Permin *et al.,* 2002).

Thorough examination of cracks and crevices within the sleeping area of chicken was carried out to ensure that the parasites with nocturnal activities like *Argas persicus* and *Dermanyssus gallinae* were identified.

3.9 Faecal worm egg and coccidial oocyst counts

A faecal sample was collected from the rectum during the post mortem examination to determine the total worm egg and coccidial oocyst counts using a modified McMaster technique (MAFF, 1986) as described below.

3.9.1 Modified McMaster technique

Two grams were weighed and transferred into labeled container. Twenty – eight ml floatation fluid of Sodium chloride (specific gravity, 1.204) was added and the mixture mixed thoroughly with a stirring device. The faecal suspension was poured through a tea strainer into another labeled container. The retained debris were discarded. A sub-sample was taken with a Pasteur pipette and both sides of the McMaster counting chamber filled. This chamber was allowed to stand on a table for 3-5 minutes before counting in order for the eggs to float. This chamber was allowed to stand on a table for 3-5 minutes before counting, so as to allow the eggs to float. The eggs were counted using a microscope and the number multiplied by 50. All the eggs/oocysts inside the grid in the McMaster chamber were included and those outside excluded.

3.10 Effectiveness of anthelmintics in village chicken

3.10.1 Experimental design

Thirty seven (37) adult birds were purchased from individual farmers in Mbeere sub-county, 3 days prior to the start of the anthelmintic treatment experiment. Out of 37 adult birds, post-mortem examination was done on 7 birds before the start of the experiment to determine the type of endoparasites the birds were carrying, as described in section 3.5. The rest of the birds were allowed to acclimatize for 3 days at the research facility on Kabete Campus, each bird caged separately (**Figure 4**). They were kept under housing, maintenance and feeding until the whole experiment was over.

Faecal samples were collected from the cages three times a day; morning (8pm), noon (12pm) and evening (5pm). The faecal samples were examined for nematode egg counts using the modified McMaster technique as described in section 3.9.1.

On day 4, the birds were randomly allocated to 4 treatment groups (**Table 1**); however, the only bird that excreted ascarid egg was purposively placed in the piperazine treatment group. There were 7 birds on albendazole treatment, 7 birds on levamisole treatment, 7 birds on piperazine citrate treatment, and 9 birds as controls. The number (N) in the treatment groups was as per the World Association for the Advancement of Veterinary Parasitology (WAAVP) guidelines for determination of anthelmintic efficacy in birds. The guidelines require that a minimum of 6 infected birds per treatment group be used (Yazwinski *et al*., 2003).

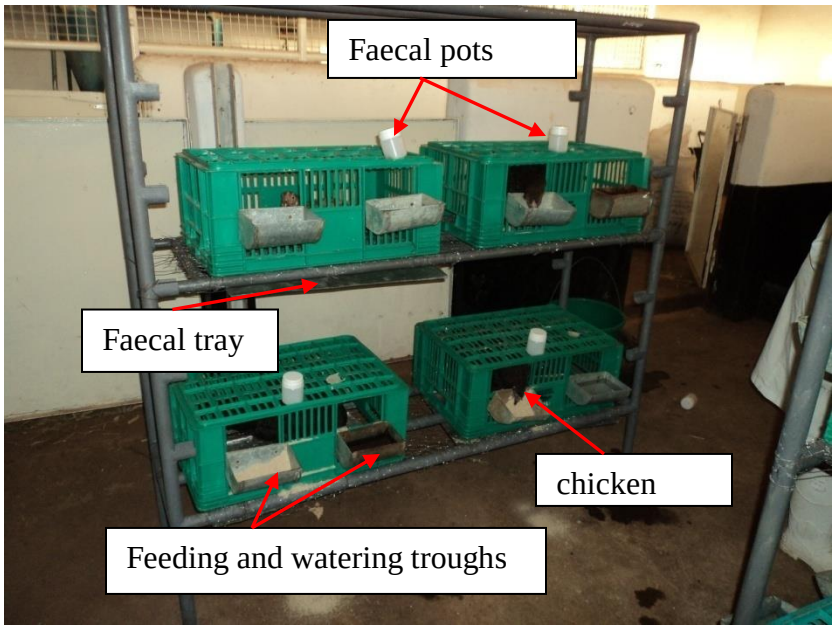

Figure 4: Chicken caged separately, faecal pots, feeding and watering troughs during the experiment

Table 1: Experimental groups of chicken with respective anthelmintic treatments

Group of chicken	**Anthelmintic treatment**	**Number of birds treated**
1	Piperazine citrate	7
2	Levamisole	7
3	Albendazole	7
4	Control	9

3.10.2 Treatment regimes

Albendazole was used at a rate of 20 mg/kg body weight (BW). The highest weight of the bird was used (2.5 kgs) in calculating the volume (0.5 mls) of albendazole used. The drug was administered orally as a single dose (according to the manufacturer's instructions).

Levamisole was given at 25 mg/kg body weight (7.5 ml) put in three litres of water. Equal division of the medicated water was done among the 7 birds where each bird was given 430 ml of water (according to the manufacturer's instructions). After 24 hours the amount of medicated water left was measured to ascertain the amount of water and the dosage taken by each chicken.

Three quarter tea spoonful of piperazine citrate (4.5 gm) was dissolved in three litres of water for the 7 birds. Each bird was given 3 mg/kg body weight piperazine citrate, derived using the weight of the heaviest bird. Equal division of the medicated water was done among the 7 birds where each bird was given 430 mls of water (according to the manufacturer's instructions). After 24 hours the amount of medicated water left was measured to ascertain the amount of water and the dosage taken by each chicken.

3.10.3 Parasite recovery and determination of effectiveness of anthelmintics

Procedures used for parasite recovery were according to the WAAVP guidelines for evaluation of anthelmintics in poultry (Yazwinski *et al*., 2003) as described below.

Seven (7) days after treatment the birds were sacrificed and the parasites recovered, identified and counted (MAFF, 1986). The effectiveness of each anthelmintic was determined by comparing the number of parasites in the treated and untreated control groups.

Efficacy of anthelmintics was evaluated by

a) Complete reduction of parasite eggs in the treated chicken.
b) Percentage effectiveness against each parasite species (or stage) was determined using the formula Yazwinski *et al*. (2003).

$$\% \text{ E} = \frac{\text{Mean No. of worms in controls} - \text{ Mean No. of worms in treated animal}}{\text{Mean No. of worms in controls}} \times 100$$

Key: % E = Percentage effectiveness, No. = number

The means of helminth population for each treatment group were used to calculate the percentage efficacy of the anthelmintics. For all anthelmintics, used, percentage efficacies of above 90 % were considered effective (Yazwinski *et al*., 2003).

3.11 Data management

Data was entered into Excel spread sheet and analyzed using GenStat 14th Edition for descriptive statistics. Cross tabulations to derive frequency of occurrence of parasites based on season and ages of birds was performed. Descriptive analysis was conducted on the questionnaire data collected from individual homesteads. Unpaired student t- test and Mann-Whitney U (Wilcoxon rank sum) test was the statistical method used to assess the difference between the presence of parasites based on seasons. Chi-square statistical method (Fisher's Exact Test) was used to evaluate association of prevalence to the age and sex based on seasons. A Kruskal Wallis One-way analysis of variance was used to analyse variation in parasite burden in the three age groups and sexes.

CHAPTER FOUR

4.0 RESULTS

4.1 Data on chicken parasites and local treatments used against parasites in Mbeere subcounty

4.1.1 Background information

Figure 5 shows the percentage of species of animals kept on the 17 study farms in Mbeere Subcounty. All the farmers interviewed kept local breed of chicken under the free range system. Other than poultry, other animals kept included goats (71.43%), cattle (64.29%), dogs (35.71%), cats (21.43%), rabbits (14.29%) and donkeys (14.29%).

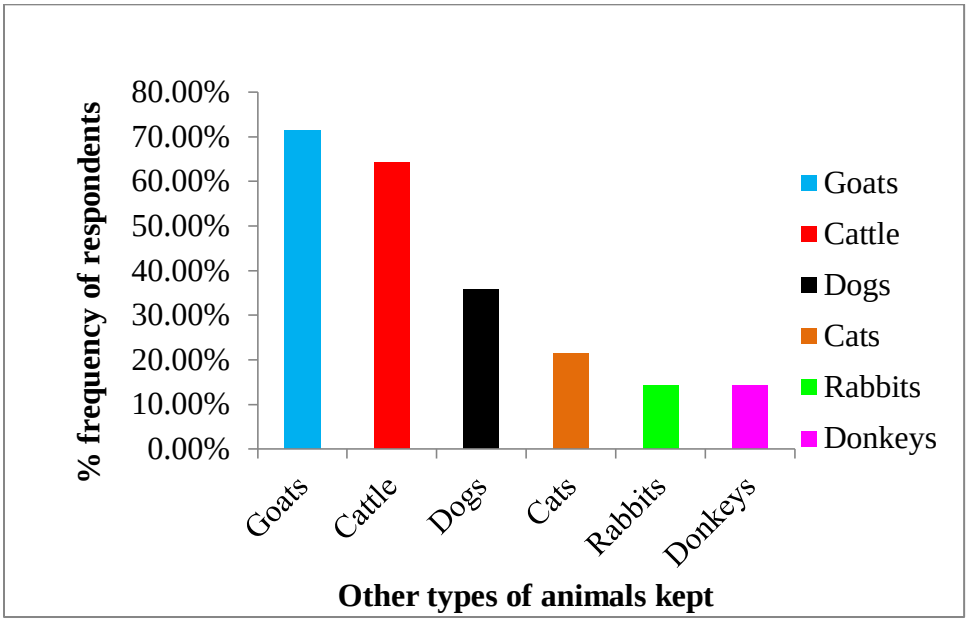

Figure 5: Different species of animals kept on 17 farms in Mbeere subcounty

Key: % - Percentage frequency of respondents

4.1.2 Management of poultry

Most of the farmers (90%) kept local breeds of chicken; almost all of them (92.86%) keeping the chicken under free range system. Ninety three percent (93%) of the farmers interviewed housed their birds, 47.05% in mud-walled houses, 35.25% in wooden houses, 5.88% in raft-walled houses, and 5.88% in iron-sheet houses (**Figures 6, 7, 8 and 9**). Majority of the farmers (87.71%) housed various age groups of chicken together while 14.29% kept different age groups in separate houses. All farmers interviewed confined their birds during the crop planting season. All farmers supplemented their birds using various feeds; 64.29% used cereal grains, 42.86% used kitchen waste and 21.43% used commercial feeds.

Figure 6: Mud -walled poultry house

Figure 7: Wooden poultry house

Figure 8: Raft –walled poultry house

Figure 9: **Iron -sheet poultry house**

4.1.3 Poultry production constraints

Table 2 shows percentage distribution of farmers who experienced various constraints in poultry production.

Table 2: Types of constraints and percentage of chicken farmers who experienced various constraints in their chicken flocks in Mbeere sub-county

Constraint	**Percentage of farmers experiencing the constraint in their chicken flocks**
Diseases	88.2%
Parasites	70.6%
Predation	52.9%
Accident	11.8%
Insufficient feed	17.6%

The constraints experienced by the highest proportion of farmers were diseases (88%) and parasites (70.6%) in their chicken flocks. The diseases were; Newcastle disease (82.4%), fowl pox (17.6%), fowl typhoid (11.7%), lameness, coccidiosis and chronic respiratory disease (5%).

4.1.3.1 Poultry parasites

The most commonly encountered ecto-parasites were ticks and fleas with equal rates of occurrence (47.06%), and mites and lice (17.65%), while the endo-parasites were worms (29.14%). Majority of the farmers (64.71%) noted that all age groups of the chicken were commonly affected; 11.78% mentioned adults as being mainly affected, while 5.88% mentioned chicks as being mainly affected. A proportion of the interviewed farmers (17.65%), however, did not have any idea about the occurrence of these infections in different age groups of birds.

Farmers could identify symptoms of parasite infestations. For the ecto-parasites, 70.58% of farmers could identify fleas, ticks and lice on the skin of chicken. The signs that farmers associated with parasitic infections included scratching (17.65%), scale on legs (5.88%), while others (5.88%) could not tell any signs of infection. Similarly 47% of the farmers observed worms in faeces, 11.77% redness of faeces, 11.77% greenish diarrhoea and 11.77% mouth discharge, which they associated with disease. The farmers identified the months of July to September (35.29%), January to March (11.76%), April to June (5.88%), October to December (5.88%) and all year round (11.76%) as the periods when parasites were many.

4.1.3.2 Parasite control

Seventy one percent (71%) of farmers sought for treatment of birds against worms. Among these farmers, 12 (35.29%) used piperazine citrate, while 35.71% did not know the type of treatment used. The frequency of deworming varied with 29.41% saying they dewormed their chicken every three months, 17.64% when they saw worms in faeces, every six months and anytime; 52.94% could not remember or know how often they should deworm their birds.

Most farmers (82.35%) said that they controlled ectoparasites and they used various medications. Majority of the farmers (52.94%) used cabaryl (Sevin^{R}), 11.56 % used cooking fat and ectomin 11.56%; while 23.52% did not know the type of treatment given (**Figure 10**).

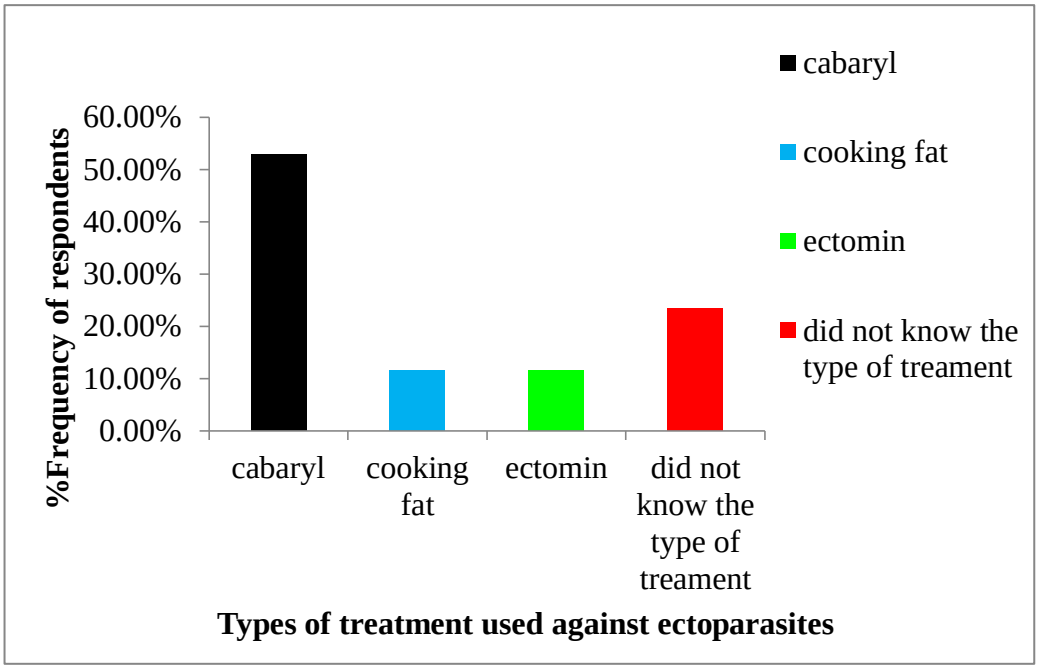

Figure 10: Drugs used against poultry ectoparasites in chicken

Of the 12 (70.58%) farmers who sought treatment, 52.94% administered the medicine themselves, 11.76% got help from animal health assistant, 5.88% from veterinarians and 23.53% did not have any idea how to treat their birds.

