

**THE EPIDEMIOLOGY AND CONTROL OF SCHISTOSOMIASIS AND SOIL  
TRANSMITTED HELMINTHES IN TWO COMMUNITIES WITHIN THE  
MWEA IRRIGATION SCHEME IN CENTRAL KENYA. /**

**BY**

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**A THESIS SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIRMENTS  
FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN  
APPLIED PARASITOLOGY.**

**SCHOOL OF BIOLOGICAL SCIENCE  
UNIVERSITY OF NAIROBI**

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## DECLARATION

I hereby declare that this is my original work and has not been presented for a degree in any other University.

Signed.......... Date..26<sup>th</sup> March 2009.....

Kingori Isabell Wairimu

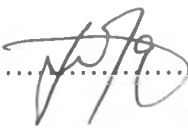
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**DEDICATION**

To

My Family and friends

For the love and encouragement you gave me.

## ACKNOWLEDGEMENT

I would like to pass my sincere gratitude to all those who in one way or another helped make my research study a success.

Special thanks go to my supervisors Dr. W.T. Mutahi and Dr. E. Mathenge, to whom I am greatly indebted for their dedication and constant encouragement, without which completion of this research would not have been possible. Equally I would like to sincerely extend my heartfelt gratitude to the Kenya Medical Research Institute and the Kimbimbi Sub-district hospital, Division of Vector Borne Diseases (DVBD), administrative, technical and scientific staff for their support.

Special thanks go to Dr. Charles Mwandawiro, who ensured that all the requirements for my study were met.

To Beatrice Mucheru I am particularly grateful for her assistance in data analysis.

The debt I owe my Family and in Particular my parents are immeasurable. I deeply express my sincere thanks to my mother and father, Mr. and Mrs. Kingori for their confidence and support, their encouragement, moral and Financial Support.

May God bless them richly.

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## ABBREVIATIONS

<b>STH</b>	Soil Transmitted Helminthes
<b>WHO</b>	World Health Organization
<b>SEA</b>	Soluble Egg Antigen
<b>EPG</b>	Eggs per Gram
<b>TPE</b>	Tropical Pulmonary Eosinophilia
<b>WHA</b>	World Health Assembly
<b>HIA</b>	Health Impact Assessment
<b>AIDS</b>	Acquired Immune Deficiency Syndrome
<b>HIV</b>	Human Immune Virus
<b>ESACIPAC</b>	Eastern and Southern Africa center for International Parasite control
<b>KARI</b>	Kenya Agricultural Research Institute
<b>SPSS</b>	Statistical Package for Social Science
<b>ID</b>	Identification Number
<b>DVBD</b>	Division of Vector Borne Diseases
<b>DBL</b>	Danish Bilharziasis Laboratory

## ABSTRACT

Evidence from recent literature indicates that schistosomiasis remains a major public health problem in developing countries even in the 21<sup>st</sup> century. *Schistosoma mansoni* can infect all members of a population but the most vulnerable group with the highest rate of infections is found in children between the ages of 5 and 15 years. Praziquantel is currently the drug of choice for the treatment of all schistosome species occurring in man. The main objective of this study was to investigate the infection and reinfection pattern of Schistosomiasis in school going children after 3 years of therapeutic intervention with praziquantel.

Four parasitological surveys were carried out in two primary schools in Mwea, an irrigation scheme region in central Kenya after 3 years of mass chemotherapy. Two thousand one hundred and eight pupils aged between five and twenty four years were examined for *Schistosoma mansoni* infection by Kato thick smear technique.

A total of 100 homesteads were sampled on the aspects of risk factors that were believed to play a role in the transmission of schistosomiasis and Soil Transmitted Helminthes (STH). Malacological surveys were also conducted to evaluate the temporal variation in both vector and cercarial densities. The study involved parasitological surveys in two communities with different geographical settings. The study showed that prevalence of infection was 22.7 and 31.1 before treatment, and 6.99 and 8.73 after treatment in Mianya and Mukou respectively. Malacological surveys revealed the presence of 3 species of freshwater snails, namely *Biomphalaria pfeifferi*, *Physca acuta*, and *Bulinus globossus*. The risk factor survey provided qualitative and quantitative data on hygiene and sanitation, water contact and the shoe wearing practice.

One of the schools is placed in the Mwea Township (Mukou) while the other is placed in the village (Mianya), yet there was no major difference in the transmission, reinfection or water contact patterns. Though the prevalence of soil transmitted helminthes is quite low, intestinal Schistosomiasis is still prevalent among the primary school children in the irrigation scheme even after 3 years of mass chemotherapy. Infection and reinfection of schistosomiasis among the school children has therefore been observed even after treatment with praziquantel and the study recommends among other measures non selective mass chemotherapy in the study area.

## CHAPTER ONE

### 1.0 GENERAL INTRODUCTION AND LITERATURE REVIEW

#### 1.1 GENERAL INTRODUCTION

##### 1.1.1 Introduction

Parasitic infections are responsible for extensive morbidity and mortality in Sub-Saharan Africa. It is estimated that worldwide, more than 200 million persons are infected with schistosomes with 85% of the cases occurring in Africa, and more than 1.5 billion are affected with Soil Transmitted Helminthes, (STH) (WHO 1993). The burden of disease due to Schistosomiasis in Africa has been estimated as seventy million individuals having haematuria associated with *Schistosoma haematobium* infection and 18 and 10 million respectively suffering major bladder wall pathology and hydronephrosis (Van der Werf *et al.*, 2003). *Schistosoma haematobium* related mortality due to non-functioning kidney and portal hypertension due to *Schistosoma mansoni* are estimated to be respectively 150 and 130 thousand per year (Van Der Werf *et al.*, 2003). The burden of disease associated with schistosomiasis and soil transmitted helminthic infections is overwhelming. It is estimated that more than 2 billion people are currently infected worldwide. Of these, some 300million suffer severe and permanent impairments as a result (WHO 2005). The health impact due to helminthes is being increasingly recognized as a significant public health problem, particularly in the developing world. Schistosomiasis and soil transmitted helminthes are most common among the poorest of communities, where poverty, poor nutrition, inadequate sanitation, lack of clean drinking-water and minimal health care prevail. Schistosomiasis and STH can infect all members of a population but the most vulnerable group and the highest rate of infections are often in children between the ages of 5 and 15 years. Although not normally fatal, worm infections can cause permanent organ damage, anemia, poor physical growth, poor intellectual development, and impaired cognitive function.

In Kenya, reports of Schistosomiasis occurrence are sporadic and at times contradictory (Jordan, 1985) while control interventions are short lived. The major endemic areas for intestinal Schistosomiasis are central Kenya and the Lake Victoria region (Doumenge *et*

*al.*, 1987). In Mwea region Schistosomiasis transmission was recorded soon after the irrigation scheme was initiated in the 1950s. This area borders Machakos, another endemic area in central Kenya where irrigation is not practiced. Constructions of river impoundments for irrigation and/or hydroelectric power generation in tropical and subtropical regions have often led to dramatic increases in the transmission of Schistosomiasis (Brinkmann *et al.*, 1988). However no comparative studies on impact of irrigation on the transmission of the disease have been carried out in Kenya. A study carried out in Mwea to determine the current status of intestinal Schistosomiasis among children attending schools located in irrigation and non-irrigation areas of Kirinyaga and Machakos district respectively, showed that high prevalences ranging from 73% to 94% were noted among the children in all the participating schools. 41% of the infected children had heavy infection (>400 eggs per gram), 27% had moderate infection (101-400 eggs per gram) and 32% had light infections (10-100eggs per gram) (Mutahi and Thiongo 2005). The situation in Mwea scheme is likely to worsen with the expansion of areas under rice cultivation. There has also been an upsurge of small-scale rice growing along river valleys and streams in the neighborhood of the scheme, increasing the risk of spreading the infection to new areas (Mutahi and Thiongo, 2005).

### **1.1.2 Schistosomiasis**

The term human Schistosomiasis can be said to indicate a complex of acute and chronic parasitic infections caused by mammalian blood flukes (*Schistosoma*). The infections are transmitted by specific aquatic or amphibious snails which occur in a wide variety of freshwater habitats.