Sixty five percent (65%) of the respondents used herbal medicine to control endoparasites (**Table 3**). Twenty nine percent (29.41%) used Aloe species, 17.65% used pepper, 11.76% used ‘’*mikau*’’ and 11.76% used ‘’*githongu*’’ (*Solanum incanum*). Twenty nine percent (29.41%) applied Aloe species in drinking water, 11.76% used it topically while 58.82% had no idea on how it is used.

Other control methods (**Table 3**) used by the farmers to control ectoparasites and endoparasites included liquid paraffin (35.29%), used engine oil (11.76%), improved hygiene (11.76%), milk (5.88%) while 52.94% had no other control method.

Table 3: Herbal medicine, other treatments used by farmers and the parasites acted on

Herbal medicine	**Parasites acted on**
Aloe species	Endoparasites
Pepper	Endoparasites
''Mikau''	Endoparasites
''Githongu''	Endoparasites
Other treatments Milk	 Endoparasites
Used engine oil	Ectoparasites
Improved hygiene	Ecto- and Endo-parasites
Liquid paraffin	Ectoparasites

4.2 Seasonal prevalence, intensity and identity of ectoparasites and endoparasites

4.2.1 Overall results

A total of 48 live chicken (24 per season) were examined, out of which 19 (39.58%) were males and 29 (60.04%) females. In both the dry and wet seasons all birds (100%) had endoparasites. Ectoparasites were found in all the birds during the wet season and in 95.83% of the birds in the dry season. **Table 4** shows the prevalence rates for endoparasites during the wet and dry seasons.

Table 4: Prevalence rates for endoparasites during the wet and dry seasons

Endoparasites	Prevalence rate (%)	
	Wet season	Dry season
Nematodes	95.83	87.50
Cestodes	87.50	83.33
Coccidia	20.83	0
Haemoparasites	79.17	62.50

The ectoparasites recovered in the wet and dry seasons were mites, 70.83% (17/24) and 54.17% (13/24), lice 100% (24/24) and 79.17% (19/24), ticks 25% (6/24) and 41.67% (10/24) and fleas 62.50% (15/24) and 29.17% (7/24), respectively (**Figure 11**).

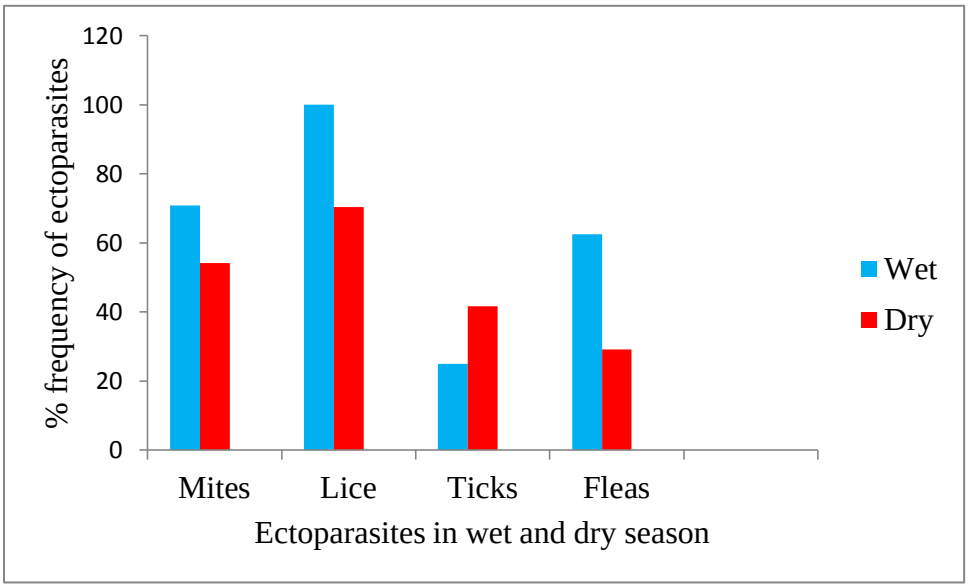

Figure 11: Prevalence of ectoparasites in chicken in Mbeere sub-county during the wet and dry seasons

Key= %- Percentage frequency of ectoparasites

Among the haemoparasites recovered in wet and dry seasons were: *Plasmodium gallinaceum* 79.16% (19/24) and 62.5% (15/24), *Leucocytozoon schoutedeni* 25% (7/24) and 12.5% (3/24), *Aegyptinella pullorum* 4.17% (1/24) and 16.67% (4/24) and *Eperythrozoon* species 16.67% (4/24) and 4.17% (1/24), respectively.

4.2.2 Examination of ticks, Seasonal prevalence and intensity of the ectoparasites

Examination of cracks and crevices within the sleeping area of chicken showed adult and nymphal stages of *Argas persicus*.

During the wet season all the 24 chicken had ectoparasites while during the dry season 95.83% of them had ectoparasites. Four types of ectoparasites were found namely: lice, mites, ticks and fleas. The prevalences of ectoparasites recovered were: lice 100% (24/24) and 70.37% (19/24), mites 70.83 % (17/24) and 54.17% (13/24), ticks 25% and 41.67% (10/24) and fleas 62.50% (15/24) and 29.17% (7/24) in the wet and dry seasons, respectively.

The four types of ectoparasites were found in chicks, growers and adults and in both females and males. All the age groups had high levels of ectoparasite infestation; adults and growers were 100% infested in both wet and dry seasons, while the chicks had a slightly lower infestation of 88.88% during the dry season. There was no significant difference in occurrence of ectoparasites in the two seasons ($p>0.05$).

4.2.2.1. Lice infestation in chicken

Overall, for both the wet and dry seasons, 89.58% (43/48) had lice on their body surface, wings and feathers. Four species of lice were found: *Menacanthus stramineus, Menopon gallinae,*

Lipeurus caponis and *Gonoides gigas* (**Table 5 and 6**). **Table 6** shows the range and mean intensity of lice and its different species isolated per chicken in wet and dry seasons. For both seasons, all the adult and grower chicken were infested at equal rates of 100%, while the chicks were infested at 100 % (7/7) in wet season and 44.44% (4/9) in dry season. All male and female chicken were 100% infested with lice during the wet season (16/16 for males and 8/8 for females) (**Figure 12**), while in the dry season, males were more infested, at a rate of 83.33% (10/12); the females were infested at 75.00% (9/12). Overall, prevalences of lice in both seasons were higher in adults and growers (at 100% for both), compared to the chicks which were infested at 100% (7/7) during the wet season and 44.44% (4/9) during the dry season (**Figure 13**). There were, therefore, more lice in the wet season than in the dry season (**Tables 5 and 6**). There was a statistically significant difference in lice occurrence between the wet and dry seasons ($p<0.05$) but not between the sexes and between the age groups ($p>0.05$).

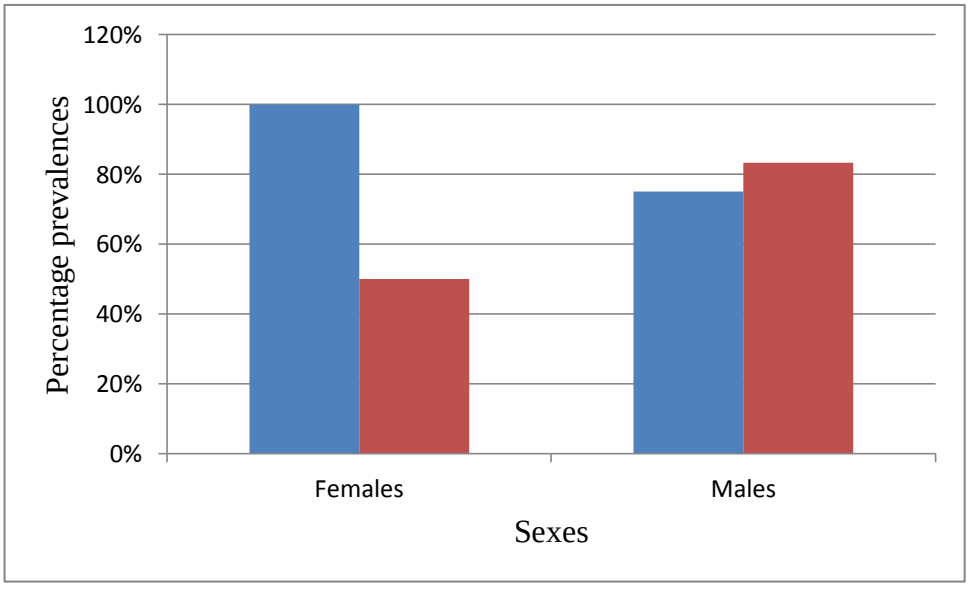

Figure 12: Prevalence of lice infestation in female and male chicken

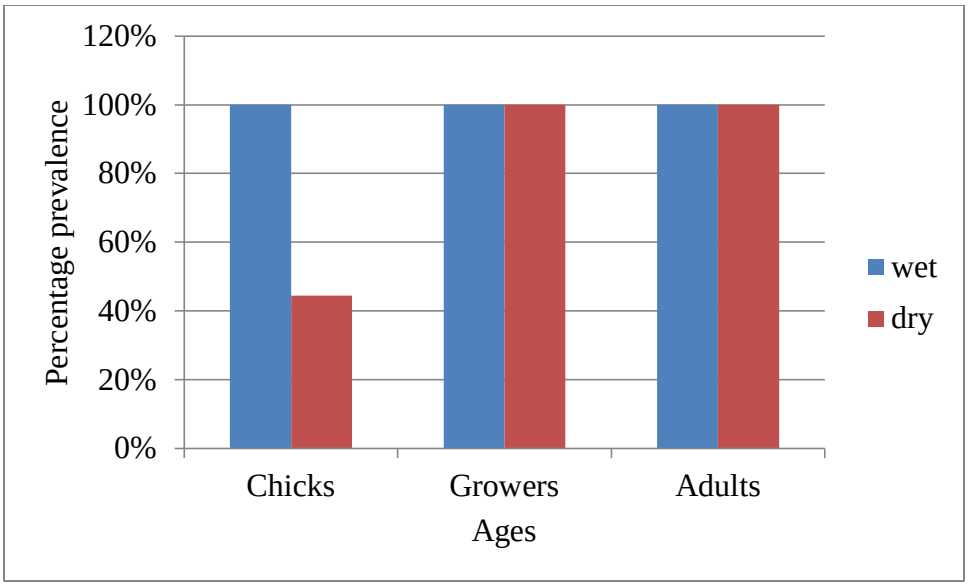

Figure 13: Prevalence of lice infestation in chick, grower and adult chicken

Table 5: Seasonal prevalence of various ectoparasite species found on indigenous village chicken and their predilection sites

Ectoparasites	**Predilection site**	**Seasonal percentage prevalence**	
		Wet	**Dry**
Lice *Menacanthus stramineus*	All over the body	**100 (24/24)** 100 (24/24)	**79.16 (19/24)** 79.17 (19/24)
Menopon gallinae	Feather shafts and all over the body	91.67 (22/24)	50.00 (12/24)
Lipeurus caponis	Underside of wing feathers	16.67 (4/24)	12.50 (3/24)
Gonoides gigas	Body feathers	16.67 (4/24)	12.50(3/24)
Mites *Dermanyssus gallinae*	Entire body of bird	**70.83 (17/24)** 58.33 (15/24)	**54.17 (13/24)** 45.83 (11/24)
Cnemidocoptes mutans	Lower limbs	16.67 (4/24)	8.33 (2/24)
Stick tight flea *Echidnophaga gallinacea*	Comb, wattles, around eyes	62.50 (15/24)	29.17% (7/24)
Soft tick *Argas persicus*	Ventral abdominal area and below wings	25.00 (6/24)	37.50 (9/24)

Table 6: Range and mean counts of the lice; *Menacanthus stramineus, Menopon gallinae, Lipeurus caponis and Gonoides gigas*

Ectoparasite	Wet season		Dry season	
	Range	**Mean counts± SD**	**Range**	**Mean counts± SD**
Lice	**0- 222**	**68.25± 53.60**	**0-115**	**25.00± 32.98**
Menacanthus stramineus	0- 158	52.79± 41.69	0- 104	21.62± 28.35
Menopon gallinae	0- 18	7.21 ± 6.69	0- 15	2.38 ± 3.76
Lipeurus caponis	0- 5	0.46± 1.18	0- 1	0.13± 0.34
Gonoides gigas	0-58	7.88±17.45	0- 9	0.88±2.00

Among the lice species isolated in both seasons, the mean intensity of *Menacanthus stramineus* was highest followed by *Menopon gallinae*, *Lipeurus caponis* and *Gonoides gigas.*

4.2.2.1.1. *Menacanthus stramineus*

Of the 48 chicken examined in both seasons, 43 (89.58%) had *M. stramineus* (**Table 5**). *Menacanthus stramineus* (**Figure 14**) was the most prevalent louse. In both seasons, adult and grower chicken had higher rates of infestation of *Menacanthus stramineus* (all at 100%), compared to the chicks which were infested at 100% (7/7) during the wet season and 44.44% (4/9) during the dry season (**Table 7**). Male birds were more infested with *Menacanthus stramineus* in both wet and dry seasons, at 100% (8/8) and 83.33% (10/12), respectively, compared to females which were infested at 93.75% (15/16) and 75.00% (9/12), respectively. The rates of occurrence of *Menacanthus stramineus* between the wet and dry seasons were statistically significantly different ($p<0.05$) but not between the chicken ages and sexes ($p>0.05$).

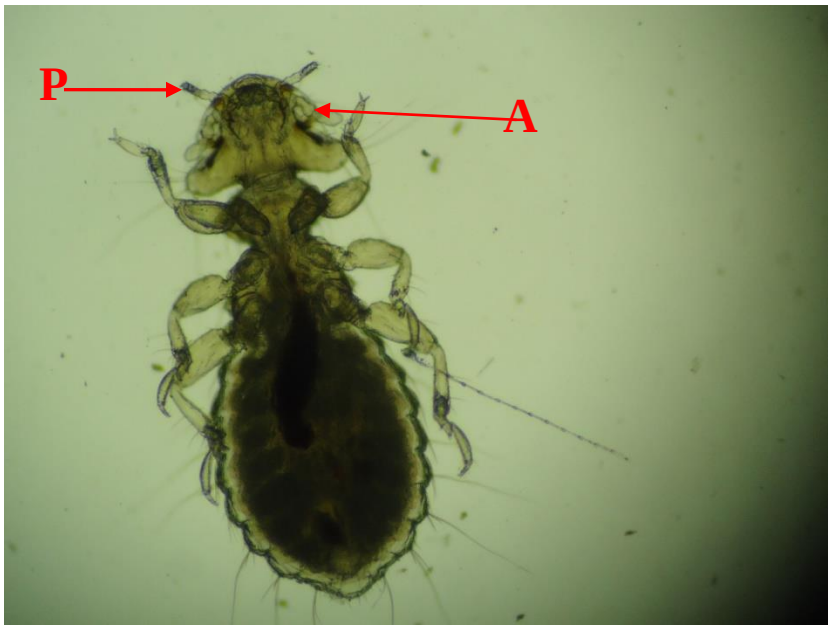

Figure 14: *Menacanthus stramineus* from chicken showing palps (P) and four segmented antennae (A) that were distinct (Ventral view; × 100)

4.2.2.1.2 *Menopon gallinae*

Of the 48 birds examined in both seasons, 34 (70.83%) had *M. gallinae* (**Table 5**). *Menopon gallinae* (**Figure 15**) was the second commonest louse isolated in both seasons. In seasons, adult and grower chicken had higher rates of infestation of *Menopon gallinae* 100% (9/9) and 85.71% (6/7) for adults; 100% (8/8) and 50.00% (4/8) for growers in the wet and dry seasons, respectively. The chicks were infested at 57.14% (4/7) during the wet season and 22.22% (2/9) during the dry season (**Table 7**). Both male and female birds were infested more in the wet than in the dry seasons 75% (6/8) and 93.75% (15/16) in the wet season; 58.33% (7/12) and 41, 67 % (5/12) in the dry season, respectively. The rates of occurrence of *Menopon gallinae* between the wet and dry seasons were statistically significantly different ($p<0.05$) but not between the chicken ages and sexes ($p>0.05$).