*S.mansoni* infection is estimated to occur in 53 countries ranging from the Arabian peninsula, numerous countries in the African continent, particularly the Nile valley neighbors, Sudan and Egypt, to the New world: Countries such as Brazil, Surinam, Venezuela and seven islands in the Caribbean (Doumenge *et al.*, 1987).

There are two types of schistosomiasis, the urinary type, caused by *Schistosoma haematobium* and the intestinal type, caused by *Schistosoma mansoni*. Schistosomes are small parasitic worms (flukes) that live in blood vessels around the bladder (urinary type) or intestine (intestinal type).

### 1.1.2.1 Life cycle of Schistosomiasis

The life cycles of all species of schistosome infecting man are similar, with a pathway from a sexual generation of adult worms within the vascular system of the definitive host (humans), an asexual phase in the freshwater snail host and a return to the man through cercarial invasion of the skin or mucosa once a host's body is exposed to cercarial infested fresh water.

In the human host, adult schistosomes live as pairs within capillary blood vessels, with the slender filiform female being held in the gynaecophoric canal of the male. Copulation takes place and the females produce eggs daily through out their life. Eggs are laid intravascularly toward the peripheral branches of the capillary venules. Some eggs pass through the vessel wall, aided by their spine and cytolytic secretions, into the lumen of the genitourinary tract (*S. haematobium*) or the bowel (*S. mansoni*) and reach the external world in the excreta (urine and/or faeces). Other eggs embolize from their intravascular origin to liver, lung and many other sites.

Viable schistosome eggs are excreted and reach fresh water, this can be either by direct deposition or by being washed in from neighboring site. In a conducive environment of warmth and light, the larvum within each egg becomes active and, aided by osmosis, the egg ruptures or 'hatches' and the larvum, now called a miracidium emerges.

Miracidia are infective to snail intermediate hosts for some 8-12 hours, and must find a suitable fresh water snail for continuance of the cycle.

The miracidia then penetrate the soft tissue of the snail, under the influence of numerous variables, including chemotaxis, relative numbers of larvae and snails within a water body, length of contact time and physical characteristics of the surrounding medium, i.e. water temperature, velocity of flow, turbulence and presence of ultraviolet light.

Normally its only one or two miracidia that undergo further intramolluscan development, producing a sacculate mother sporocyst which in turn produces daughter sporocysts. This is followed by migration to the digestive gland of the snail and thereafter cercarial development.

After an incubation period within the snail, cercariae escape from the daughter sporocyst and emerge from the snail under suitable conditions of temperature, light and pH.

Free swimming fork-tailed cercariae, about 1mm in length, penetrate human skin or mucosa when man comes into contact with infested water and, after passage through the tissues as schistosomula, will develop into a male or female schistosome.

After the schistosomula have migrated to the portal vascular system, further growth occurs in the intrahepatic vessels. Male and female schistosomes pair on sexual maturity, and then migrate to the preferred sites of egg deposition: *S. mansoni* and *S. intercalatum* in the distribution of the inferior mesenteric veins; *S. japonicum* and *S. mekongi* in the distribution of the superior and inferior mesenteric veins; and *S. haematobium* in the distribution of the vesical veins and the pelvic plexus. Egg deposition begins and the cycle is complete. Figure 1 below shows a simple life cycle of Schistosomiasis.

Water Transmission  
Worms (Bilharzia)

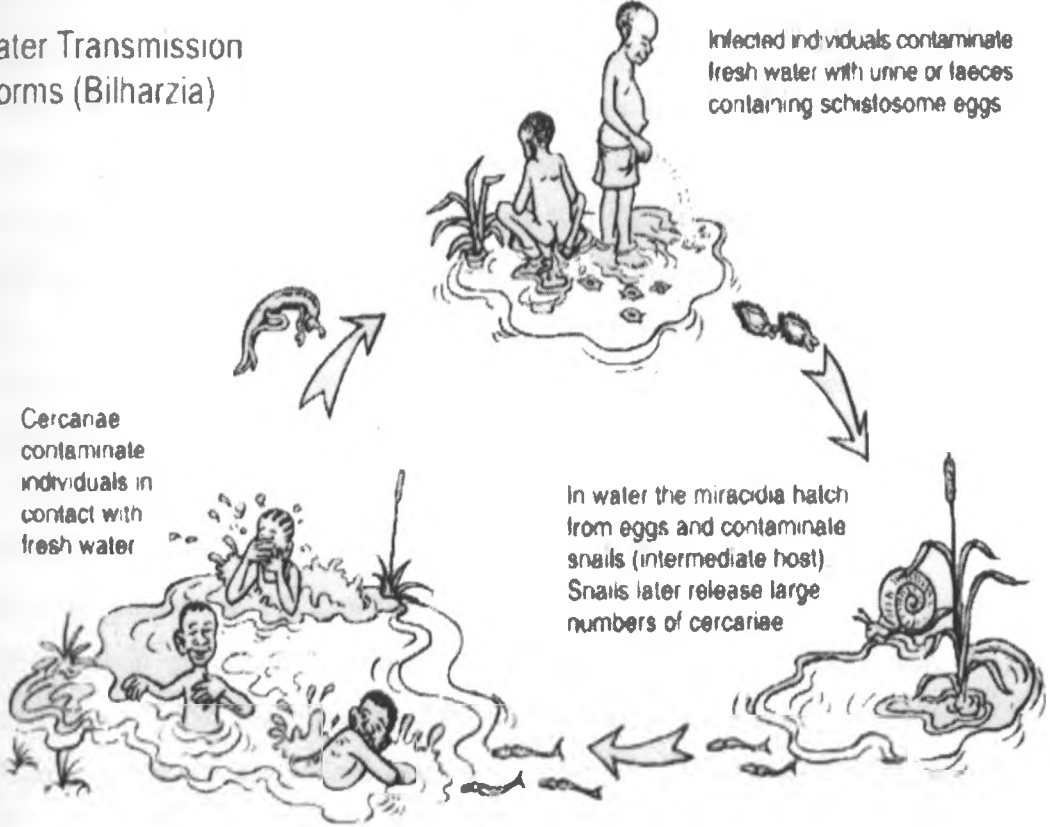


Figure 1: Life Cycle of Schistosomiasis (According to WHO.02.146).



### 1.1.2.2 Pathology of Schistosomiasis

The morbidity due to infection with Schistosomes comes not from the adult worms themselves but from the eggs. Just about half the eggs produced by the adult worms leave the body in the faeces (intestinal type) or urine (urinary type). The rest of the eggs stay in the body where they may lodge in blood vessels causing inflammation, obstruction and damage. Chronic, repeated infection can lead to damage of the liver, intestines, lungs, kidneys, bladder and other organs. The pathology of Schistosomiasis results from collections of granulomas from fibroblastic lesions obstructing vessels and fibroinflammatory swellings containing millions of eggs (Von Lichtenberg, 1987). Schistosomiasis infection causes hepatomegally, splenomegally female genital Schistosomiasis, male genital Schistosomiasis which further leads to abortion and sterility, among others (Wright et al 1982 and Chen et al 1989). Schistosomiasis can contribute to anaemia and in some areas urinary Schistosomiasis is also associated with a high rate of cancer of the bladder. In children, chronic infection can also lead to growth retardation, absence from school and decreased school performance (WHO 2002).

Disease syndromes and symptoms associated with Schistosomiasis are related to the stage of infection, previous host exposure, worm burden, and host response. These include cercarial dermatitis when actual cercarial penetration has occurred, acute Schistosomiasis (katayama fever), and related tissue changes resulting from egg deposition (Chen M G et al, 1988).

### 1.1.2.3 Diagnosis and Treatment

Direct saline microscopy of stool has rather low diagnostic sensitivity due to the small size of the fecal specimen examined. Today, the cellophane thick smear, the Kato technique or one of its numerous modifications (Komiya and Kobayashi, 1966; Katz *et al.*, 1972) has become a standard diagnostic tool in both clinical and epidemiological studies.

Antischistosomal drugs can be divided into two categories, the one drug that is effective against all species of schistosome infecting man, Praziquantel and the two monospecific drugs effective against only one species of schistosome, i.e. oxamniquine which is effective only against *S. mansoni*, and metrifonate, effective only against *S. haematobium*

infections. Although metrifonate is known to have some activity against *S. japonicum* and *S. mansoni*, it is not used in their treatment and conventionally is termed a nonspecific antischistosomal drug.

These three Antischistosomal compounds are on the WHO list of essential drugs and much experience has been accumulated in their large-scale use in recent years. The older drugs, e.g. antimonials, niridazole, hycanzone, are not of much common use today because of their adverse side effects.

### **Praziquantel**

Praziquantel is the drug of choice for all forms of Schistosomiasis occurring in man. It is also effective in the treatment of most trematode infections, clonorchiasis, paragonimiasis and opisthorchiasis, and in infections due to the adult cestodes, *Taenia solium*, *T. saginata*, *Hymenolopsis nana* (Leo *et al.*, 1997).

Praziquantel is available as a 600mg tablet, biltricide (Bayer AG) for patients with light infections. For treatment of individual patients with heavy infections by *S. mansoni* (over 800 eggs per gram of stool) a total dose of 50 or 60 mg/kg, given in two equal doses of 4-6 hours apart, can be given. Single doses are best given after food and, if possible in the evening. (Chidiac *et al.*, 1986)

Patient tolerance is good and most trials have confirmed the absence of toxicity in the liver, kidney, haemopoietic or other body organs and functions. But minor side effects do occur, such as abdominal discomfort, vomiting, anorexia, and loose stool. The Cure rates for schistosomiasis are high; it can be expected that with the appropriate dose they will be around 80% (Duong *et al.*, 1988).

### **Metrifonate**

Metrifonate is an organophosphorus compound used in the treatment of *S. haematobium* infection. It also has some activity against *S. mansoni*, *S. japonicum*, various intestinal nematodes onchocerciasis and both dermal and cerebral cysticercosis but is never normally given in the treatment of these parasitic infections in man. The sole indication is in the treatment of *S. haematobium* infection. A standard dose of 7.5 or 10.0 mg/kg body weight is given in three oral doses at an interval of 14 days. (Davis & Bailey., 1969)

## Oxamniquine

A tetrahydroquinoline compound distantly related to hycanthone, oxamniquine is effective against *S.mansoni*. In animal models it was found inactive against *S. japonicum* and early trials in man showed virtually no activity against *S.haematobium* or *S. mattheei* (Foster & Cheetham 1973).

### 1.1.3 Soil-Transmitted Helminthes (Geohelminths)

These are intestinal nematodes, of which part of their development takes place outside the body in the soil. Soil transmitted nematodes are of particular importance in the health of many populations in developing countries whereby the frequency of infection can be used as a general indication of the local level development of hygiene and sanitation. Figure 2 below shows a simple life cycle diagram of soil transmitted helminthes

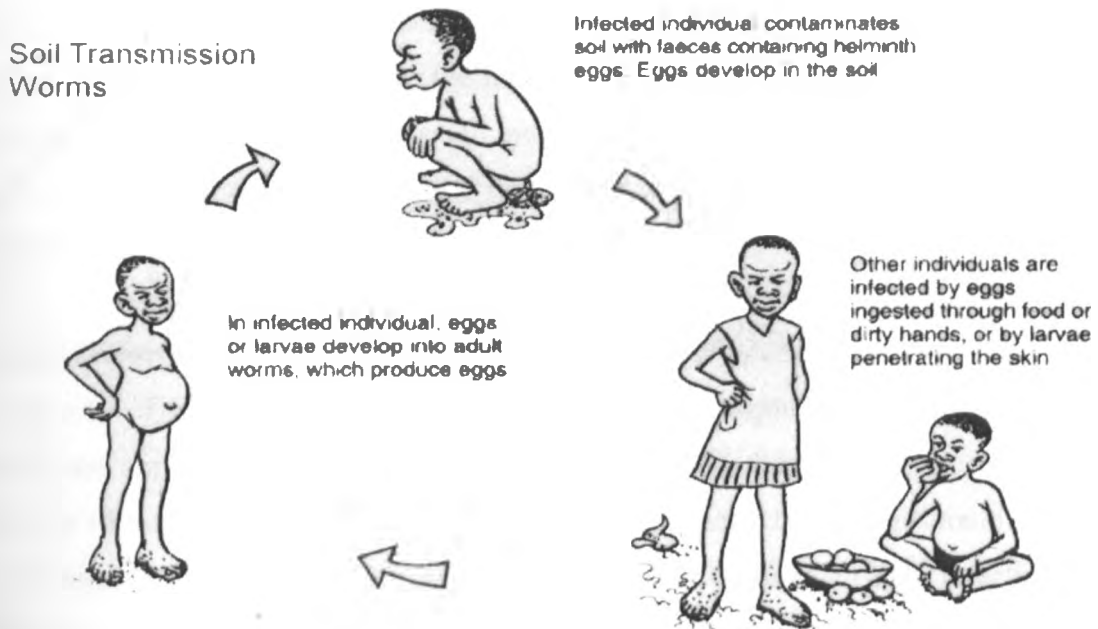


Figure 2: Life cycle of Soil Transmitted Helminthes (According to WHO.02.145).

### 1.1.3.1 Trichuriasis (*Trichuris trichura*) (Whipworm)

*Trichuris trichura* is of worldwide occurrence. It is estimated that 755 million people in the world are infected (Muller, 1975). *Trichuris trichura* is a greyish-white worm, often slightly pink, which lives in the caecum and appendix. The male (30-45 mm long) has an attenuated anterior portion containing a cellular esophagus and a caudal extremity curved through 360° with a single spicule in the sheath which is studded with spines. The female is (30-35mm long) has the posterior half occupied by a stout uterus packed with eggs. The egg (50 x 22 µm) is brown with a single shell and a plug at each end.

#### Life cycle

*T. trichura* worms live in the caecum; here they maintain their position by transfixing a superficial fold of mucosa and lie embedded in the mucus between the intestinal villi. Eggs are laid unsegmented, and embryonation takes at least 21 days. It can withstand low temperatures but not desiccation. Transmission is direct from mature eggs to the mouth via fingers contaminated from infected soil, and infection is direct from faeces. The egg hatches after being swallowed into the intestine, here the shell is digested by intestinal juices and the larva emerges in the small intestine; it penetrates the villi and develops for a week until it re-emerges and passes to the caecum and colorectum. In the colorectum it attaches itself to the mucosa and becomes adult.

#### Clinical features

In majority of infections, which are usually light, the worms live harmlessly in the caecum and appendix but when the infection is heavy (more than 10000 eggs/g of faeces) there can be marked symptoms and signs. The prepatent period from ingestion of eggs to the appearance of the eggs in the stool is approximately 60 days. In light infections are symptomless, but when associated with *Ascaris* or hookworm mild symptoms occur. Epigastric pain, vomiting, distention, flatulence, anorexia and weight loss may occur (Wolfe, 1978).

Pain in the epigastrium is common (Swartzwelder, 1939). When associated with *Entamoeba histolytica*, *Balantidium coli* or shigellosis, symptoms can be marked and dysenteric symptoms occur. Anemia and low and serum albumin are more pronounced in

double infections with *Trichuris* than in amoebic infections alone (Gilman *et al.*, 1976). There is usually no eosinophilia.

### **Diagnosis and Treatment**

Diagnosis is made by finding the characteristic eggs in the stool by direct smear or by concentration methods. An egg count will show the degree of infection and 30,000eggs/g of faeces or more is a heavy infection (Jung and Beaver, 1952) which could indicate the presence of several hundred worms.

Protoscopy in cases of dysentery will show numerous worms attached to the mucosa-which is reddened and ulcerated where they are responsible for the dysentery.

Mebendazole is the drug of choice. A single oral dose of 600 mg will reduce the egg count by over 85% (Callender *et al.*, 1993) and is efficient as the standard dose of 100mg twice daily for 3 days. Albendazole is equally effective at a single dose of 400mg.

#### **1.1.3.2 Ascariasis (*Ascaris lumbricoides*)**

Ascariasis is one of the most common and widespread human worm infections. Possibly one in four of the world's population is infected. It occurs in Asia, Central and South America, Europe, Africa and North America.