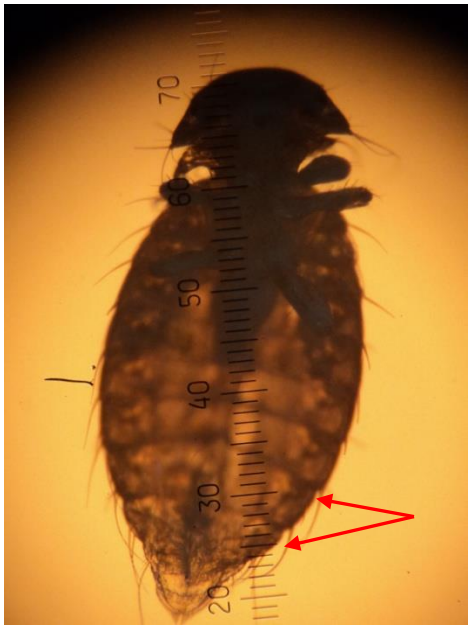

Figure 15: *Menopon gallinae* from chicken, showing the abdomen that had sparse covering of small to medium-length setae (arrows) (×100)

4.2.2.1.3 *Lipeurus caponis*

Of the 48 chicken examined in both seasons, 7 (14.58%) had *Lipeurus caponis* (**Table 5**). **Figure 16** shows *Lipeurus caponis*. During the wet season only adult and grower chicken were affected at a rate of 22.22% (2/9) and 25.00 % (2/8), respectively, while during the dry season, only adults were affected, at a rate of 42.29% (3/7) (**Table 7**). During the wet season, female birds were infested at a rate of 18.75% (3/16) while the male birds were infested at a rate of 12.50 % (1/8). In the dry season, only the males were infested, at a rate of 25.00 % (3/12). There was no significant difference in the occurrence of *Lipeurus caponis* between the wet and dry seasons ($p>0.05$).

Figure 16: *Lipeurus caponis* from a chicken showing slender body and long hind legs (arrows) (ventral view ×100)

4.2.2.1.4 *Gonoides gigas*

Out of 48 chicken examined in both seasons, 7 (29.17%) had *Gonoides gigas* (**Table 5**). **Figure 17** shows *Gonoides gigas*. During the wet season, only adult and grower chicken were infested, at a rate of 22.22% (2/9) and 25.00 % (2/8), respectively. During the dry season, only the adult chicken were infested, at a rate of 42.29% (3/7) (**Table 7**). Female birds were more infested during the wet season at 43.75% (7/16), compared to the male ones at 12.50% (1/8), while during the dry season, male birds were more affected at a rate of 50.00% (6/12) compared to 8.33% (1/12) in females. There was no significant difference in the occurrence of *Gonoides gigas* between the age groups, sexes and in both seasons ($p>0.05$).

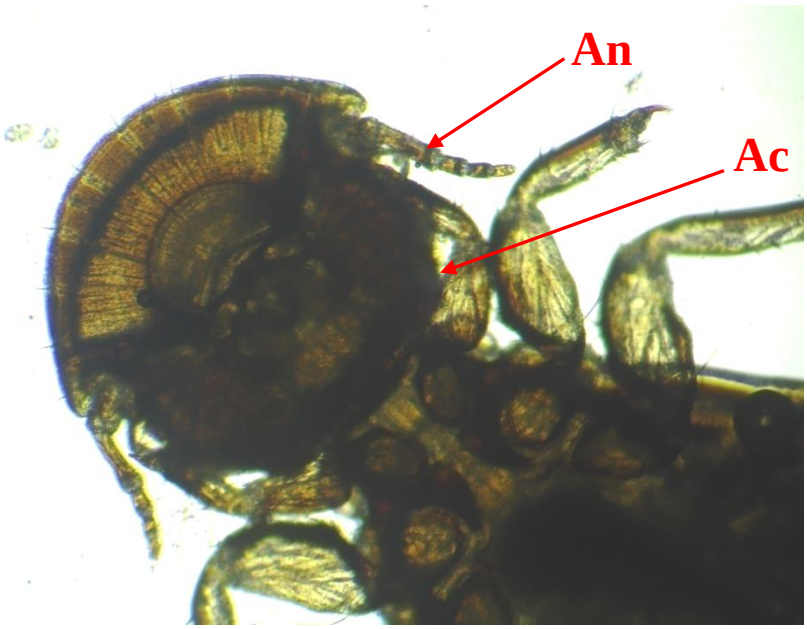

Figure 17: Head of *Gonoides gigas* from a chicken showing the antennae with five segments (An) and angular corners (Ac) (ventral view (×100)

4.2.2.2 Poultry ticks

Argas persicus was the only soft tick observed from the chicken in both seasons. Out of the 48 chicken examined in both seasons 16 (33.33%) had the tick (**Table 5**). Larval stages of the tick (**Figure 18**) were found on the skin of the chicken. Some ticks were also found to infest legs of the chicken; the infestation was characterized by presence of blood clots. The total tick count ranged between 0 and 34 for wet season and 0 and 27 for dry season. The mean counts per chicken in the wet and dry seasons were 2.50±7.28 and 2.42±5.76, respectively. Chicks were more affected by ticks compared to adult and grower chicken. During the wet season 42.86% (3/7) of the chicks were infested with the parasite, while during the dry season 66.67% (6/9) were infested. Adult birds were infested at 42.86% (3/7) during the wet season and at 14.28% (1/7) in the dry season; grower birds were infested by the tick in the dry season only, at 37.50 % (3/8) (**Table 7)**. Female birds were more infested in the dry season at a rate of 58.33% (7/12),

compared to male birds infested at 25% (3/12), while during the wet season, male chicken were more infested at 37.5% (3/8), compared to the female chicken at 18.7% (3/16). There was no significant difference in the occurrence of *Argas persicus* occurrence between the wet and dry seasons, sexes and the age groups ($p>0.05$).

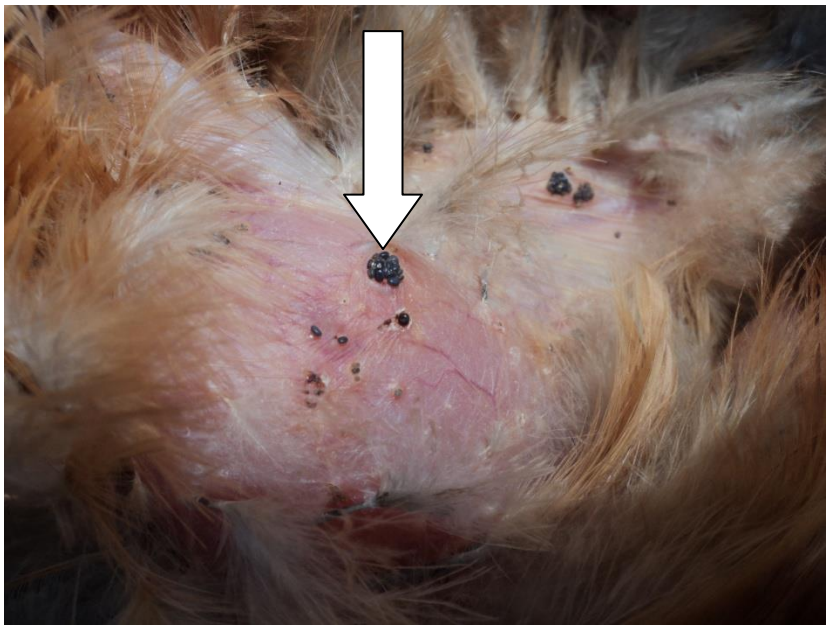

Figure 18: A cluster of larvae of *Argas persicus* on the skin (white arrow) of a chicken (×100)

4.2.2.3. Poultry flea

Echidnophaga gallinacea (**Figure 19**) was the only flea observed in the chicken in the wet and dry seasons. Out of the 48 birds examined in both seasons, 50% (24/48) had *Echidnophaga gallinacea* (**Table 5**). During the wet season, 62.50% (15/24) of the chicken were infected with *Echidnophaga gallinacea* while during the dry season, the infestation rate was at 37.50% (9/24). The total *Echidnophaga gallinacea* ranged between 0 and 68 for wet season and 0 and 55 for dry season. The mean counts per chicken were 6.04 and 3.75 for the wet and dry season,

respectively. Occurrence of the flea in wet season was slightly higher in the chicks where 71.42% (5/7) were infected during the wet season followed by adult birds 66.67% (6/9) and growers 50%. During the dry season adult birds were slightly more infested at a rate of 42.85% followed by growers 37.50% (3/8) then chicks 33.33% (3/9) (**Table 7**). Female and male birds were equally infested in the wet season each at rate of 62.50% (10/16) for females and 62.50% (5/8) for male birds. In the dry season, however, the occurrence of the flea was higher in the male 41.67% (5/12) than in female 33.33% (4/12) birds. There was no significant difference in the occurrence of *Echidnophaga gallinacea* occurrence between the wet and dry seasons, sexes and the age groups ($p>0.05$).

Figure 19: *Echidnophaga gallinacea* with a head sharply angled at the frons (arrow)

4.2.2.4. Poultry mites

In both seasons 62.50% (30/48) chicken had mites on their body surface (**Table 5**). Two genera of mites were isolated (*Cnemidocoptes mutans* and *Dermanyssus gallinae*). About 61% (17/24)

had the mites during the wet season while 54.17% (13/24) had mites during dry season. There was no significant difference in the occurrence of mites in the two seasons ($p<0.05$).

4.2.2.4.1. *Dermanyssus gallinae*

Out of the 48 chicken examined in wet and dry season, 54.17% (26/48) had *D. gallinae* (**Table 5**). It occurred on the body of the chicken. It was red in colour after taking a blood meal and grayish- white when unengorged. These mites (**Figure 20**) were visible with the naked eye. The mite counts ranged between 0 and 37 for the wet season and 0 and 8 for the dry season. The mean counts per chicken were 3.75±7.63 and 1.58±2.24 in wet and dry seasons, respectively. In the wet and dry seasons this mite occurred in the adult chicken, at a rate of 55.56% (5/9) and 85.71 % (6/7), respectively. The occurrence rates for grower birds were 62.50 % (5/8) and 50.00 % (4/8) and for chicks 71.42 % (5/7) and 11.11% (1/9), respectively (**Table 7**). Male birds were more infested at rate of 75.00% (6/8) and 58.33% (7/12) than female birds at a rate of 56.25% (9/16) and 33.33% (4/12) in wet and dry seasons, respectively. There was a significant difference in the occurrence of *Dermanyssus gallinae* in the chicks in the two seasons but no significant difference in the rates of infestation with *Dermanyssus gallinae* in the wet and dry seasons ($p>0.05$).

Figure 20: *Dermanyssus gallinae* showing the egg shaped non-segmented body (white arrow) (×100)

4.2.2.4.2 *Cnemidocoptes mutans*

These were isolated from 12.50% of the chicken in both seasons (**Table 5**). They were mainly found under the scales of legs. *Cnemidocoptes mutans* was only isolated in the adult chicken (**Table 7**).The occurrence rates were 44.44% (4/9) during the wet season and 28.57% (2/7) during the dry season. There was no significant difference in the rates of infection with *Cnemidocoptes mutans* between the two seasons ($p>0.05$).

Table 7: Types of ectoparasites and their prevalence rates in different age groups

Age of chicken	No of birds in wet and dry season		% (number) positive															
			E. gallinacea		*M. gallinae*		*M. stramineus*		*L. caponis*		*G. gigas*		*A. persicus*		*D. gallinae*		*K. mutans*	
	Wet	**Dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**	**wet**	**dry**
Chicks	7	9	71.4 (5)	33.3 (3)	57.1 (5)	22.2 (2)	100 (7)	44.4 (4)	0	0	0	0	42.9 (3)	66.7 (6)	71.4 (5)	11.1 (1)	0	0
Growers	8	8	50 (4)	37.5 (3)	100 (8)	50 (4)	100 (8)	100 (8)	25 (2)	0	25 (2)	0	0	37.5 (3)	62.5 (5)	50 (4)	0	0
Adults	9	7	66.7 (6)	42.9 (3)	100 (9)	85.7 (6)	100 (9)	100 (7)	22.2 (2)	42.3 (3)	22.2 (2)	42.9 (3)	42.3 (3)	14.3 (1)	55.6 (5)	85.7 (6)	44.4 (4)	28.6 (2)
Total birds	24	24	62.5 (15)	37.5 (9)	91.7 (22)	50.0 (12)	100 (24)	79.2 (19)	16.7 (4)	12.5 (3)	16.7 (4)	12.5 (3)	25.0 (6)	41.7 (10)	62.5 (15)	48.8 (11)	16.7 (4)	8.3 (2)

Key: E. gallinacea =Echidnophaga gallinacea, M. gallinae= Menopon gallinae, M. stramineus= Menacanthus stramineus L. caponis= Lipeurus caponis, G. gigas=Gonoides gigas, A. persicus=Argas persicus, D. gallinae= Dermanyssus gallinae, K.mutans= Knemidocoptes mutans

4.2.3 Seasonal prevalence of endoparasites

4.2.3.1 Seasonal prevalence for gastrointestinal nematodes

Four genera of nematodes were recovered from the gastrointestinal tracts of birds examined during the dry and wet seasons. These were *Heterakis* species, *Subulura, Tetrameres* and *Gongylonema* species (**Table 8**).

Table 8: Types of nematodes, their predilection site in the gastrointestinal tract and seasonal prevalence

Nematodes species observed	**Predilection site**	**Infected chicken**		**Seasonal Prevalence (%) (x/24×100)**	
		Wet	**Dry**	**Dry**	**Wet**
Heterakis species	Caecum and large intestine	23	19	95.83	79.17
Heterakis isolonche	Caecum and large intestine	18	14	75.00	58.33
Heterakis gallinarum	Caecum and large intestine	5	0	20.83	0
Subulura brumpti	Caecum and large intestine	17	16	70.83	66.77
Gongylonema ingluvicola	Crop	7	2	29.17	8.33
Tetrameres americana	Proventriculus	14	10	58.33	41.16

4.2.3.1.1 Caecal worms

Heterakis species, *Heterakis gallinarum, Heterakis isolonche and Subulura brumpti* were the caecal worms that were recovered from the caecum. **Table 9** shows the range and mean counts of the caecal worms for both wet and dry seasons. *Heterakis* species were the most frequently encountered in both seasons while *Heterakis gallinarum* was uncommon. The occurrence of caecal worms was slightly higher in the grower chicken [100% (8/8) and 100% (8/8)], than in adult birds [88.89% (8/9) and 100% (7/7)] and in chicks [85.71% (6/7) and 66.67% (6/9)] in wet and dry seasons, respectively. Female birds were more affected in both the wet and dry seasons than male birds. Female birds had 100% infection rate in wet season and 91.67% in the dry season while male birds had 87.50% infection rate in the wet season and 83.33% in the dry season. Most caecal worms occurred in the wet season, although there was no significant difference in occurrence of caecal worms between the two seasons, sexes and among the age groups ($p>0.05$).