In central Asian republics of the former USSR it is common in humid areas. In Central and South America the average rate of infection is 45%, and in parts of Africa 95%.

#### **Life cycle**

*Ascaris lumbricoides* is a comparatively large worm which inhabits the small intestines. Eggs are laid in the small intestine and are passed out as immature ova containing unsegmented or differentiated embryo. An embryo develops in damp soil at temperatures of 36-40<sup>0</sup>C in 2-4 months (at the optimum temperature of 25<sup>0</sup>C in 3 weeks); it lies coiled up in the egg undergoing one molt before being hatched as an infective second stage rhabditiform larva in the small intestine once the egg has been swallowed. Here the rhabditiform larva penetrates the mucous membrane, enters the bloodstream and reaches the lungs via the right heart. It is then carried up the trachea to the larynx, where it moves over the epiglottis and enters the esophagus, and is swallowed a second time to reach the

small intestine. The whole process of migration takes 10-14 days during which the larvae also undergo molting. Larvae may reach the intestines as early as the fifth day. In man the period from infection to the first passage of ova in stool is 60-70 days.

Infection is usually acquired from ingestion of eggs in contaminated soil, usually by children when playing around the house situated by suitable soil.

### **Clinical features**

Most infections are symptomless but heavy infections in childhood do give rise to symptoms. The heavy infections are controlled by immunity, or by diminished exposure, so that adults have much lighter infections than children, but reinfection can also occur throughout life. In larval ascariasis pulmonary symptoms occurs 4-16 days after infection.

Light infections are usually symptomless, though a single adult worm can cause a liver abscess or block the common bile duct. Acute manifestations are roughly proportional to the number of worms harbored and serous disease may be caused when the burden amounts to 100 worms or more.

### **Larval ascariasis**

During the migratory stages the larvae cause a pneumonitis 4-16 days after infection-with fever, cough, sputum and radiological infiltration of the lungs. There is a high eosinophilia and larvae can be found in the sputum or gastric juice-especially if a quantity is collected, digested with trypsin and centrifuged. Seasonal attacks of *Ascaris* pneumonia have occurred in Saudi Arabia following the onset of spring rains and the restarting of transmission (Gelpi and Mustafa, 1967). The pneumonitis is of short duration, about 3 weeks (in contrast to tropical pulmonary eosinophilia (TPE) which lasts for many months).

There may be asthma, which can be so intense as to cause *status asthmaticus*, (Beaver and Danaraj, 1958) and the liver may be affected, becoming enlarged and tender.

On reaching the general circulation larvae may cause symptoms similar to those of *Toxocara canis*. Neurological disorders including convulsions, epilepsy, insomnia and tooth grinding during the night may occur. When the larvae wander into the brain they

cause granulomas-presenting as small tumors in the brain, if the larvae wander to the eyes or other organ they also cause granulomas in the eyes or in any other organ presenting as tumors.

### **Adult ascariasis**

The major manifestation of adult ascariasis is small bowel obstruction, which usually occurs in children, and as many as 1000 worms have been removed from one patient. Gastrointestinal discomfort, colic and vomiting are quite common. Ascariasis is the most common cause of abdominal surgical emergency in children in South Africa and Rangoon (Loue J.H., 1966; Thein-Hlaing., 1985).

Adult worms tend to migrate when their environment is disturbed. In the presence of tetrachlorethylene, anesthetics or fever they migrate and wander into the bile ducts, ampulla of Vater, appendix, perineal sinuses and Eustachian tubes. They can cause volvulus and gangrene of the bowel, intestinal perforation and peritonitis, acute pancreatitis, suppurative cholangitis, liver abscess, acute cholecystitis and obstructive jaundice.

### **Diagnosis**

A diagnosis can be made from passage of worms in stool or by finding characteristic eggs in faeces.

Fertile eggs are oval and measure about 60x45  $\mu\text{m}$ . The shell is transparent, is surrounded by an outer mamillated shell stained by bile pigments and contains an unsegmented embryo.

Unfertile eggs are longer and narrower (90x40  $\mu\text{m}$ ), have a thinner shell, more irregular outer covering and are found in about two-thirds of infections, due either to a shortage or absence of males. In male only infections, there are no eggs passed in the stool.

## **Treatment**

Treatment is effective only against the adult worms. Although the vast majority of *Ascaris* infections cause few, if any, symptoms it is easy to treat it and it is wise to treat any established infection. The drugs of choice are as follows:

Albendazole: for children 2-5 years a single dose of 200mg; for older children and adults, one dose of 400mg is given. Mebendazole: 100mg twice daily for one day only. Levamisole: a single dose of 5 mg/kg body weight. Pyrantel pamoate: a single dose of 10 mg/kg body weight. They are best given between meals, without any special diet, fast, or use of purgatives before or after therapy.

### **1.1.3.3 Ancylostomiasis (hookworm)**

Hookworm disease (ancylostomiasis) is caused by two hookworms *Ancylostoma duodenale* and *Necator americanus* and is a very common infection. In many cases the nematodes, which are often present in huge numbers are found attached to the small intestine, where they suck blood and protein, causing disease (hookworm anemia, hookworm disease)

### **Geographic distribution**

The hookworm occurs in all tropical and subtropical countries. (Faust *et al.*, 1964)

*A. duodenale* is essentially a parasite of southern Europe, the north coast of Africa, northern India, north China and Japan.

*N. americanus* is predominant in western, central and southern Africa, southern Asia, Melanesia and Polynesia. It is widely distributed in the Southern USA, the islands of the Caribbean, Central America and northern South America where it's believed to have been introduced by slaves from Africa.

### **Morphological features**

*A. duodenale* is a small cylindrical white, grey or reddish-brown (from ingested blood) thread-like worm. Both male and female worms have a buccal capsule containing two pairs of teeth for attaching to the small intestinal mucosa.

*N. americanus* closely resembles *A. duodenale* but it is shorter and more slender.



### **Life cycle**

The eggs are deposited into the lumen of the intestine. The eggs contain two, four or eight blastomeres and are passed out in the faeces where, if deposited in damp shaded soil they hatch into *rhabditiform* (first stage) larvae. The first stage larvae are free living and have a bulbed esophagus. They feed on bacteria. The larva molts between the third and the fifth day, at optimum temperatures of 20-30°C. It then moves away from the faeces into the soil and molts again to form a filariform (infective) larva. The larva has a simple muscular esophagus and a protective sheath. The larva moves towards oxygen and cannot survive in water. The larvae are mostly found in the upper 2.5 cm of the soil but can ascend from deeper layers. Protected from desiccation they can live in warm damp soil for 2 years. When filariform larva comes into contact with the skin of the host it penetrates through and enters the bloodstream, reaching the lungs on the third day. The larva breaks through the alveoli, enters the bronchioles and moves up the trachea. It is swallowed through the esophagus to the stomach and small intestine. During this migration the third molt takes place and the buccal capsule is formed. It arrives in the intestine on the seventh day and a fourth molt to adult worm takes place. The worm attaches to the mucosa of the small intestine, where it continues to suck blood. Worms become sexually mature in 3-5 weeks and the female starts to produce eggs. Adult worms live from 1-9 years and produce 30,000 eggs per day (Necator 9000 eggs daily).

### **Clinical features**

After the adult worms have established themselves in the intestines the female starts to lay eggs. The number of eggs passed bears a direct relation to the number of female worms. The higher the worm load the greater the blood loss so that where iron intake is satisfactory then up to 100 worms may cause no symptoms. With worm loads of 500-1000 then significant blood loss and anemia will result, even in the presence of an adequate iron intake.

In larval ancylostomiasis symptoms appear 1-2 weeks after the primary infection, and in established infection eggs appear from the 42<sup>nd</sup> day onwards after infection.

### **Larval hookworm**

The symptoms are as common as those of larval ascariasis. At the site of entry of the infective larvae there is a 'ground itch', which consists of an irritating rash at the exposed portion(s) of the body, usually the soles of the feet. After 1-2 weeks pulmonary symptoms develop with a dry cough and asthmatic wheezing. Fever and a high degree of eosinophilia are found. These symptoms are self limiting and disappear within 2-3 months.

### **Light infections**

Light infections may be seen in Europeans and other expatriates who have arrived in an endemic area and are especially common in children. Minor degrees of anemia induce a tendency to fatigue and lassitude, and digestive disturbances are seen to be common. Any of these symptoms accompanied by eosinophilia should lead to the suspicion of infection. In the indigenous communities most light infections are asymptomatic.

### **Diagnosis and Treatment**

Diagnosis is made by finding eggs in the stool. Rhabditiform larvae may be found in stale stools and are usually mistaken for *Strongyloides stecoralis*. The eggs may also be confused with those of *Trichostrongylus* which are more translucent and smaller. In light infections concentration methods such as zinc sulphate concentration, formol ether or Kato smear are necessary. The worm load can be estimated by an egg count.

Treatment is usually directed against the adult stages but there is evidence that Albendazole in a single dose of 400 mg is active against the preintestinal larval stages of *N. americanus*. (Cline *et al.*, 1984)

## 1.2 LITERATURE REVIEW

### 1.2.1 Epidemiology of Human Schistosomiasis

The epidemiology of schistosomiasis is complicated. It involves a definitive host in man, an intermediate host in various species of aquatic or amphibious snails, a freshwater environment which man contaminates with excreta, and from which infection is also acquired through repeated water contact (Davis *et al.*, 1985). Transmission is influenced by numerous variables, the major ones being:

- The distribution biology and population dynamics of the intermediate snail host(s)
- The patterns and extent of environmental contamination with human excreta which in turn depend on the prevalence and intensity of human infection and the socioeconomic and hygienic background.
- Human water contact activities, pattern and duration.
- The host-parasite relationship in man and the role of protective immune mechanisms

Schistosomiasis is one of the most widespread parasitic infections of man, as illustrated by data advanced by WHO (WHO, 1985) and (Doumenge, 1987). The disease ranks second only to malaria in terms of socioeconomic and public health importance in many tropical and subtropical areas. Schistosomiasis affects more than 200 million people worldwide, of whom more than 30 million suffer from associated severe morbidity causing 155,000 deaths annually (Compton, 1999). Exposure to infection is due to low socioeconomic status on background of poverty and ignorance, with resultant poor housing, lack of portable water and inadequate hygienic conditions. Exposure to infection is also attributed to few if any sanitary facilities and a multitude of activities bringing a population into contact with water into which eggs are passed, and in which are found intermediate snail hosts, e.g. domestic, hygienic occupational, recreational or religious.

Children are particularly important as reservoirs of infection because of their indiscriminate excretory habits, and their unrivalled opportunities for water contact in hot climates.

Major factors associated with the spread and intensification of schistosomiasis are its links with water development projects, particularly man-made lakes and irrigation

schemes. These are often sites of population immigrations for farming and fishing, so much a feature of the present tropical scene.

In many countries, schistosomiasis prevalence figures are frequently gross underestimates. There is generalized correlation between prevalence and intensity of infection which means that, for all practical purposes, the higher the prevalence, the greater the intensity of infection in a population or community.

### 1.2.2 Epidemiology of *Trichuris*

*Trichuris trichura* is primarily a human infection but *Trichuris suis* of pigs is indistinguishable from the human species and can infect man. There has been an increased incidence of *Trichuris* infection in people handling pigs.

*Trichuris* infection is mostly found in areas of high rainfall, high humidity, dense shade and poor sanitation and contaminated soil. The highest prevalences are in children of primary school age who pollute the soil around the house and who develop heavy worm burdens. *Trichuris* infection is often associated with *Ascaris* and *Toxocara*, which share a similar epidemiology. Control measures include: avoidance of soil pollution and periodic mass chemotherapy.

### 1.2.3 Epidemiology of *Ascaris*

*Ascaris* eggs develop well in shady damp soil and are tolerant to cold and to disinfectants. But the eggs are killed by direct sunlight and by temperatures above 45°C. Infection is spread by faecal pollution of the soil.

In endemic areas three distinct trends in the prevalence and intensity of endemic *Ascaris* in man are common: High prevalence (over 60%) in the whole population over 2 years, with the intensity of infection lower in adults. Common and constant exposure to invasive *ascaris* eggs by dirty hands can contaminate food.

In moderate prevalence (below 50%) with its peak at preschool or early school ages and low values in adults, a household or family type of transmission probably prevails. At low prevalence (below 10%), infections tend to have a focal distribution related to particular housing and sanitary conditions or to agricultural and behavioral practices (Crompton et al., 1985).

Ascariasis is spread countrywide in few regions where climatic and social conditions are almost similar; and its distribution may be stratified in many other countries. It is therefore possible to find that, in the 'shanty' overcrowded towns of non-industrialized societies with poor hygiene, prevalence may be higher in urban than in rural areas. In drier areas of the tropics, transmission is limited to the short rainy season. Coprophagous arthropods e.g. dung beetles, cockroaches and animals can act as 'agents' of spreading the infection widely by ingesting and excreting viable eggs.

"Apart from the spatial differences in *Ascaris* prevalence at the level of country, village and family, there is considerable difference in intensity and infection among individuals, giving a negative binomial distribution" (Croll *et al.*, 1981).

#### **1.2.4 Epidemiology of Hookworm**

Man is the only reservoir of infection. The proportion of hookworm infection depends upon a number of things; an adequate source of infection in the human population, the deposition of eggs in a favorable environment for extrinsic development of the parasite, appropriate conditions of the soil (moisture and warmth) to allow larvae to develop and suitable conditions for the infective larvae to penetrate the skin.

In many tropical and subtropical countries transmission is perennial but in cooler and drier climates transmission may take place in the warmer wet seasons.

The methods which are used to determine the amount of hookworm in a community are determining the prevalence and intensity of infection by stool surveys and egg counts, from which the worm burden can be calculated. These survey methods will show whether the infection is low grade, moderate or severe.

#### **1.2.5 Control Objectives and Strategies**

Schistosomiasis and Soil transmitted helminthiasis are diseases associated with; poverty, poor hygiene, lack of safe water and inadequate sanitation. WHO recommends that for both schistosomiasis and STH the first objective should be a strategy for morbidity control (WHO, 2002). The currently available, effective, safe and inexpensive single-dose drugs should be used to treat both types of infection. Since a considerable part of the burden of schistosomiasis and STH involves morbidity in children, the World Health

organization recommends that children be provided with regular treatment. This treatment reduces the development of nutritional deficiencies, illness, and other sequelae in later life. Regular mass chemotherapy in the primary schools is an effective way of ensuring that most children in the population get treated. Although it is mostly school age children that are seen as the primary target group for regular treatment, other groups in the community are also at risk of morbidity.

The World health Organization also recommends that since both infections result from poor hygienic conditions, and deworming alone is unlikely to have a lasting impact on transmission, more permanent control measures can also be achieved (WHO, 2002). For example, improvements in water supplies and sanitation, together with appropriate health education can be undertaken. Improvement in sanitation and access to clean water, appropriate health education, and environmental measures, for example snail control where there is schistosomiasis should be encouraged (WHO, 2002).

In a number of countries, where the prevalence of schistosomiasis was once high, there has been success in sustaining community-wide treatment approaches for considerable periods. These have achieved low prevalences of infection with massive reductions in morbidity. Most of these countries have managed to consolidate their achievements with an improved standard of living. A few countries have also made progress in reducing schistosomiasis through environmental management and snail control (WHO, 2001).

Certain development initiatives-particularly water resource development for agriculture or energy production is likely to favor emergence or spread of the disease.

In the containment of disease in water resource development projects, specifically for schistosomiasis, preventive action is needed in two fronts: A proper health impact assessment (HIA), with procedures ensured by ministries of health through policy adjustment and capacity building; Compliance with HIA recommendations, consisting largely of environmental engineering and management measures (WHO, 2002)

“A timely HIA allows design changes in hydraulic structures and a reconsideration of settlement location, at little additional cost. Also, decision making criteria and procedures for improved water management in irrigation schemes and reservoirs that take due account of the need to reduce the risk of transmission can be implemented at little or no extra cost” (WHO, 2002).

To slow down the rate of reinfection and to sustain longer lasting reductions in transmission, regular treatment of the infected communities, has to go along with adequate access to sanitation and clean water, plus appropriate health education. And for the control of schistosomiasis to be achieved snail control measures are essential.