Table 9: Range and mean counts of the caecal worms; *Heterakis* species, *Subulura brumpti*, *Heterakis isolonche* and *Heterakis gallinarum*

Nematode	Wet season		Dry season	
	Range	**Mean counts± SD**	**Range**	**Mean counts± SD**
Caecal worms	0- 230	45.13± 57.38	0- 282	36.88± 65.47
Heterakis species	0-220	28.00±35.29	0-235	28.50± 52.82
Subulura brumpti	0- 73	10.63± 18.52	0- 31	4.92± 8.58
Heterakis isolonche	0- 33	6.08± 5.58	0- 22	3.46± 6.25
Heterakis gallinarum	0- 3	0.42± 0.98	0- 2	0.00± 0.00

4.2.3.1.1.1 *Heterakis* species

Differentiation of female of *Heterakis isolonche* and *Heterakis gallinarum* was mainly using the shape of oesophageal bulb (**Figure 21**) which is similar in appearance hence were both identified as *Heterakis* species. *Heterakis* species were the most prevalent nematodes. A total of 87.50% (42/48) of the birds had *Heterakis* species in both seasons (**Table 8**). *Heterakis* species occurred either as a single or as a mixed infection with *Subulura brumpti*. During the wet season 95.83% (23/24) had the worm compared to 79.17% (19/24) in the dry season. Among the age groups infected with *Heterakis* species in both seasons (wet and dry), adult birds had a slightly higher prevalence of 100% (9/9) and 100% (7/7), respectively; grower birds had 100% (8/8) and 87.50% (7/8), respectively, while chicks had 85.71% (6/7) and 55.56% (5/9), respectively (**Table 10; Figure 22).**

Figure 21: Anterior end of *Heterakis species* from caecum, showing oesophageal bulb (arrow) (× 100)

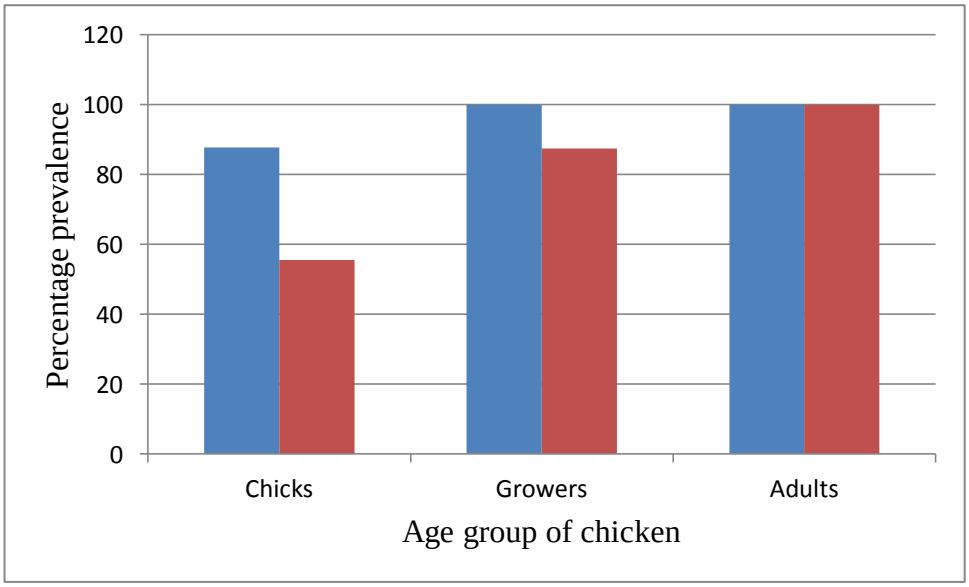

Figure 22: Prevalence of *Heterakis* species among three age groups of chicken in Mbeere subcounty

Female birds were more infected with *Heterakis* species [100% (16/16) and 75.00% (9/12) during the wet and dry seasons, respectively], compared to male birds [87.50 % (7/8) and 83.33% (10/12), respectively]. There was no significant difference between the rates of infection with *Heterakis* species between the age groups, sexes and seasons ($p>0.05$).

Table 10: Types of nematodes and their prevalence rates in different age groups

Age of chicken	No of birds in wet and dry season		% (number) positive											
			Heterakis species		*H. isolonche*		*H. gallinarum*		*S. brumpti*		*G. ingluvicola*		*T. americana*	
	Wet	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Chicks	7	9	85.71 (6)	55.57 (5)	85.71 (6)	44.44 (4)	0	0	71.42 (5)	55.57 (5)	14.29 (1)	0	28.57 (2)	22.22 (2)
Growers	8	8	100 (8)	85.50 (7)	50.00 (4)	62.50 (5)	0	0	62.50 (5)	62.50 (5)	25.00 (2)	0	62.50 (5)	37.50 (3)
Adults	9	7	100 (9)	100 (7)	88.89 (8)	71.42 (5)	44.44 (5)	0	77.78 (7)	85.71 (6)	44.44 (4)	28.57 (2)	77.78 (7)	57.14 (4)
Total birds	24	24	95.83 (23)	79.17 (19)	75.00 (18)	58.33 (14)	20.83 (5)	(0)	70.83 (17)	66.77 (16)	29.17 (7)	8.33 (2)	58.33 (14)	41.16 (10)

Key: ***H. isolonche- Heterakis isolonche, H. gallinarum- Heterakis gallinarum, S. brumpti- Subulura brumpti, G. ingluvicola-Gongylonema ingluvicola, T. americana- Tetrameres americana***

4.2.3.1.1.2 *Heterakis isolonche*

Heterakis isolonche (**Figure 23**) were found in the caecum and large intestine. Thirty two of the 48 chicken studied (66.67%) had *H. isolonche*, for both seasons (**Table 8**). Seventy five percent (18/24) of the birds had *H. isolonche* during the wet season while 58.83% (14/24) had the worm in the dry season. In both the wet and dry seasons, adult chicken were more infected with *H. isolonche*, recovered at rates of 88.89% (8/9) and 71.43 % (5/7), respectively. Recovery rates, for wet and dry seasons, in chicks were 85.71% (6/7) and 44.44% (4/9), respectively, while those for growers were 50.00% (4/8) and 62.50% (5/8), respectively (**Table 10**). Male birds were more infected in the wet season [at rate of 87.50% (7/8)] than female birds [at 68.75% (11/16)]. Females and male birds were equally infected, at rate of 58.33% (7/12) each, in dry season. There was no significant difference in the rates of infection with *Heterakis isolonche* between the age groups, sexes and seasons ($p>0.05$).

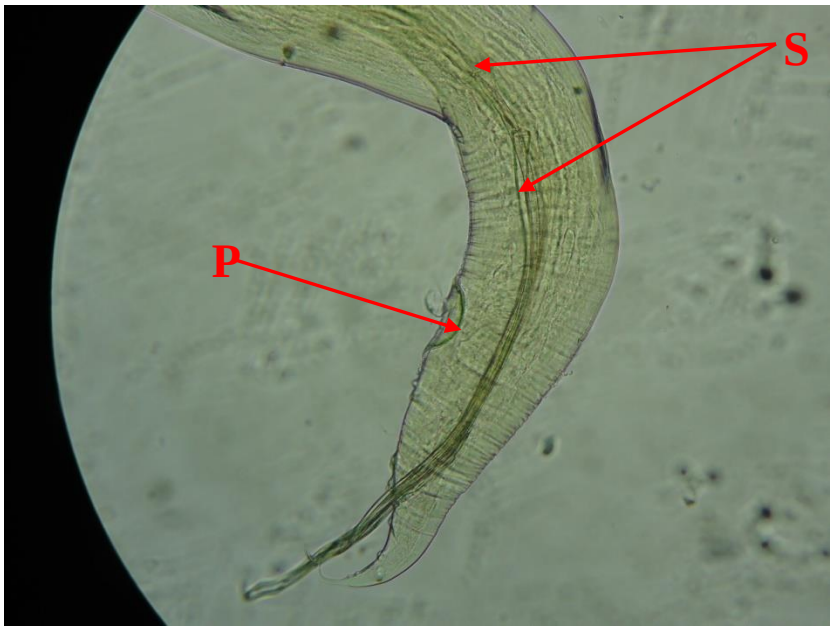

Figure 23: Posterior end of a male *Heterakis isolonche* from caecum, showing equal spicules (S) and pre-cloacal sucker (P) (× 100)

4.2.3.1.1.3 *Heterakis gallinarum*

Heterakis gallinarum (**Figure 24**) was the least isolated caecal worm. A total of 14.5% (7/48) of the birds had *Heterakis gallinarum* in both seasons (**Table 8**).There was no significant difference in occurrence of *Heterakis gallinarum* between the two seasons ($p>0.05$).

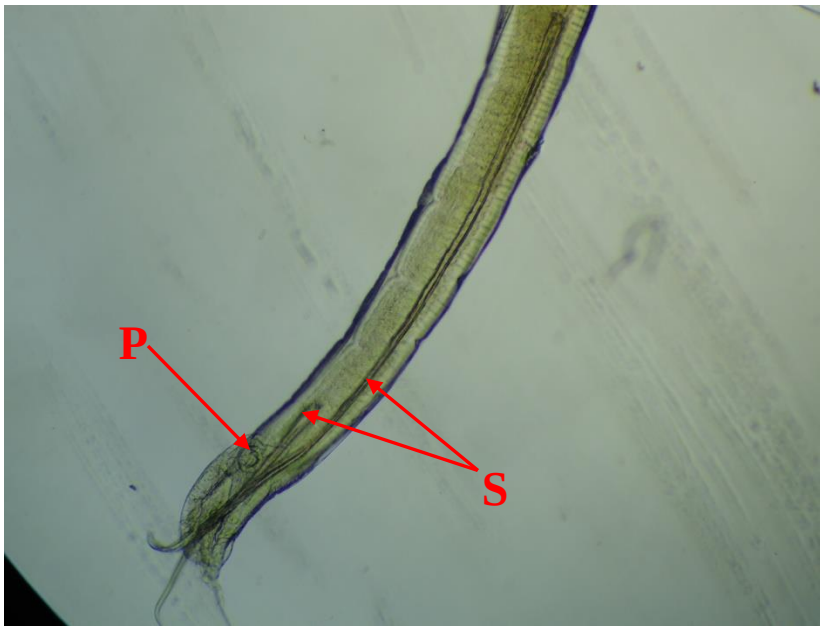

Figure 24: Posterior end of a male *Heterakis gallinarum* from caecum, showing prominent circular pre-cloacal sucker (P) and two unequal spicules (S) × 100

4.2.3.1.1.4 *Subulura brumpti*

Subulura brumpti (**Figure 25**) were found in the caecum and large intestine. Thirty three out of the 48 chicken studied (68.75%) had *Subulura brumpti,* for both the wet and dry seasons (**Table 8)**. Chicken were infected at rate of 70.83% (18/24) during the wet season while, in the dry season, the infection rate was at 66.67% (16/24). In both wet and dry seasons, adult birds were more affected at the rates of 77.78% (7/9) and 85.71% (6/7), respectively, growers were infected at 62.50% (5/8) and 62.50% (5/8), and chicks at 71.42% (5/7) and 55.56% (5/9), respectively

(**Table 10**). During the wet season, female and the male birds were equally infected at a rate of 75.00% (9/12) in females and 75.00% (6/8) in males. During the dry season the female birds were more infected [at a rate of 75% (9/12)] compared to the male birds [at 58.33% (7/12)]. There was no significant difference in occurrence of *S. brumpti* between the age groups, sexes and seasons ($p > 0.05$).

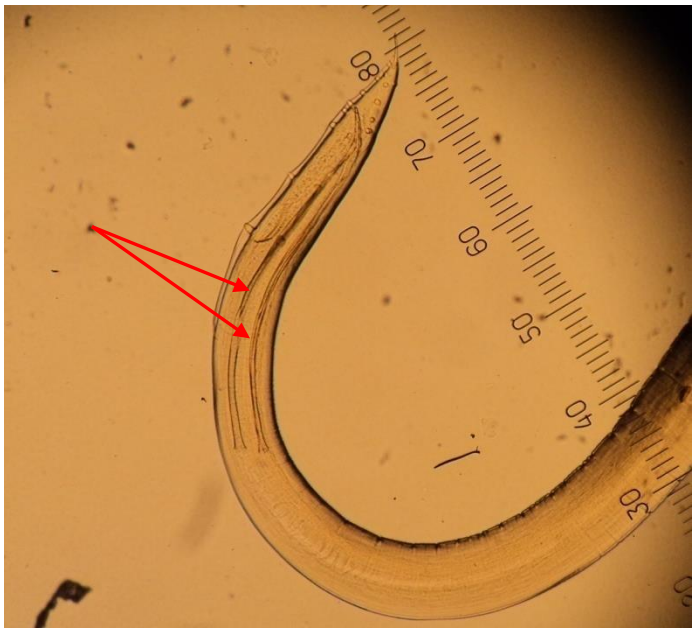

Figure 25: Posterior end of *Subulura brumpti* with two equal spicules (arrows) that do not extend beyond the body margins (×100)

4.2.3.1.2 *Gongylonema ingluvicola*

Gongylonema ingluvicola (**Figure 26)** was recovered only in the crop of the chicken (**Table 8**). The total worm count per bird ranged between 0 and 4 for the wet season and 0 and 3 in the dry season. The mean counts per bird in wet and dry seasons were 0.92±1.41 and 0.25±0.85, respectively. During the wet season, 29.1 % (7/24) of the chicken were infected while those infected in the dry season were 8.33% (2/24). Among the age groups, during the wet and dry

seasons, the infection rates were: 44.44% (4/9) and 28.57% for adult birds 25.00% (2/8), 0% (0/8) for growers and 14.28% (1/7) and 0% (0/7) for chicks, respectively (**Table 10**). The rates of infection between sexes in both wet and dry season were 37.50% (6/16) and 8.33 (1/12) in female birds and 12.50% (1/8) and 16.67% (2/12) in male birds *Gongylonema ingluvicola* occurred more in the wet season, although there was no significant difference in occurrence of *G. ingluvicola* between the two seasons, sexes and among the age groups ($p>0.05$).

Figure 26: Anterior end of *Gongylonema ingluvicola* showing bosses (arrows) (×100)

4.2.3.1.3 *Tetrameres americana*

Twenty four out of the 48 chicken studied, in both seasons, had *Tetrameres americana* species in their proventricular glands (**Table 8**). The number of parasites per bird ranged between 0 and 15 for the wet season and 0 and 6 for the dry season. The parasites were both males and females. The prevalences were: 58.33% (14/24) in the wet season and 41.16% (10/24) in the dry season (**Table 8**). The mean counts per bird during the wet and dry seasons were 2.17±3.60 and

0.96±1.52, respectively. Both female and male birds were more infected during wet season than dry season; female birds at 62.50% (10/16) and: 33.33% (4/12) and male birds at 37.50% (3/8) and 50.00% (6/12), respectively. Among the three age groups, in the wet and dry seasons, adult birds were more infected with *Tetrameres americana* [at 77.78% (7/9) and 57.14% (4/7)] ; growers were infected at 62.50% (5/8) and 37.50% (3/8) and chicks [at 42.86% (3/7) and 33.33% (3/9), respectively (**Table 10**). There was significant difference in occurrence of *Tetrameres americana* in the birds between the sexes ($p<0.05$) but not between age groups and the two seasons ($p<0.05$).

4.2.3.2 Seasonal prevalence of cestodes

Three genera of cestodes were recovered from indigenous chicken, namely: *Raillietina, Davainea, Choanotaenia* and *Hymenolepis* (**Table 11**). Eighty five percent (85.41%) of the chicken were infected in both the wet and dry season. During the wet season 91.67% (22/24) of the chicken were infected while during the dry season 79.16% (19/24) chicken were infected. **Table 12** shows the range and mean counts of cestodes and its different species isolated per chicken in wet and dry seasons. Cestodes were recovered more in adult birds in both wet and dry seasons, at rates of 88.89% (8/9) and 100% (7/7), respectively, compared to 100% (8/8) and 87.50% in growers and 71.42% (5/7) and 77.78% (7/9) in chicks, respectively. Female and male birds were equally affected with cestodes, at a rate of 87.50% each. There was no significant difference in the cestode occurrence among the age groups and between the two seasons and sexes ($p>0.05$).