### 1.3 JUSTIFICATION

For the schistosome life-cycle to become established, it is necessary for the definitive host, whether it be man, domestic or wild animal, to come into contact with fresh water and contaminate it with schistosome eggs in which the appropriate intermediate hosts are situated. Freshwater is an extremely valuable and important commodity in countries where schistosomiasis is endemic, and the last two decades have seen man make a significant impact on the environment through numerous schemes, such as creation of dams and lakes. These schemes are generally aimed at increasing water supply for the purposes of irrigation and agricultural development, and for generating hydroelectric power. However, one of the adverse effects of such development is the creation of permanent water bodies, providing new habitats for snails to colonize, a case example in this study - the rice paddies in the Mwea Irrigation scheme. In areas where piped water and sanitation facilities are non-existent or limited, natural water bodies play an essential part in the daily lives of the community at large, through activities such as fishing, washing clothes, playing, collecting water for domestic use, the tending of crops and domestic stock, consequently increasing the chances of snails and man being brought together.

This study was carried out to investigate the transmission status of schistosomiasis and soil transmitted helminthes in Mianya and Mukou school children after three years of therapeutic intervention and the risk factors involved in the transmission of both schistosomiasis and soil transmitted helminthes. Although the infection status is known and treatment has been taking place among the high-risk group, little is known about the epidemiology of schistosomiasis and soil transmitted helminthes in the communities within the irrigation schemes in Mwea region. In essence the epidemiology of schistosomiasis and soil transmitted helminthes that is much needed for a successful control program of the same.

Regular combined treatment of those infected with schistosomiasis and STH can decrease the worm burden and reduce the risk of serious complications later in life. In addition combined treatment makes logistical work easier by saving on time and money and other costs by treating Schistosomiasis and soil transmitted helminthes all at the same time.

Under the world health organization (WHO) guidelines the decision to treat all persons (mass treatment) or only school children and other high risk groups (selective treatment) depends on the prevalence of infection in a particular region. Epidemiological tools are therefore needed to identify and prioritize communities for mass treatment programs.

#### **1.4 Hypothesis**

##### **Null**

Infection and reinfection with schistosomiasis and soil transmitted helminthes does not occur in primary school children after with therapeutic intervention

##### **Alternative**

Infection and reinfection with schistosomiasis and soil transmitted helminthes occurs in primary school children after therapeutic intervention.

#### **1.5 OBJECTIVES**

##### **Main objective:**

To study the infection and reinfection patterns of schistosomiasis and STH in school children after 3 years of therapeutic intervention and the factors affecting transmission. More targeted control measures address the problem using the risk factors.

##### **Specific objectives:**

1. To determine the prevalence and intensity of schistosomiasis and STH in school going children within Mianya and Mukou primary school in Mwea Division.
2. To determine the spatial and temporal variations in vector and cercarial densities.
3. To investigate risk factors associated with *Schistosoma mansoni* and STH infection.



## **CHAPTER TWO**

### **2.0 MATERIALS AND METHODS**

#### **2.1 Introduction**

Two primary schools in Mwea region, of central Kenya were identified for comparative studies, namely Mianya and Mukou primary schools. A baseline parasitological survey was conducted in the two schools in September 2006, using the Kato technique. Similar laboratory diagnosis was carried out in January for class 3 only. Another one was done in March before the pupils received treatment, and a final one in May after treatment. 100 homesteads in the study area were sampled for risk factors believed to play a role in transmission of soil transmitted helminthes. Daily water contact surveys were also conducted for two weeks, in the possible schistosomiasis transmission points. Malacology surveys were also conducted to evaluate the temporal variations in both vector and cercarial densities.

#### **2.2 Study design**

The initial parasitological survey was to determine the prevalence among the school children before the yearly treatment, and the final parasitological diagnosis was to determine the prevalence after the yearly treatment, with praziquantel and albendazole that is offered by the Ministry of Health.

Field surveys were carried out in the community surrounding the two primary schools. A total of 100 homesteads were sampled on the aspect of risk factors that were believed to play a role in the transmission of soil transmitted helminthes. The sanitation status of the toilets in the households was surveyed.

Regarding the transmission of hookworm, the shoe wearing practice among the school children was also evaluated. To determine this, the schools were visited without prior notice and records of the pupils with and without shoes were taken.

Daily water contact surveys were also conducted for two weeks, in the possible Schistosomiasis transmission points. The time and activity of water contact were recorded, among the school children and the adults in the nearby homesteads. Water

contact and sanitation survey forms were used to generate quantitative primary data to address specific objectives of the study

Malacology surveys were conducted to evaluate the temporal variations in both vector and cercarial densities. Snails were collected in the drainage canals along and around the two schools. They were then carried to the laboratory for counting, the snails were let to shed and the number of cercariae shed was recorded. Laboratory techniques, methods and materials used are described in detail. The water and environmental characteristics were also recorded. Review of previous studies carried out by Eastern and Southern Africa Center for International Parasite Control (ESACIPAC) was used to support the findings of this study. This provided secondary data for key issues concerning the study so as to support the primary data collected.

### **2.3 Study area**

The study was conducted in Mwea division, Kirinyaga District, central province, a hundred kilometers North-East of Nairobi. The area is of low altitude and the land is flat and expansive, with distinctive black and red soils. The division has 3720 households living in 36 villages distributed on a 513 square kilometer land with a total population of approximately 125,962 people.

Kirinyaga district has an estimated population of 168,176 school age children (15-19) years (Kenya's population census 1999). The major economic activity in the area is farming, which is carried out by gravity flow using water from river Thiba and Nyamindi that originate from the slopes of Mount Kenya. The mean annual rainfall is 1036.6mm and the relative humidity is between 79.6% and 95.2%, the mean temperature per year is between 27.8<sup>0</sup> C and 15.6<sup>0</sup> C (KARI, Mwea field station 2003).

The study schools were Mianya and Mukou primary schools both located in the study area. Mianya is in North West of the Thiba school zone and Mukou is in the central part of Thiba school zone, and it borders Thiba River. Mukou primary school has approximately 351 pupils, while Mianya has approximately 312 pupils. Both schools have an approximate 1:1 ratio of boys to girls and their ages range from 5 to 24.

Figures 3 and 4 below illustrate the general and specific maps of the study area respectively.