Table 11: Types of cestodes, their location in the body and their seasonal prevalences

Cestodes species recovered	**Predilection site**	**Number of chicken infected with cestode**		**Percentage prevalence in wet and dry season (x/24×100)**	
		Wet	**Dry**	**Wet**	**Dry**
Raillietina echinobothrida	Small and large intestine, caecum	19	13	79.17	54.17
Raillietina tetragona	Small and Large intestine, caecum	13	9	54.17	37.50
Davainea proglottina	Duodenum	0	4	0	16.67
Hymenolepis cantaniana	Small intestine	0	1	0	4.17
Choanotaenia infundibulum	Small intestine	2	0	8.33	0

Table 12: Range and mean counts of cestodes isolated in indigenous chicken

Endoparasites	Wet season		Dry season	
	Range	**Mean counts± SD**	**Range**	**Mean counts± SD**
Cestodes	0- 26	6.50± 6.24	0- 10	3.75± 2.80
Raillietina echinobothrida	0-19	3.88± 4.30	0-5	1.88± 2.29
Raillietina tetragona	0- 8	2.13± 2.69	0-10	1.75± 2.69
Davainea proglottina	0	0.00± 0.00	0- 2	0.125± 0.45
Hymenolepis cantaniana	0	0.00± 0.00	0- 2	0.210± 0.52
Choanotaenia infundibulum	0-3	0.29±0.65	0	0.00± 0.00

The mean intensity *of Raillietina echinobothrida* was the highest

4.2.3.2.1. *Raillietina* species

Two species in the genus *Raillietina* were recovered, namely: *Raillietina echinobothrida* and *Raillietina tetragona*. These worms were recovered in the small intestines.

4.2.3.2.1.1 *Raillietina echinobothrida*

Raillietina echinobothrida (**Figure 27**) was the most prevalent *Raillietina* species recovered in the small intestine and caecum. Of all the chicken examined in both seasons 66.67% (32/48) had *Raillietina echinobothrida* (**Table 11**. There was no significant difference between the wet and dry seasons ($p>0.05$).

In both wet and dry seasons, adult chicken were more affected than the other age groups; the prevalences were: 88.89% (8/9) and 71.43% (5/7), respectively, followed by chicks, which had prevalences of 71.43% (5/7) and 55.57% (5/9) and lastly growers, at 75.00% (6/8) and 37.50% (3/8), respectively. The male birds were infected more during both seasons; they had prevalences of 87.50% and 58.33% while the females had prevalences of 75.00% (12/16) and 50.00% (6/12), respectively (**Figure 28**). There was no significant difference in rates of infection with *Raillietina echinobothrida* between the age groups, sexes and between the two seasons ($p > 0.05$).

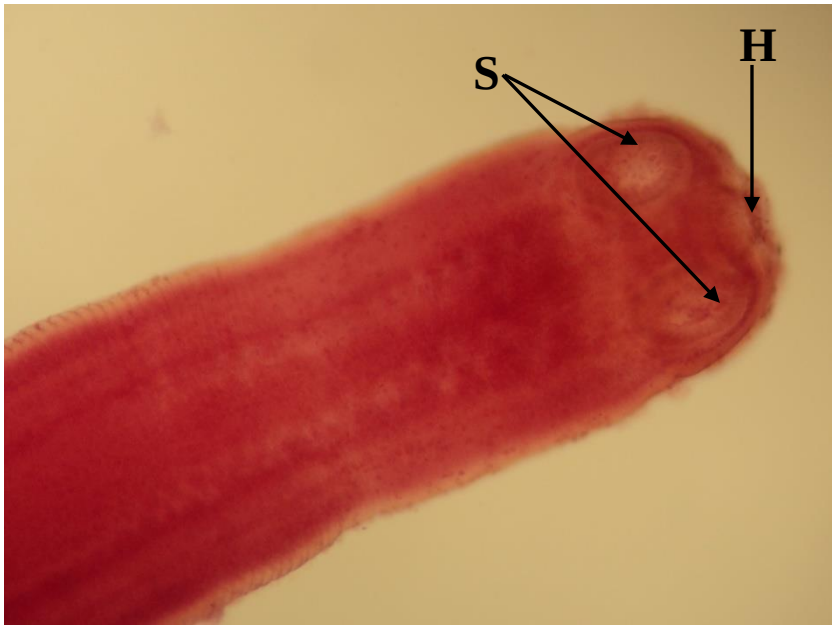

Figure 27: Anterior end of *Raillietina echinobothrida* from small intestine showing scolex with circular suckers (S) and the hooks (H)

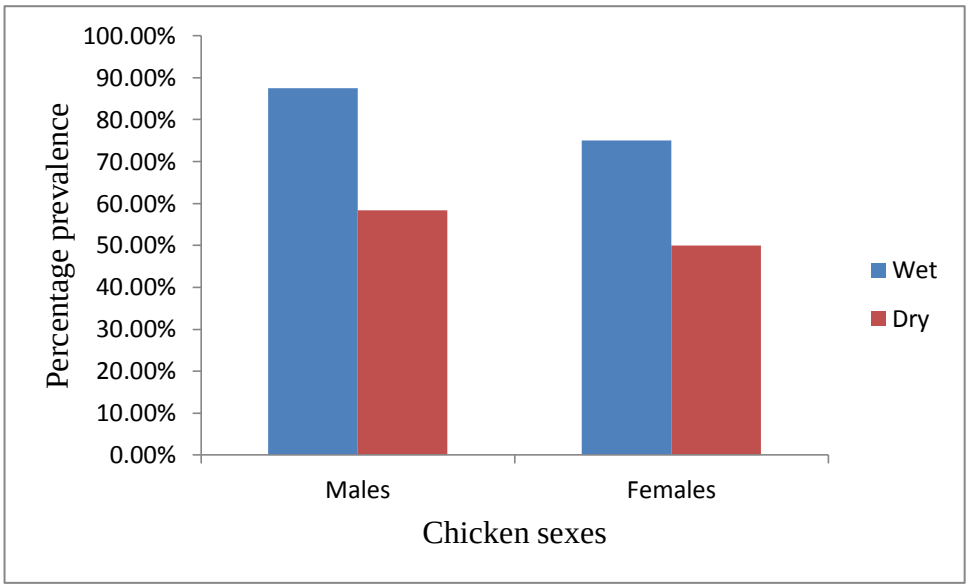

Figure 28: Prevalence of *Raillietina echinobothrida* infection in female and male chicken

4.2.3.2.1.2 *Raillietina tetragona*

Raillietina tetragona (**Figure 29**) was recovered in the small intestine and caecum (**Table 11**). Of all the chicken examined in both seasons 47.92% (23/48) had *Raillietina tetragona* (**Table 11**). In both wet and dry seasons, adult chicken had high prevalence of 66.67% (6/9) and 42.85% (3/7), respectively; followed by chicks [57.14% (4/7) and 33.33% (3/9)] and growers [37.50% (3/8) and 50.00% (4/8)], respectively. In both wet and dry seasons, female birds had prevalences of 62.50% (10/16) and 41.67% (5/12), while males had prevalences of 37.50% (3/8) and 41.67% (5/12), respectively.

There was no significant difference in rates of infection with *Raillietina tetragona* between the age groups, sexes and between the two seasons ($p > 0.05$).

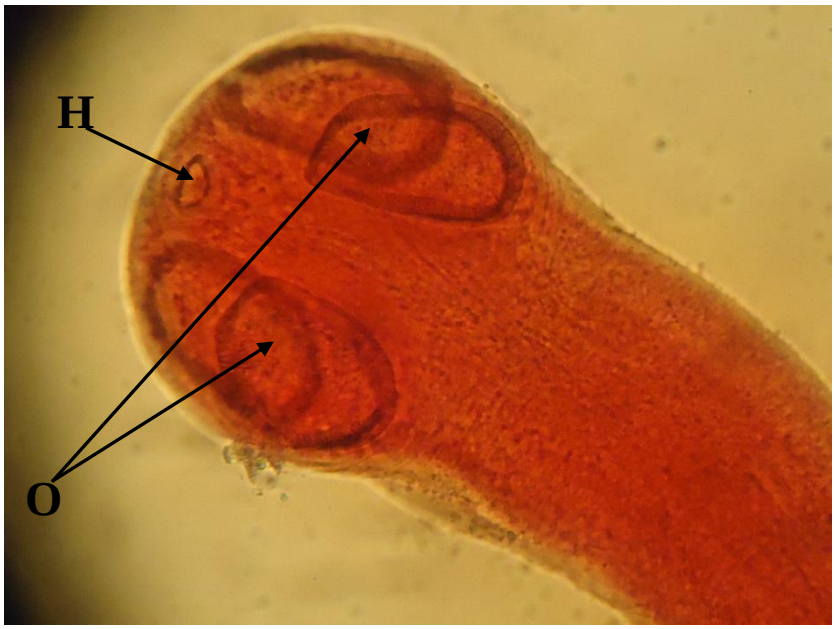

Figure 29: Anterior end of *Raillietina tetragona* from small intestine, showing a row of hooks (H) and oval suckers (O)

4.2.3.2.2.2 *Davainea proglottina*

Davainea proglottina (**Figure 30**) were isolated from the duodenum at a rate of 8.33% (4/48) (**Table 11**). During the wet season none of the chicken had this cestode but it was only recovered in the dry season at rate of 16.67% (4/24) (**Table 11**). There was no significant difference in rates of infection with *Davainea proglottina* between the age groups, sexes and between the two seasons ($p > 0.05$).

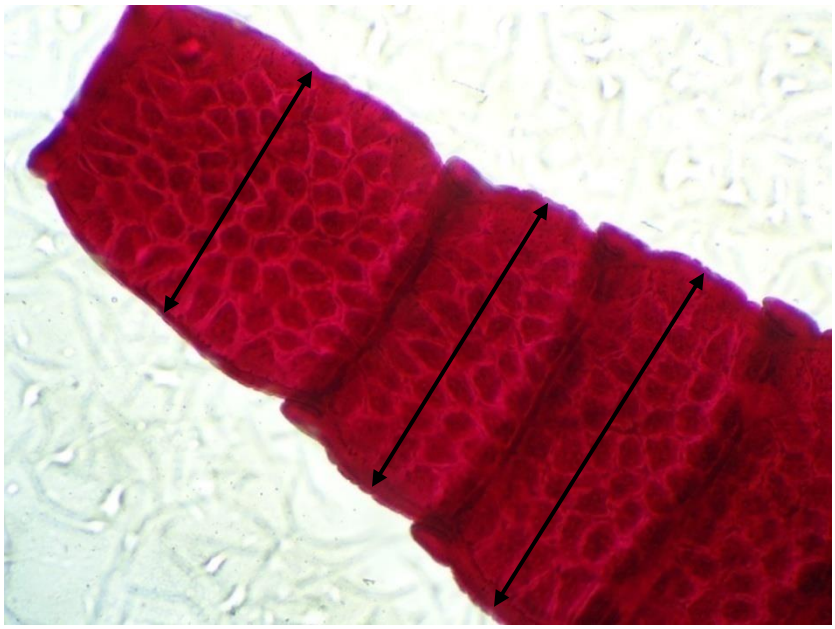

Figure 30: Anterior end of *Davainea proglottina* showing increasing breadth (arrows) of each succeeding segment

4.2.3.2.2.3 *Hymenolepis cantaniana*

Out of the 48 chicken examined only one chicken 2.08% had *Hymenolepis cantaniana* which was only isolated in the dry season (**Table 11**). It was isolated from small intestine. It was isolated from a female grower chicken. There was no significant difference in rates of infection with *Hymenolepis cantaniana* between the age groups, sexes and between the two seasons ($p > 0.05$).

4.2.3.2.2.4 *Choanotaenia infundibulum*

Of all chicken examined, 4.17% had *C. infundibulum* isolated only in the wet season (**Table 11**). These worms were recovered in the small intestine. There was no significant difference in rates of infection with *C. infundibulum* between the age groups, sexes and between the two seasons ($p > 0.05$).

4.2.3.3. Seasonal prevalence of coccidial oocyst counts

Eight percent (4/48) of the faecal samples processed were positive for coccidial oocyst. These were mainly isolated during the wet season where four adult females chicken were positive.

4.2.3.4 Seasonal prevalence of haemoparasites

Out of 48 chicken examined in the wet and dry seasons, 34 (70.83%) were infected with haemoparasites. Four haemoparasite species identified were: *Plasmodium gallinaceum*, *Leucocytozoon schoutedeni*, *Aegyptinella pullorum* and *Eperythrozoon* species. The occurrence rates were 79.17% (19/24) during the wet season and 62.50% (15/24) during the dry season. The haemoparasites occurred as single or mixed infection(s). All the ages of chicken were infected with haemoparasites in both seasons (**Table 13**). Adult chicken had prevalence rates of 88.88% (8/9) and 57.14 % (4/7), followed by growers at 87.50% (7/8) and 62.50% (5/8) and chicks at 57.14% (4/7) and 66.67% (6/9) in wet and dry seasons, respectively (**Table 13**). Female birds were more infected in the wet season [at rate of 87.50% (14/16)] than male birds [at rate of 62.50% (5/8)] while during the dry season male birds were infected more [at a rate of 75.00% (9/12)] than females [at rate of 50.00% (6/12)]. There was a significant difference in occurrence of haemoparasites between the sexes ($p<0.05$) but not among the age groups and between the wet and dry seasons ($p>0.05$).

Table 13: Seasonal prevalence for haemoparasites in different age groups of indigenous chicken

Age of birds	Number of chicken in wet and dry season		% (number) positive							
			Plasmodium gallinaceum		*Leucocytozoon schoutedeni*		*Aegyptinella pullorum*		*Eperythrozoon species*	
	Wet	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**	**Wet**	**Dry**
Chicks	7	9	57.14 (4)	66.67 (6)	14.29 (1)	0	0	22.22 (2)	14.29 (1)	0
Growers	8	8	87.50 (7)	62.50 (5)	37.50 (3)	0	12.50 (1)	12.50 (1)	25.00 (2)	12.50 (1)
Adults	9	7	88.88 (8)	57.14 (4)	33.33 (3)	28.57 (3)	0	0	14.29 (1)	0
Total chicken	24	24	79.16 (19)	62.50 (15)	29.17 (7)	12.50 (3)	4.17 (1)	12.50 (3)	16.67 (4)	4.17 (1)

4.2.3.4.1 *Plasmodium gallinaceum*

Plasmodium gallinaceum **(Figure 31**) was the most common haemoparasite isolated in both seasons. Overall 70.83% (34/48) of the chicken examined were infected with *Plasmodium gallinaceum*. The occurrence rates were 79.17% (19/24) in the wet season and 62.50% (15/24) in dry season (**Table 13**). The prevalences of this parasite among the age groups for the wet and dry seasons were 88.89% (8/9) and 57.14% (4/7) in adult chicken, 87.50% (7/8) and 50% (4/8) in growers and 57.14% (4/7) and 77.77% (7/9) in chicks, respectively. Female birds were more infected in the wet season at a rate of 87.50% (14/16) than male birds at a rate of 62.50% (5/8). During the dry season male birds were more infected at a rate of 75.00% (9/12) than females at 50.00% (6/12). There was a significant difference in occurrence of *Plasmodium gallinaceum* between the sexes ($p<0.05$) but not among the age groups and between the wet and dry seasons ($p>0.05$).