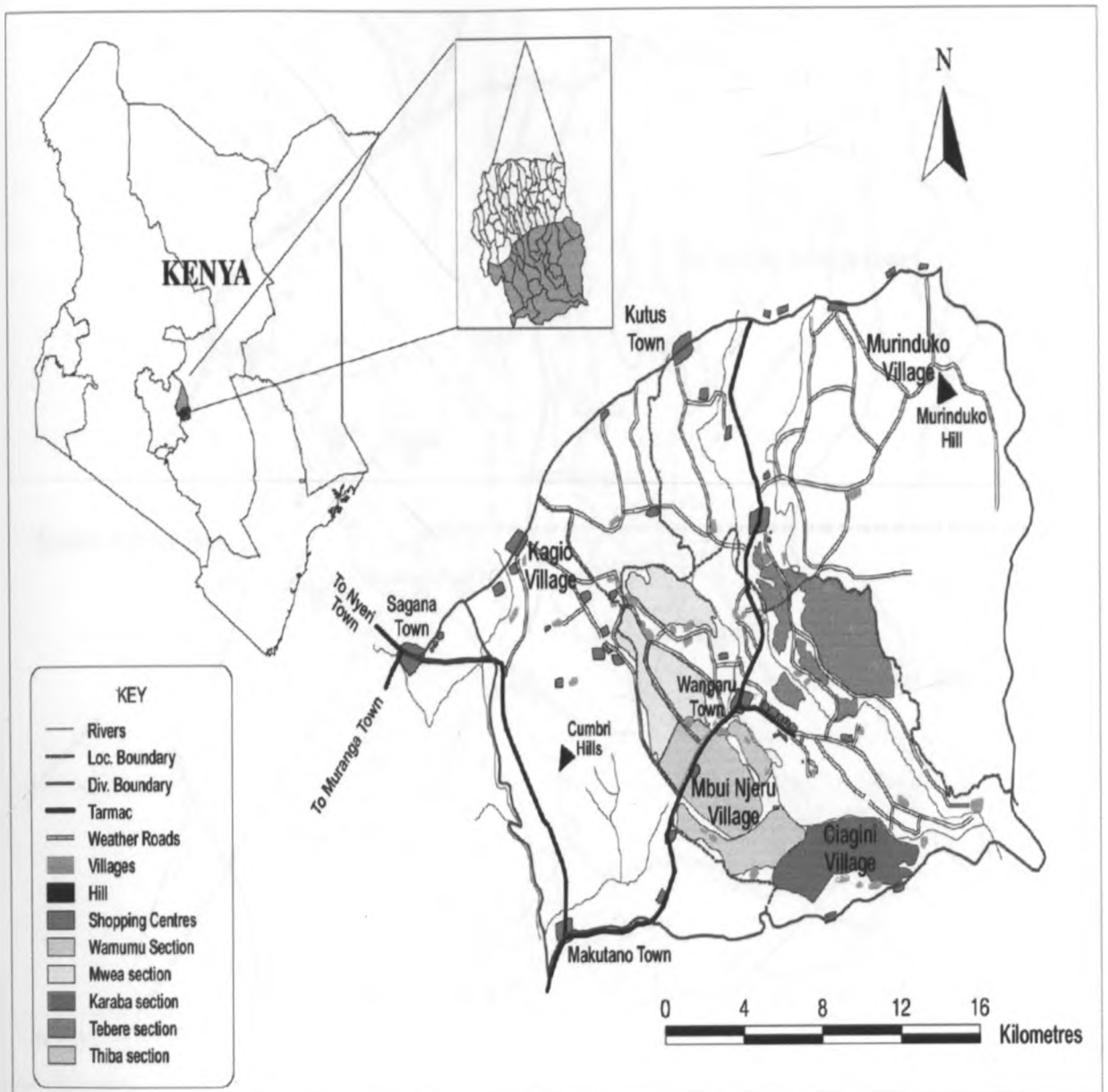


Figure 3: Map of study area

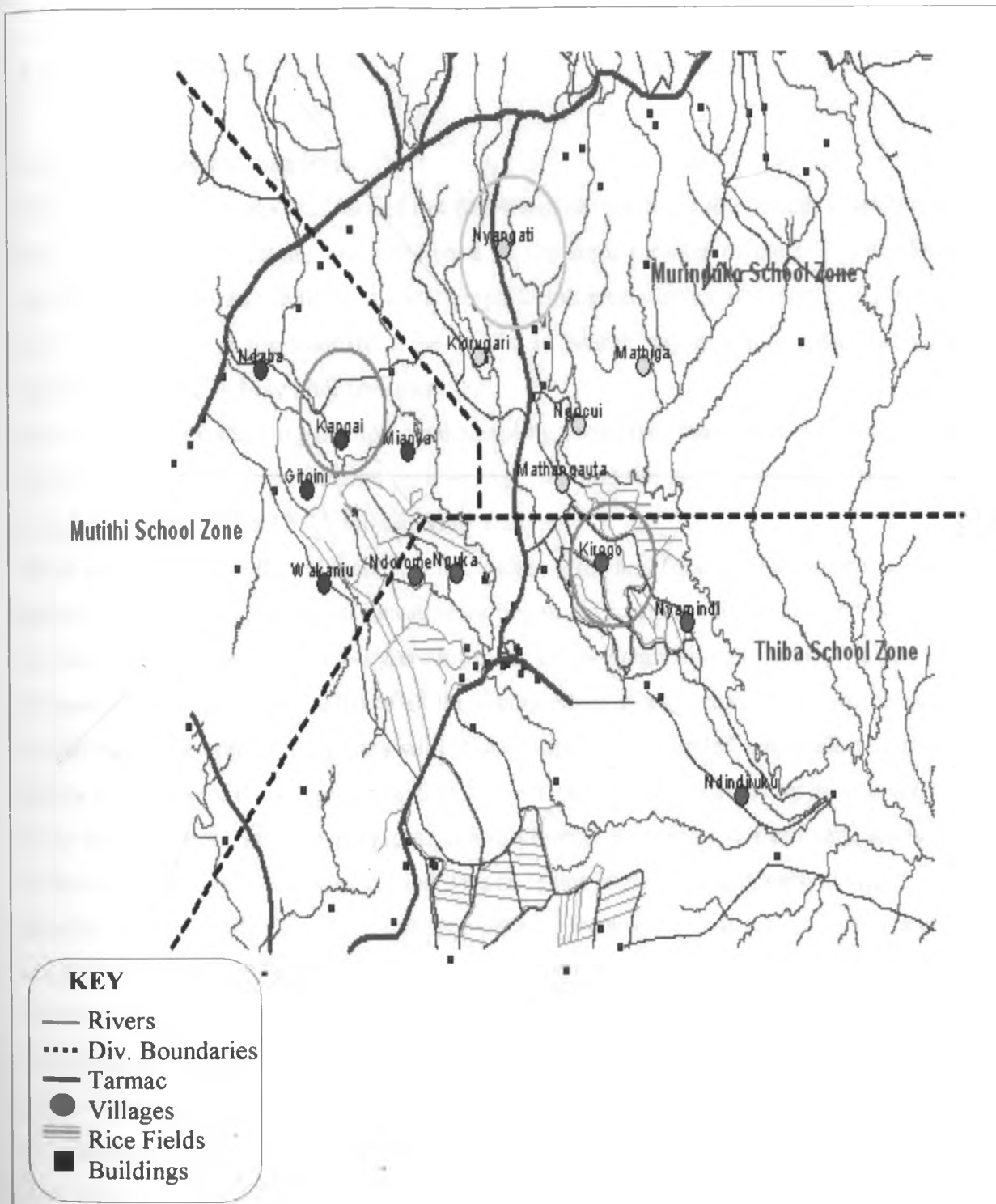


Figure 4: Specific map of study area

## **2.4 Sampling methods**

### **2.4.1 Parasitological diagnosis**

Parasitological diagnosis was carried out four times during the study period, whereby the Kato-thick smear technique was performed on the stool samples of the primary school children. In September 2006 as a baseline parasitological survey was done, in January 2007 one was done for standard three pupils, in March, again before treatment with anthelmintic and in May after treatment.

The data was recorded, in parasitological sampling forms (see appendix), with inclusions of the student name, identification number, age, sex and the infection status. These data was then fed into SPSS 12.0.1 for statistical analysis.

Stool samples were collected from school children attending Mianya and Mukou primary schools respectively. Before the survey work begun the schools were visited and the head teachers of the respective schools were informed of the diagnosis to take place. Upon the consent of the head teacher, a list of all the school children was prepared and the message passed on to the pupils. Poly pots with sticker labels were handed out to all the school pupils on the eve of the sample collection day. The pupils were advised on how to collect early morning stool into the poly pots. The following morning the stool samples were collected and each poly pot was labeled with an identification number, each of which was specific for each child. The stool samples were then transported to the laboratory and a single Kato slide was prepared from the stool sample of each child. In the Kato technique faeces were pressed through a mesh screen to remove large particles. A portion of the sieved sample was then transferred to the hole of a template on a slide. After filling the hole, the template was then removed and the remaining sample was covered with a piece of cellophane soaked in glycerol.

The smears were systematically observed with the help of experienced technicians. Schistosme and STH eggs observed were counted and the information recorded on data sheets. Prevalence's and intensities of infections were the calculated.

#### 2.4.2 Cellophane faecal thick smear examination for diagnosis of intestinal schistosomiasis

The cellophane faecal thick smear examination technique was introduced by Kato and Miura in 1954. Subsequent to the first English publication of this technique by Komiya and Kobayashi in 1966, many modifications of the original technique have appeared. This technique has proved to be a useful and efficient means of diagnosis of intestinal helminthic infections, as well as *Schistosoma mansoni* and *S. japonicum*

##### 1. Materials

(a) Glass microscope slides. The ordinary slides 25x75 mm are appropriate.

(b) Flat-sided wooden applicator sticks or similar devices made of plastic or other material.