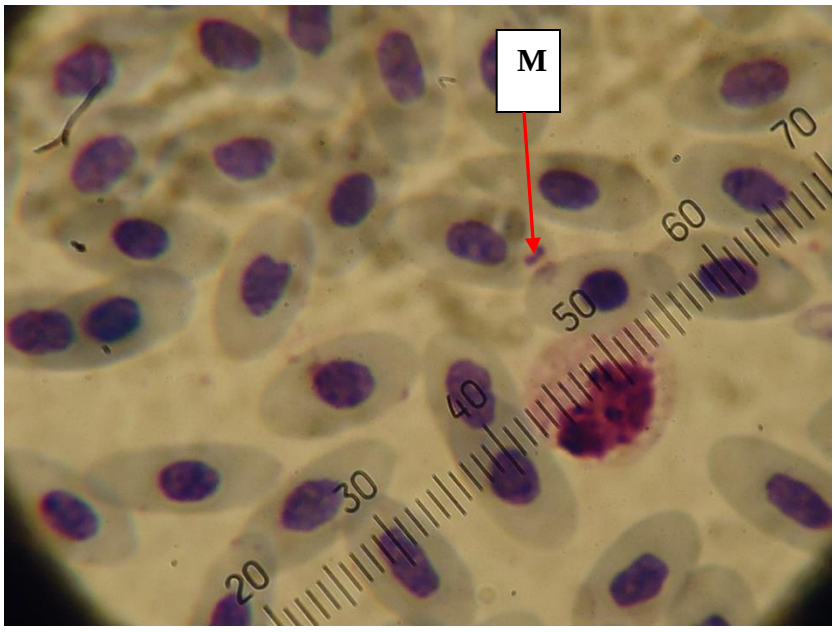

Figure 31: Chicken blood smear showing a ‘’signet ring’’ merozoites (M) of *Plasmodium gallinaceum* (×100

4.2.3.4.2 *Leucocytozoon schoutedeni*

Leucocytozoon schoutedeni **(Figure 32*)*** was isolated in 20.83% (10/48) of the chicken examined were infected with *L. schoutedeni* (**Table 13**). The occurrence rates were 29.17% (7/24) in wet season and 12.50% (3/24) chicken in dry season. The prevalences of this parasite among the age groups, for both wet and dry seasons, were 22.22% (2/9) and 28.57% % (3/7) for adult chicken, 37.50% (3/8) and 0.00% (0/8) for growers and 14.22% (1/7) and 0.00% (0/9) for chicks, respectively (**Table 13**). Female birds were infected only during the wet season at a rate of 37.50%. There was no significant difference in occurrence of *L. schoutedeni* between the age groups, sexes and between the two ($p > 0.05$).

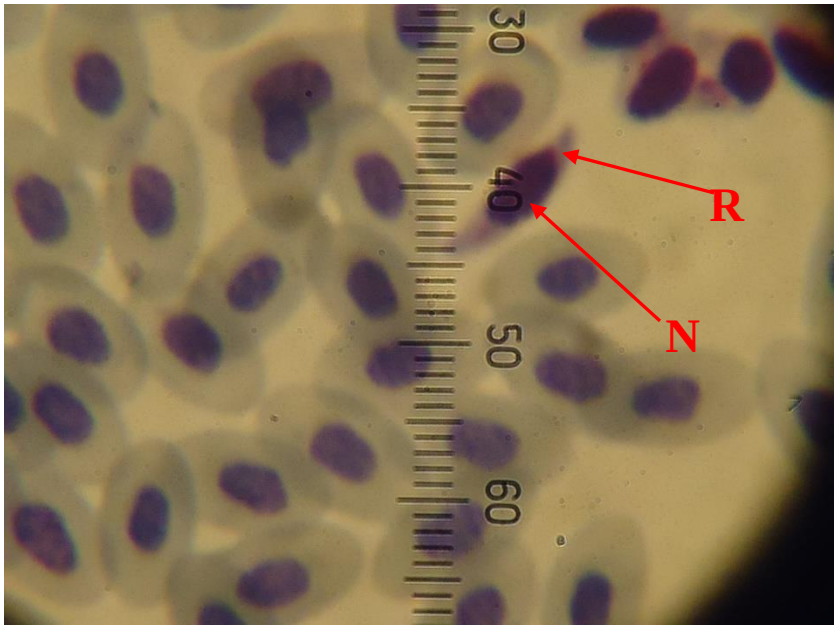

Figure 32: A blood smear from chicken showing distorted infected red blood cell (R) with the nucleus of the host being elongate (N) due to infection of *L. schoutedeni*

4.2.3.4.3 *Aegyptinella pullorum*

Figure 33 shows *Aegyptinella pullorum* in chicken erythrocytes. Out of the 48 chicken examined, 5 (10.42%) had *Aegyptinella pullorum* (**Table 13**). The occurrence rates were 4.17% (1/24) in wet season and 16.67 % (4/24) in dry season. Only growers and chicks were infected. For growers, only one (12.50%) was infected in each season, while for chicks, two (22.22%) were infected during the dry season but none in wet season. Female birds were infected in both wet and dry seasons, at 6.25% (1/16) and 8.33% (1/12), respectively. Male birds were only infected during the dry season, at a rate of 16.67% (2/12). There was no significant difference in rates of infection with *Aegyptinella pullorum* between the age groups, sexes and between the two seasons ($p > 0.05$).

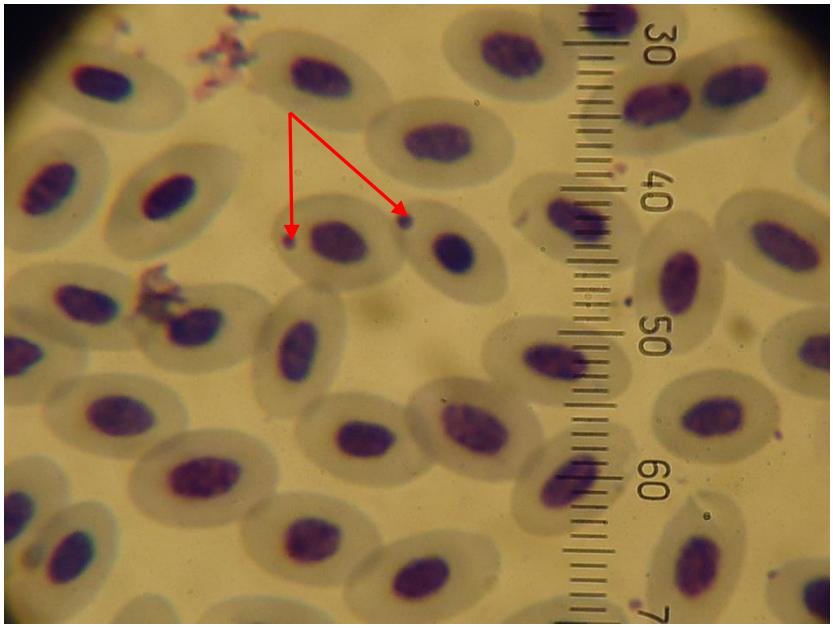

Figure 33: Chicken blood smear showing red blood cells infected with *Aegyptinella pullorum* (arrows) (×100)

4.2.3.4.4 *Eperythrozoon* species

A total of 5 out of 48 (10.42%) chicken examined in both seasons were infected with *Eperythrozoon* species (**Table 13**). Of the 5 infected chicken, adults and chicks were only infected during the wet season, comprising 11.11 % (1/9) of adults and 14.29% (1/7) of chicks; growers were infected in both wet and dry seasons [two (25.00%) and one (12.50%), respectively] . There was no significant difference in the rate of occurrence of *Eperythrozoon* species in both seasons, between the age groups and sexes ($p > 0.05$).

4.3 Effectiveness of selected anthelmintics used on the village chicken

The helminths found in the 7 chicken sacrificed prior to the start of experiment were nematodes (caecal worms and *Tetrameres americana)* and cestodes (*Raillietina echinobothrida* and *R. tetragona)*.

On screening of the 30 chicken used in this experiment prior to treatment, faecal samples from two chicken were positive for *Heterakis* species eggs and one for *Ascaridia galli* eggs (**Figure 34)**. The chicken shed the eggs more in the morning than in the noon and evening. The shedding of the eggs was completely reduced two days later after the treatment.

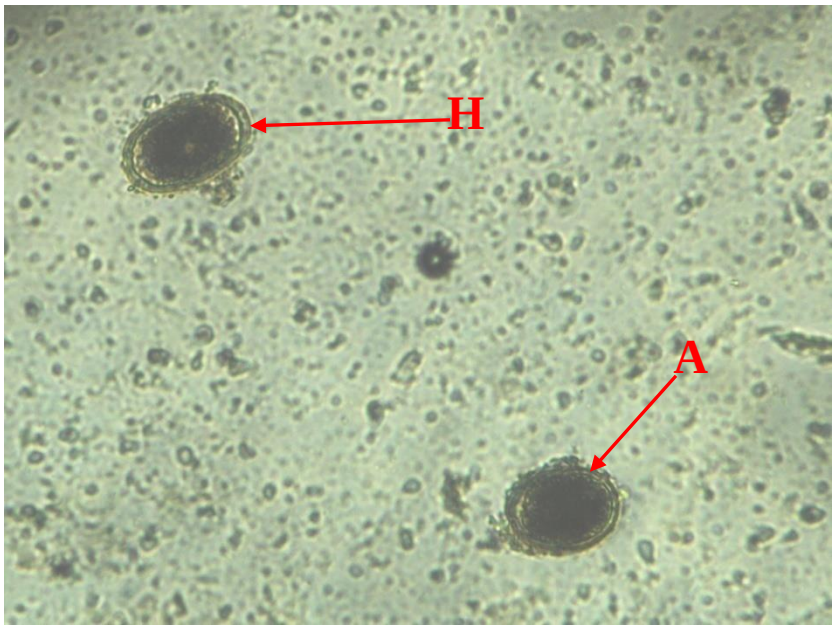

Figure 34: *Heterakis* species (H) and *Ascaridia galli* eggs (A) isolated from chicken faecal samples

Table 14 shows the amount of medicated water left, the amount of water and the dosage taken by each chicken after 24 hours.

Table 14: Amount of medicated water consumed and left and dosage taken by each bird

	Piperazine citrate at 3mg/kg bwt		
Chicken number	**Amount of medicated water left (mls)**	**Amount of medicated water consumed (mls)**	**Dosage taken (mg/ kg body weight)**
23P	110	320	2.2
22P	105	325	2.3
17P	102	328	2.3
18P	85	345	2.4
11P	135	295	2.1
21P	93	337	2.4
16P	390	40	0.3
	Levamisole HCL at 25mg/kg bwt		
10L	84	346	20.3
19L	0	430	25.0
13L	135	295	17.2
14L	21	409	23.8
15L	35	395	23.0
20L	120	310	18.0
12L	0	430	25.0

Key: **P**=Piperazine citrate, **L**=Levamisole HCL

Albendazole at 20 mg/kg body weight was 100% effective against *Heterakis* species: *H. isolonche*, *Subulura brumpti*, *Raillietina tetragona* and *Raillietina echinobothrida*. Some of the tapeworm segments recovered at post-mortem had been distorted morphologically. **Figure 35** shows one such case.

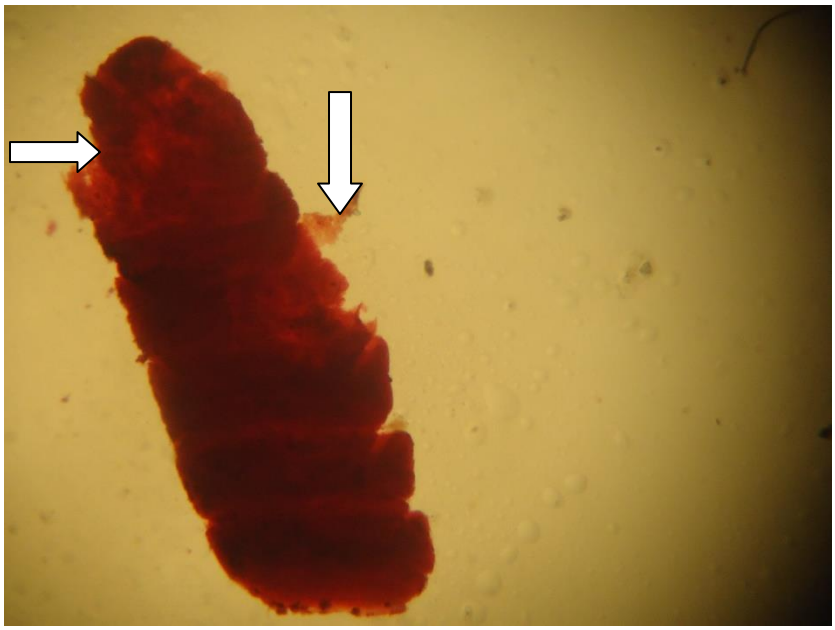

Figure 35: Distorted tapeworm segments (white arrows) after treatment with albendazole

Levamisole HCL 25 mg/kg body weight was 100% effective against the caecal worms and 62.84% efficacy against *Tetrameres americana*. It had very little efficacy of 25.59% and 17.62% against cestodes *Raillietina echinobothrida* and *R. tetragona*, respectively.

Piperazine citrate at 3 mg/kg was not effective against cestodes (*Raillietina* species), caecal worms (*Heterakis* species, *Subulura brumpti*) and *Tetrameres americana*; it was found to be effective against *Ascaridia galli* only.

The mean numbers of worms ((**Appendix 2**) for each treatment group were used to calculate the percentage efficacy of the anthelmintics. The number of the different species of worms were more in the control group compared to the treated groups.

After treatment, no adverse effects were observed on birds' appearance, behaviour and appetite. The helminths found at necropsy after treatments were nematodes (caecal worms and *Tetrameres americana)* and cestodes (*Raillietina echinobothrida* and *Raillietina tetragona)* in groups 1, 2 and 4.

Table 15 shows different anthelmintics that had different efficacies against different nematodes and cestodes. Anthelmintics that had percent reduction rates of above 90 % were considered effective.

Table 15: Efficacies of the different anthelmintics used to treat the birds; based on percent reduction rates

Helminth	**Piperazine citrate**	**Levamisole HCL**	**Albendazole (20mg/kg) BW**
Heterakis species	59.16%	100%	100%
Heterakis isolonche	58.44%	100%	100%
Subulura brumpti	55.71%	100%	100%
Tetrameres americana	11.18%	69.84%	100%
Raillietina tetragona	13.44%	25.59%	100%
Raillietina echinobothrida	49.46%	17.62%	100%

Key: BW= Body weight

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSIONS AND RECOMMEDATIONS

5.1 DISCUSSION

5.1.1 Data on chicken parasites and local treatments used against them in Mbeere sub-county

This study showed that chicken roamed freely during the day and were housed at night mainly using the mud walled type of housing. Mud walled houses are associated with ticks, fleas and blood sucking mites (Mungube *et al.,* 2008). Most farmers also housed different age groups of birds together; a practice that was likely to facilitate the spread of ectoparasites and endoparasites across the ages. Most of the farmers, however, were aware that all age groups of birds were at high risk of infections; chicks got infected at an early age resulting in stunted growth and poor production. The fact that the majority of the farmers confined their birds during the planting season worsened the situation; confinement introduced some kind of stress to the birds (Njagi, 2008) and facilitated close interaction of birds, leading to transmission of ecto-parasites.

Among the constraints of poultry keeping reported were diseases, parasites, predation, insufficient feeds and accidents; diseases being quoted as the major constraint. This supports what was reported previously by Njagi (2008). The most common parasites were fleas and ticks. The farmers were able to note the presence of fleas and ticks on the skin of birds. These parasites are normally associated with poor hygiene and housing in the farm/ chicken house. Cleaning of the chicken litter is not frequent in the chicken houses; this facilitates spread of fleas and ticks. The occurrence of ticks, blood sucking mites and fleas was highest on farms with mud-walled type of housing where the ticks hide in the cracks and crevices.

Some farmers kept other types of animals particularly goats, cattle, dogs and cats which can also be parasitized by fleas (*Echidnophaga gallinacea*) (Gordon and Jordan, 1982; Soulsby, 1982). Some rodents, such as rats, usually hide in mud-walled houses and can act as alternate hosts for fleas. The prevalence rate of the soft tick *Argas persicus* was 47.06%. This is in contrast to 29.3% recorded by Maina (2005), who examined traded birds in Nairobi and 5.6% recorded by Sabuni *et al*. (2010) who examined farm birds from Embu and Mbeere Districts, Kenya and 11.1% by Mungube *et al.* (2008), who examined birds in Machakos District, Kenya. In Zimbabwe prevalences of 6% and 14% in young and adult chicken, respectively have been reported (Permin *et al*., 2002). *Argas persicus* sucks blood from chicken which can result in anaemia and death of the birds. They also transmit *Borrelia anserina* that causes spirochaetosis and *Aegyptinella pullorum* which causes a rickettsial infection in fowl (Gordon and Jordan, 1982; Soulsby, 1982).

Echidnophaga gallinacea (stick tight flea) occurred in the chicken at rate of 47.06 % as farmers did not use insecticides as control methods. The prevalence was in contrast to that of 29.2% recorded from previous findings in Kenya by Sabuni *et al*. (2010) but lower than 50% reported by Maina (2005) and 76.7% reported by Mungube *et al*. (2008). Mites and lice were present at 17.65% each; this was lower than that of ticks (47.06%) and fleas (47.06%). The reason behind this is that lice run very fast on the skin and hence most farmers were not able to visualize them.

Majority of the farmers were aware of treatments used against ectoparasites. Most of them used cabaryl (Sevin^{R}) which they dusted on the skin of the birds. A few people used ectomin (cypermethrin) that causes nervous toxicity (Permin and Hansen, 1998). Other traditional control

methods included usage of cooking oil, liquid paraffin and even used engine oil. Liquid paraffin and cooking oil were mainly used to cater for scaly leg mite where the oils are thought to cause suffocation of the parasites. Used engine oil was applied in poultry houses mainly in the cracks to cater for ticks.

Worms were also mentioned as being present, at 47%. Although most of the farmers believed that the drug, which they were using (piperazine citrate), worked, it had no effect on caecal worms and tapeworms which were later found to be very common in the area. Chicken in the area had minimal infection with *Ascaridia galli*, indicating that piperazine citrate had taken care of them. Most farmers had no idea of how often they should deworm their birds.

Other worm control methods given included herbal medicine, such as usage of Aloe species, pepper, ‘’*mikau*’’, ‘’githongu’’. The mechanism of the herbal medicines has not been evaluated.

5.1.2 Seasonal prevalence, intensity and identity of ectoparasites and endoparasites

In the present study, it is evident that the village chicken of Mbeere subcounty had high prevalences of 98.95% for both ecto- and endo-parasites in the wet and dry seasons which indicates that parasitic infection is a common problem in this area. All ages and sexes of chicken were found to be infected with endo- and ecto-parasites. This is due to similar environmental stress factors such as shortage of food, water, extreme temperatures that depress the immune system. Similar observations have been reported in tropical African countries such as Nigeria (Fabiyi, 1980; Sadiq *et al*., 2003), Ethiopia (Abebe *et al*., 1997), Zimbabwe (Permin *et al*., 2002), Malawi (Njunga, 2003) and Kenya (Maina, 2005; Mungube *et al.*, 2008; Sabuni *et al*., 2010 and 2011). Birds kept under total confinement, roam less hence harbor no endoparasites

which require an intermediate host. In this study, the high prevalence of parasites observed in free range chicken can be attributed to the fact that the birds roam around in the village; hence the birds are in continuous contact with the parasites or the intermediate hosts of the parasites.

In this study, there was no difference in occurrence of both ecto- and endo-parasites between the wet and dry seasons. This is in contrast with previous findings by Mungube *et al*. (2008) who recorded endoparasites as being more in the wet season and ectoparasites more prevalent in the dry season. Variations in the results could be attributed to different climatic conditions. This persistent occurrence of the parasites in both seasons in the current study could be explained by the fact that transmission of the respective parasites was not affected by the weather changes in the study area.

Ectoparasites are regarded as the basic cause of retardation in growth, lowered vitality and poor conditions of birds (Ruff, 1999). In this study, all the chicken in the wet and dry seasons harboured ectoparasites with a prevalence rate of 100%. Similar findings have been reported in village chicken in Nigeria (Fabiyi, 1996), Ethiopia (Abebe *et al*., 1997), Zimbabwe (Permin *et al*., 2002), and Kenya (Maina, 2005; Sabuni *et al*., 2010). The ectoparasites isolated were lice, fleas, ticks and mites. All four groups of ectoparasites were isolated in all the age groups and sexes. In the wet and dry seasons, all the adult and grower birds were 100% infested. During the dry season the chicks had a slightly lower prevalence of infestation (88.88%). This may be attributed to similar management system hence high prevalences among all the age groups in both seasons. Ectoparasites are associated with poor hygiene in the farm/chicken houses. The poor hygiene conditions, including the fact that all ages of birds are housed together, therefore,

facilitate the spread of ectoparasites like lice, mites and ticks. Most farmers do not clean the chicken houses whose litter harbor eggs of some ecto-parasites like fleas, lice and ticks. Most of farmers constructed mud-walled type of housing where the cracks and crevices are hiding sites for adult stages of *Argas persicus*. Birds kept under total confinement are associated with good hygiene where fumigation of houses is done and different age groups of birds are kept separate; this plays an important role in controlling ecto-parasites.

Among the ectoparasites found, lice were the most prevalent. This is similar to previous findings in Kashmir valley (Salam *et al*., 2009), Ethiopia (Mekuria and Gezahegn, 2010) and Kenya (Sabuni *et al*., 2010). It is, however, in contrast to previous findings by Maina (2005) and Mungube *et al*. (2008) where the stick tight flea (*Echidnophaga gallinacea*) was found to be the most prevalent at rates of 56% of 75 chicken and 76.70% of 360 chicken examined (Mungube *et al.,* 2008). This could have been attributed to climatic differences in the study areas. Lice were also prevalent because most farmers used Cabaryl (Sevin^{R}) which is not effective against the lice (Permin and Hansen, 1998). All adult and grower birds were infested with lice in both the wet and dry seasons; chicks had a lower rate of infestation (44.44%) in the dry season. During the wet season, all female and male birds were affected with lice, while in the dry season, males were more affected, at a rate of 83.33%, while the female birds were affected at 75.00%. There is need for further research to explain these variations.

Lice were common in the wet season compared to the dry season. This is in contrast to the previous findings in Kashmir valley (Salam *et al.,* 2009) where lice were found to be more prevalent during the dry season than the wet season. In the wet season in Mbeere, chicken tend to

hurdle together for warmth which could facilitate the spread of the lice. The high prevalence in the wet season could also be explained by permanent housing during the planting season when the chicken are confined. Lice cause the birds not to feed well and be restless. *Menacanthus stramineus* was the most prevalent lice in concurrence with previous report of 71.4% (Mungube *et al.,* 2008). It is, however, contrary to the findings in Kashmir valley (Salam *et al.,* 2009) where *Lipeurus caponis* was the most prevalent at a rate of 96.86% of 478 chicken examined and in Kenya (Sabuni *et al.,* 2010) where this parasite was not recorded but *Menopon gallinae* was found to be the most prevalent. This may be attributed to difference in the period of study. Although adult and grower birds had a higher infestation rate of 100% for *Menacanthus stramineus* in both seasons than chicks, which had a rate of 44.44% in the dry season there was no significant difference in their occurrence. This is similar to earlier findings in Zimbabwe (Permin *et al.,* 2002) where adult birds were affected at a rate of 90% of 50 adults compared to 88% of 50 young chicken examined. In this study, male birds had a higher prevalence of *Menacanthus stramineus* in both wet and dry seasons at prevalences of 100% and 83.33%, respectively compared to female birds (93.75% and 75.00%, respectively), although there was no significant difference ($p>0.05$). The high prevalence in the *Menacanthus stramineus* in males could be explained by the fact that males are larger in size hence they are parasitized more than the females. *Menacanthus stramineus* has been reported to reduce weight gain and egg production, loss of plumage in free range chicken (Soulsby, 1982).

The flea isolated was the stick tight flea (*Echidnophaga gallinacea*). It was recorded in both wet and dry seasons, at rates of 62.50% and 37.50%, respectively. Mungube *et al*. (2008) and Permin *et al*. (2002) recorded higher rates of 76.7% of 360 chicken and 73% of 100 chicken examined, respectively. The variation in prevalence rates of the flea is likely due to climatic factors between

the areas. This flea causes the chicken to become restless and scratches affected area (Taylor *et al*., 2007).

Argas persicus was the only tick isolated in this study. In both seasons it occurred at a rate of 50%; unlike previous reports in Zimbabwe (Permin *et al.,* 2002) with prevalences of 6% and 14% for adults and young chicken and in Kenya (Maina, 2005; Mungube *et al.,* 2008; Sabuni *et al*., 2010) with prevalences of 29.3% of 121, 11.1% of 360 and 5.6% of 144 chicken examined, respectively. The differences could have probably been due to different environmental factors in the study areas. *Argas persicus* has been implicated as a cause of high mortalities due to the blood-sucking habit of the parasite and may act as a vector of *Aegyptinella* species. The nymphs and adults of the tick are temporary obligate parasites and only visit the bird while feeding, indicating the prevalence recorded in this study could have been higher.

All the village chicken had endoparasites in both the wet and dry seasons. Endoparasites are known to cause interference with the host metabolism resulting in poor feed utilization and reduced growth rate (Nandi *et al.,* 2007).

The most prevalent endoparasites were caecal worms and cestodes. Among the nematodes encountered, caecal worms (*Heterakis* species and *Subulura brumpti*) were the most prevalent in both the wet (95.83%) and dry (87.50%) seasons. This is in contrast with the previous findings by Mungube *et al.* (2008) who reported *Ascaridia galli* to be the most prevalent nematode at a rate of 33.3% of 360 chicken examined. In the current study, *Ascaridia galli* was not isolated because most farmers mainly used piperazine citrate which is effective against it (results of another study). The findings of this study are however, supported by the report of Maina (2005),

who also recorded caecal worms as the most prevalent. *Heterakis* species had high prevalences of 98.83% and 79.17% in the wet and dry seasons, respectively. *Heterakis isolonche* and *Subulura brumpti* were also common in wet and dry seasons. The least common caecal worm was the *Heterakis gallinarum*. The findings of this study were in contrast to a study conducted in semi arid zone of Kenya (Mungube *et al.*, 2008) where he found *Heterakis gallinarum* to be more common at rate of 22.2% than *Heterakis isolonche* and *Subulura brumpti*. The differences could have probably been due to different climatic factors in the study areas. Also, another study carried out in Zimbabwe (Permin *et al*., 2002) documented *Heterakis gallinarum* was the most common nematode with a prevalence of 64% and 62% in young and adult chicken, respectively. In this study, there was no association in occurrence of the caecal worms among the age groups and between the sexes; this, however, needs to be investigated further. The caecal worms may contribute to poor productivity of village chickens. *Heterakis isolonche* has been associated with diarrhoea, emaciation and death (Permin and Hansen, 1998). In the current study, caecal worms were common among the three age groups of village chicken indicating that the chicks are affected at a young age; this may lead to stunted growth. The high prevalences of caecal worms in the wet and dry seasons may be attributed to constant contact of chickens with the intermediate hosts (earthworms) throughout the two seasons. It was also noted that the farmers were only aware of piperazine citrate (Ascarex^{R}) as an anthelmintic for chicken. As mentioned above, the drug does not remove the caecal worms, which could explain the high prevalence of the worms.

Other nematodes recorded with lower rates of prevalence included *Tetrameres americana*. Both males and females of this parasite were isolated. Maina (2005) who studied the occurrence of

helminths in chicken from markets in Nairobi only reported the occurrence of female parasites but no males. The prevalence of *T. americana* recorded in this study is slightly lower (37.7%) than that previously reported in Kenya (Mungube *et al*., 2008). A higher prevalence of 70% and 60% in young and adult birds, respectively has been reported in Zimbabwe (Permin *et al.*, 2002). The difference in geographical areas could probably be the reason for the differences observed. Infected chicken with *Tetrameres americana* may lose weight and become anaemic (Permin and Hansen, 1998).

Gongylonema ingluvicola was isolated at a rate of 29.17% and 8.33% in wet and dry seasons, respectively. This is in contrast to a report from a previous study in Zimbabwe (Jansen and Pandey, 1989) where 3.3% of 80 commercial chicken were found to have *Gongylonema ingluvicola*, the parasite was also found in ducks at a rate of 24.14% of 145 ducks examined (Mavuti, 2010). It occurred more in the wet season than the dry season due to high population of beetles that act as intermediate hosts.

Cestodes were present in the wet and dry seasons at high prevalences of 87.50% and 79.16%, respectively. The high prevalences of cestodes recorded in this study can be attributed to the scavenging diet that includes variety of earthworms that act as intermediated hosts of these parasites. *Raillietina echinobothrida* and *Raillietina tetragona* were the two commonly isolated cestodes in the chicken while *Hymenolepis cantaniana, Choanotaenia infundibulum, Davainea proglottina* were a rare species. They were more common in adult birds since they are familiar with the environment hence they tend to roam more and pick intermediate infective stages. Female and male birds were equally infected with cestodes, at a rate of 87.50% each. This could

be attributed to similar management system; reproductive system of the bird seems not to be directly related. There was no difference in occurrence of these tapeworms between the wet and dry seasons. This could be attributed to the fact that tapeworms live for extended periods of time in the intestines of untreated hosts (Soulsby, 1982). Piperazine citrate, the anthelmintic used by most farmers in the study area, is not effective against cestodes (results of another study).

Raillietina echinobothrida and *R. tetragona* are considered to be harmful to chicken (Ashenafi and Eshetu, 2004). *Raillietina echinobothrida* is associated with nodular lesions in the small intestine, malabsorption, poor nutritional state; heavy infestation may cause mortality in young chicken and loss of egg production in laying birds (Gordon and Jordan, 1982; Soulsby, 1982). *Raillietina echinobothrida* was the most prevalent cestode at 79.17% and 54.17% in the wet and dry season, respectively. This concurs with previous reports by Maina (2005) and Mungube *et al*. (2008) who reported that the parasite was most prevalent although they recorded lower prevalence rates of 37.4% and 33.3%, respectively. Prevalences of between 34% and 81% have been reported by Permin *et al*. (1997; Poulsen *et al*. (2000); Permin *et al*., (2002); and Irungu *et al.* (2004). A much lower prevalence of 8.3% has been reported in Somalia (Terregino *et al*., 1999). In the current study, adult birds were more affected than the other age groups, with respect to wet and dry seasons (88.89% and 71.42%), followed by chicks, (71.43% and 55.57%) and lastly by growers (at 75.00% and 37.50%), respectively. Similar observations had been reported in Zimbabwe by Permin *et al*. (2002) who reported that adult chicken had a higher prevalence (66%) than chicks (34%). This could be due to the fact that chicks and growers still lack the knowledge hence roam less distances compared to adults; minimizing their chances of being infected. In this study, both male and female chicken were infected more during the wet

season (87.50% and 75.0%, respectively) than dry season (58.33% and 50.00%, respectively). These parasitic variations could not be explained and need further study. Season and sex did not affect the occurrence of *R. echinobothrida*.

Raillietina tetragona was isolated in the small intestine and caecum. It had a high prevalence of 54.17% and 41.67% in wet and dry seasons, respectively. In contrast, a study conducted by Kaingu *et al.* (2010) reported a lower prevalence of 13.24% of 710 chicken examined. This variation could be caused by different climatic factors. *Raillietina tetragona* are less pathogenic and they cause reduced weight gain.

Coccidial oocysts are common among deep litter system and free range chicken and may lead to high mortality rates (Mc Douglas, 1998). In the present study, coccidial oocysts were only reported in the wet season with a low rate of 16.67%. This is in agreement with previous findings in Kenya (Mungube *et al*., 2008) who also found coccidial oocysts more in the wet season. They, however, reported a higher prevalence of 28.9%. Also, in this study, coccidial oocysts were only reported in adult chicken; this is contrary to the previous findings in Zimbabwe (Permin *et al.*, 2002) where both adults (18%) and young chickens (47%) had coccidia. A study conducted in Kenya by Kaingu *et al.* (2010) reported coccidial oocysts at prevalence of 25.63%. The reason why coccidial oocysts were found in the wet season is due to conducive weather conditions that favour their survival. Coccidia are known to cause drop in egg production and weight loss (Taylor *et al*., 2007).

Haemoparasites were recorded at a rate of 70.83% in both seasons. Four haemoparasite species were identified, namely *Plasmodium gallinaceum*, *Leucocytozoon schoutedeni*, *Aegyptinella pullorum* and *Eperythrozoon* species. Survey on indigenous chicken in Ghana (Poulsen *et al*., 2000) showed the presence of *Aegyptinella pullorum*, *Leucocytozoon* species, *Plasmodium gallinaceum* and *P. juxtanucleare*. The difference is most likely connected to variations in appearance of vectors. During the wet season more chicken (79.17%) were infected with haemoparasites than during the dry season (62.50%). This agrees with previous findings in Malawi (Njunga, 2003) and in Kenya (Sabuni *et al*., 2011) where prevalences of 71.03% and 79.2%, respectively were recorded. All ages and sexes of chicken were infected with haemoparasites in both seasons. There was no difference in occurrence of haemoparasites in the two seasons, between the sexes and among the age groups. This could have been due to presence of vectors of the haemoparasites during both the wet and dry seasons.

Plasmodium gallinaceum was the most prevalent haemoparasite in both seasons with a prevalence rate of 79.16%. This was slightly higher than 53.7% reported by Sabuni *et al*. (2011) and 14.9% reported by Permin *et al.* (2002). The prevalence of *P. gallinaceum* was higher during the wet season compared to the dry season. This can be attributed to the fact that mosquito vectors are usually more prevalent during the wet season compared to the dry season. All ages were affected by *P. gallinaceum* during the two seasons. There was a significant difference in occurrence of *Plasmodium gallinaceum* between the sexes. Females were infected more in wet season compared to the males which were infected more in the dry season. This variation needs further investigation. *Plasmodium gallinaceum* is highly pathogenic to chicken causing anaemia

and paralysis when the number of parasites in blood capillaries is high. Infections can also result in high mortalities in the chickens (Soulsby, 1982).

Leucocytozoon schoutedeni had a prevalence of 18.75% in both seasons. This was lower than previous reports in Tanzania (Fallis *et al.*, 1973) and Kenya (Sabuni *et al*., 2011), giving prevalence rates of 50% of 150 chicken and 52.1% of 144 chicken examined, respectively. This could have been accounted by different climatic conditions and localities. *Leucocytozoon schoutedeni* causes anaemia in chicken (Permin and Hansen, 1998).

This study records *Aegyptinella pullorum* in chicken in Kenya for the first time although it has been reported previously in ducks (Mavuti, 2010). The parasite occurred at a rate of 8.33% during both the dry and wet seasons. These results are in agreement with previous findings in Zimbabwe where a rate of 7 and 6% for adults and young chickens was recorded (Permin *et al*., 2002). *Aegyptinella pullorum* is transmitted by soft ticks mainly *Argus persicus* which hides in the chicken house and attacks the birds mainly during the night (Soulsby, 1982). Results from the current study indicated that there was no statistically significant difference in the occurrence of *Aegyptinella pullorum* between wet and dry seasons. *Aegyptinella pullorum* causes anaemia, diarrhoea and fever in affected birds (Levine, 1985).

This study also records the occurrence of *Eperythrozoon* species in chicken in Kenya for the first time. The parasite occurred at a rate of 10.42%, which is slightly higher than that previously reported in ducks in Kenya (3.35%) by Mavuti (2010). There was no difference in occurrence of *Eperythrozoon* species between the dry and wet seasons.

5.1.3 Effectiveness of selected anthelmintics

Results of this study indicated that the chicken were infected with caecal worms and the cestodes *Raillietina tetragona* and *Raillietina echinobothrida*. Piperazine citrate at 3 mg/kg body weight was only effective against *Ascaridia galli* and not effective against cestodes and nematodes contrary to the farmers' belief. From oral interview with the farmers in Mbeere, they indicated wide usage of piperazine on their birds; in fact, the farmers seemed to take Ascarex^{R}/Piperazine citrate as the only commercial anthelmintic. This could thus be the reason for not recovering *Ascaridia galli* from the birds – Piperazine citrate could have eliminated them. The fact that Piperazine citrate had no effect on other parasites explains why carriage of the other parasites in the birds was high.

With respect to other parasites, Levamisole HCL at a dose of 25 mg/kg body weight was only effective against the caecal worms; *Heterakis* species, *Heterakis isolonche* and *Subulura brumpti*. It had no effect on tapeworms and *Tetrameres americana*. Other studies in Sudan (Thienpoint *et al*., 1966), found that Levamisole HCL did not have any anthelmintic efficacy against tapeworms. Most of the farmers in the area are not familiar with levamisole HCL which is commercially available and did not therefore use the drug. Levamisole HCL poultry formulation in liquid form is commercially readily available in Kenya.

Albendazole at 20 mg/kg body weight was 100% effective against *Heterakis* species, *Subulura brumpti, Tetrameres americana, Raillietina tetragona* and *Raillietina echinobothrida.* Other studies in Arkansas, United States (Tucker *et al*., 2007) reported that Albendazole at 20 mg/kg body weight was effective against *Ascaridia galli, Capillaria obsignata, Heterakis gallinarum*

and *Raillietina cesticillus* but they did not report on *Subulura brumpti, Tetrameres* and the two species of tapeworms reported in this study. Albendazole was also effective in deworming chicken infected with *R. cesticillus* (96.2% reduction) and caused no adverse effects (Tucker *et al*., 2007). A similar study in Sudan (Saeed, 2007) showed that albendazole administered at 25 mg/kg body weight was 100% effective against experimental *Raillietina tetragona* infection in chicken. This is the first experiment of this kind to be done on chicken and reported in Mbeere District, Kenya. 5% Albendazole powder form for poultry is readily available in China but not in Kenya. Most pharmaceutical companies in Kenya are challenged by high cost of production of the drug.

In this study, no results are given, with respect to effectiveness of Levamisole and Albendazole on ascarids, because the experimental chicken did not have the parasites.

5.2 CONCLUSIONS

1. The most commonly used commercial drug against ectoparasites and endoparasites was cabaryl (Sevin^{R}) and piperazine citrate (Ascarex^{R}).
2. Ecto- and endo-parasites were found to be common in the study area with high prevalences of 97.9% and 100%, respectively in the wet and dry season. There was no difference in occurrence of ecto- and endo-parasites between the two seasons.
3. Albendazole at 20mg/kg body weight was found to be the most effective anthelmintic against cestodes (*Raillietina echinobothrida* and *Raillietina tetragona*) and nematodes (caecal worms and *Tetrameres americana*).

5.3 RECOMMENDATIONS

1. There is need for vigorous control measures for both ecto- and endo-parasites in chicken in the study area. Farmers should practice good hygienic practices; separate chicken houses based on age groups and construct houses having no cracks and crevices.
2. The use of albendazole is recommended to ensure total control of worms, but there is need to prepare a formulation of the drug that is suitable for application in poultry.
3. Farmers should be encouraged to use other permethrins in addition to Cabaryl to control fleas, lice and mites.

CHAPTER SIX

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7.0 APPENDICES

Appendix 1: **Questionnaire on chicken production in Mbeere District**

No..... Date of interview..... Name of interviewer.....

A) BACKGROUND INFORMATION

1. Name of the homestead ……..……..

2. Location.....Sub- location.....Village.....

3. Number of chicken owners in the homestead: (1) male (….), (2) female (….)

4. Name of person interviewed (respondent).....Sex 1=male 0=female

5. Respondent's age group: (1) up to 30 years (2) >30 – 60 years (3) over 60 years

6. Occupation of the respondent: (1) farmer, (2) trader, (3) employee, (4) others (specify)……...

7. What is the relationship of respondent to the household head? (1) self (2) spouse (3) son (4) daughter (5) employee (6) relative, specify ----------

8. Poultry kept in the homestead?

Poultry	Number	Reason for raising (1-7)
1. Chicken		
2. Ducks		
3. Pigeon		
4. Guinea fowls		
5. Turkeys		

Key: 1=family food, 2=selling to earn money, 3=for manure, 4=for ceremonies, 5=as wealth 6=social culture, 7=others

9. Which other animals are kept in the homestead (indicate numbers)...

10. Which crops do you grow?

.....

B) MANAGEMENT OF POULTRY

11. What type of birds do you keep? (a) Local breeds (b) Cross breeds

12. What type of management system do you practice? (a) Free-range system (b) backyard system

13. Who does the day to day management of the animals? (1) husband (2) wife (3) children (4) employee (5) others, specify ----------

14. Where do you source your chicken stock? (1) purchase (2) gift (3) inheritance (4) others…….

15. Number of chicken kept. (1) adult male…… (2) adult female…….. (3) growers…….. (4) chicks……

16. Do you house your birds at night? (a) Yes (b) No

If Yes what type of house do you use to keep your birds? (a) mud-walled (b) grass thatched (c) stone house (d) wooden house (e) others.....

17. How are the birds housed? (a) all of them together (b) adults different from growers and chicks (c) different birds at different areas.

18. Do the birds have laying nests? (1) Yes (2) No

19. (i) Do you confine your birds? (1) Yes (2) No

(ii) What is the reasons confinement……

(iii) When do you confine your birds? (1) planting season (2) harvesting season (3) wet season (4) dry season (3) others……..

20. (i) Do you give feed supplement to your chicken? (1) Yes (2) No

(ii) What type of feeds do you supplement with? (1) commercial chicken feeds (2) kitchen leftovers (3) cereal grains (4) bran (5) others……

21. Rank the problems you face in poultry keeping

i. diseases ……..…..

ii. predation ……

iii. accidents

iv. lack of feed

v. lack of water

vi. lack of market

vii. lack of medication/vaccines

viii. parasites

ix. others, specify ----

22. What diseases do you commonly encounter? (Rank them)

i. ……

ii. ……..…….

iii. ……..…….

……

C) PARASITES AND THEIR CONTROL

25. What parasites do you commonly encounter?

(a) worms (b) ticks (c) lice (d) fleas (e) mites (d) others.....

26. Which age groups are commonly affected by parasites? (a) chicks

(b) growers (c) adults (d) mixture of all ages

27. How do you know that your birds are infested /infected with parasites?

(a) pale combs (b) scratching (c) emaciation (d) scales on the legs (d) presence of fleas, ticks on the skin (e) worm in faeces (f) decreased egg production (g) reduced growth/light weight (h) others.....

28. Which months of the year are there many parasites?

(a) January to March (b) April to June (c) July to September (d) October to December

29. Do you deworm your birds? (a) Yes (b) No

30. If yes, what types of medicine do you use? .....

31. Do you control ectoparasites? (a) Yes (b) No

32. If yes, what types of medicine do you use? .....

33. Who treats /deworms your birds? (a) owner (b) vet doctor (c) animal health assistant

(d) other.....

34. Do you use herbal medicine to control parasites? (a) Yes (b) No

35. If yes, which ones and for which parasites?.....

.....

36. How is the medicine administered to the chickens?.....

…….....

37. Other than medicine do you use any of the following methods to control parasites?

(a) Plastering walls of chicken houses with mud, cement, ash, lime, dung

(b) Improved hygiene

(c) Paraffin, old oil, Vaseline

(d) Others (i).....

(ii).....

(iii).....

38. How often do you deworm your birds? (a) Every 3 months (b) yearly (c) >1 year

Appendix 2: Means of helminth by treatment group

Treatment	***Heterakis* species**	***H. Isolonche***	***S. brumpti***	***Tetrameres americana***	***R. tetragona***	***R. echinobothrida***
Control						
N	9	9	9	9	9	9
Mean±SD	52±72.45	7.22±8.77	8.67±11.28	1.89±11.28	2.11±2.26	2.78±2.82
Geometric mean	18.77	0.00	0.00	0.00	0.00	0.00
Levamisole						
N	7	7	7	7	7	7
Mean±SD	0.00±0.0	0.00±0.00	0.00±0.00	0.57±0.98	1.57±1.27	2.29±1.60
Geometric mean	0.00	0.00	0.00	0.37	0.48	0.61
Piperazine Citrate						
N	7	7	7	7	7	7
Mean±SD	21±19.10	3±2.94	3.86±5.05	2.86±3.08	1.86±1.35	1.86±1.46
Geometric mean	16.61	0.00	0.00	0.00	0.00	0.00

Continuation of appendix 2						
Albendazole N Mean±SD Geometric mean	7 0.00±0.00 0.00	7 0.00±0.00 0.00	7 0.00±0.00 0.00	7 0.00±0.00 0.00	7 0.00±0.00 0.00	7 0.00±0.00 0.00
Total N Mean±SD Geometric mean	30 20.50±45.10 0.00	30 2.87±2.87 0.00	30 3.50±7.39 0.00	30 1.20±2.09 0.00	30 1.43±1.68 0.00	30 1.80±2.07 0.00

Key: *H. isolonche- Heterakis isolonche, S. brumpti- Subulura brumpti, R. tetragona- Raillietina tetragona, R. echinobothrida- Raillietina echinobothrida*

Appendix 3: Mann-Whitney U (Wilcoxon rank-sum) test

Variables	**Season**	
	Value of U	**P-value (adjusted for ties)**
Lice (Overall)	**228.0**	**0.04***
Menacanthus stramineus	240.0	0.0188*
Menopon gallinae	180.0	0.011*
Liperus caponis	276.0	1.000 (ns)
Gonoides gigas	276.0	1.000 (ns)
Fleas (*Echidnophaga gallinacea*)	216.0	0.148 (ns)
Ticks (*Argas persicus*)	240.0	0.359 (ns)
Dermanyssus gallinae	240.0	0.385 (ns)
Caecal worms (**Overall**)	**264.0**	**0.609 (ns)**
Heterakis species	252.0	0.348 (ns)
Subulura brumpti	264.0	0.752 (ns)
Heterakis isolonche	228.0	0.227 (ns)
Tetrameres americana	252.0	0.564 (ns)

Continuation of Appendix 3

Variables	**Season** **Value of U**	 **P-value (adjusted for ties)**
Tapeworms (Overall)	**264.0**	**0.701 (ns)**
Raillietina echinobothrida	216.0	0.125 (ns)
Raillietina tetragona	216.0	0.148 (ns)
Choanotaenia infundibulum	276.0	1.000 (ns)
Hymenolepis cantaniana	276.0	1.000 (ns)
Gongylonema ingluvicola	240.0	0.286 (ns)

Key, * statistically significant ($p<0.05$)

ns – Not significant ($p>0.05$)

Appendix 4: Kruskal Wallis one way ANOVA tables of various haemoparasites among age groups

Variables	**Age groups**	
	H-value (adjusted)	P-value
Haemoparasites	**0.7899**	**0.674 (ns)**
Plasmodium gallinaceum	0.7899	0.674 (ns)
Leucocytozoon schoutedeni	3.214	0.201 (ns)
Eperythrozoon	1.749	0.417 (ns)
Aegyptinella pullorum	2.136	0.344 (ns)

Key: ns- Not significant (p>0.05)