(c) Cellophane, wettable, 40 to 50 microns in thickness in 22 (or 25) mm x 30 to 35mm strips.

(d) Glycerin-malachite green solution (50% solution);

-100 ml water

-100ml glycerin

-1ml 3% aqueous malachite green or 3% aqueous methylene blue.

(e) Screen. Made of either wire steel cloth (105 mesh, stainless steel, bolting cloth) or plastic (60 meshes per square inch or 250  $\mu$  mesh size). A stainless steel screen welded onto an oval steel ring with a handle is re-usable.

(f) Template. Made of stainless steel (Peters *et al.*, 1980) plastic (Kato-Katz) or cardboard (Japanese Association of Parasite Control) templates of varying diameters have been used. The size (20mg to 50mg) may depend on local requirements; in any event, the template permits accurate delivery of a standard stool specimen and determination of quantitative egg counts.

Before the technique was carried out, poly pots were arranged on the bench and a glass slide was put on top of each poly-pot. The poly pots had identification numbers, each of which represented each child. The number was transferred on to the frosted side of the slide using a pencil; once all the slides had been labeled the procedure begun.

## 2. Procedure for Kato-technique

(a) Cellophane strips were soaked in 50% Glycerin-malachite green (methylene blue) Solution for at least 24 hours.

(b) A small amount of faeces about 50mg was transferred onto a 105 mesh metal sieve.

(d) Using a flat sided wooden tongue depressor, the upper surface of the screen was scraped across to sieve the faecal sample.

(e) A template was then placed on a clean microscope slide.

(f) A small amount of sieved faecal material was transferred into the hole of the template to carefully fill the hole, then Leveled flat with the applicator stick.

(g) The template was removed carefully so that all the faecal material was left on the slide and none was left sticking to the template.

(h) The faecal sample on the slide was covered with a Glycerin soaked cellophane strip.

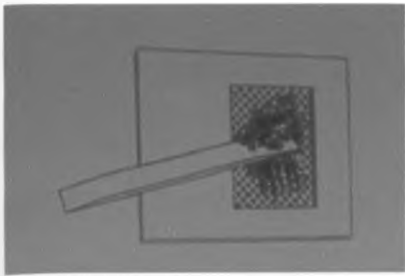
(I) Excess Glycerin found present on the upper surface of the cellophane was wiped off with a small piece of toilet paper or absorbent tissue.

(j)The microscope slide was inverted and the faecal sample pressed against the cellophane on a smooth surface (this was on top of a layer of news papers) to spread the sample evenly.

(k) The slide was not lifted straight up as the cellophane may separate. The microscope slide was gently slid sideways while holding the cellophane.

Once preparation of the slide was complete, excess glycerin was wiped off with a piece of toilet paper to ensure that the cellophane stayed fixed.

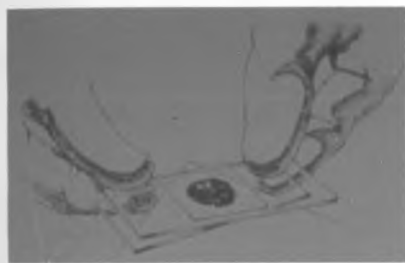
The smear was left until it cleared-about 60 minutes at room temperature. The clearing process was slowed down by inverting the slide and placing on a piece of card or by placing at 4°C until it was convenient to examine. Figure 5 below is an illustration demonstrating the Kato technique.



**A. Transfer of faecal material to sieve using an applicator stick**



**B. Transfer of sieved material to template on slide**



**C. Application of cellophane on the slide with faecal material**



**D. A pressed slide with cellophane onto a newspaper background**

**Figure 5: Kato-Katz technique**



### 3. Examination

(m) The slides were examined using the x 4.0 objective

(n) Hookworm ova were visible for up to 30 minutes after preparation. *Trichuris* and *Ascaris* ova could be seen up to even a few days after the slide preparation.

As the cellophane coverslips were soaked in a malachite green solution the background color of the slides was green. Schistosome and hookworm ova appeared colorless.

### 4. Recording

Recording of examined slides was done on to prepared data forms, which contained the Identification number (ID), name, sex age and class of the pupils (see appendix). The ID on the slide was used to match an ID on the data sheet-which had the full names of the pupil, class and age.

The number of eggs found on the slide after observations were recorded, 1-1000 was recorded for eggs that were seen and counted and 0 for slides that did not have any *Schistosoma* or soil transmitted eggs.

### 2.5 Malacological surveys

Snails were collected by hand picking, using a hand forceps measuring about 19 cm in length and a 1.2m length metallic scoop. Because the risk of becoming infected with schistosomiasis could not be assumed, plastic gloves and gumboots were used to protect against infection. Samples were collected along the rice paddies, canals, and streams with floating vegetation (*Typha domingensis*, grass, e.t.c.) in 4 different sampling sites in the two study areas. The soil was mostly black cotton with a Ph of 6.5-7.5. The purpose of the Malacological surveys was to determine the spatial and temporal variation in vector and cercarial densities. A copy of the sampling forms is in the appendix

#### Collection of snails

The long handled scoop, shown in Figure 6 was submerged in water to collect floating snails. The net was shaken in water after it had been through submerged vegetation. Most snails loosen their hold on the plants and drop to the bottom of the scoop. The contents

were then emptied into clean basins where it was easy to see the snails and pick them up with a pair of forceps.

Snails were collected between 10am and 12noon, they were put in basins with little water and then transported to Kimbimbi Sub District hospital at the Division of Vector Borne diseases (DVBD) where they were identified taxonomically and their numbers recorded.

### **Transportation of snails**

The snails were transported on clean basins with water up to the laboratory.

For long distances, the snails were placed onto laboratory gauze that was damp, but not dripping wet, and layered on top of each other.

On arrival at the laboratory the snails were placed individually into test tubes, which were in a test-tube rack, with dechlorinated water, and left overnight-for cercarial accumulation until the next morning's examination.

### **Examination of snails**

Snails were then examined for trematode infection by exposure to sunlight. By exposing a test tube with snails to sunlight it was possible to observe the cercariae shedding. These were regarded as infective snails and therefore positive for infection. The negative snails were then examined a second time by exposure to artificial illumination using a bench lamp (Refer to figure 7) for about two hours. Further identification of cercariae was done under a dissecting microscope. For the positive snails the emerging cercariae were identified to the genus level with the help of a dissecting microscope, using tail morphology and taxonomic keys, and later recorded onto data forms (see appendix). The snail genera were identified using taxonomic keys provided by Danish Bilharziasis Laboratory (DBL) and the World Health Organization (WHO). Malacology surveys were carried out seven times during the study period.



**Figure 6: Metallic hand scoop, used for scooping snails out of canals, paddies and drainages.**



**Figure 7: Bench lamps, used for exposing snails to light.**

## **2.6 Risk factor survey**

The risk factors in the Mukou and Mianya villages were divided into 3 categories according to transmission. The importance of this survey was to investigate the risk factors associated with *Schistosoma mansoni* and STH infection. The first survey was on latrines and leaky tins and it checked on sanitation. The second survey was the water contact, which checked on water contact at possible transmission points. These are the points where Biomphalaria snails were collected. The third survey was on shoe wearing practice, this was to investigate the transmission of hookworms. Data was recorded in accordance with the presence and the condition of each parameter being investigated.

### **2.6.1 Latrines and Leaky tins Survey**

Here the sanitation status of the latrines and the leaky tins in the study area was evaluated. In the respective villages under the study, 50 homesteads were selected at random and in each home the number of toilets in and out of use was counted and recorded. The condition of the toilet was also evaluated in terms of construction material used. Usage of the latrines was evaluated by identifying the number of toilets that were actually being used and the ones that were out of use. Those not in use were padlocked or the latrine hole covered. A similar evaluation was done in Mukou and Mianya primary schools, and a leaky tin survey was conducted in both schools. The leaky tins are domestic tins that have been recycled back into use, in the schools such that they are now used by the pupils to wash their hands after visiting the toilets in the school. Pictures of the latrines were also taken.

### **2.6.2 Water contact survey**

The second survey was the water contact survey. This survey was carried out in both studies areas. The sites were chosen according to the closeness/nearness of water contact points, to first and foremost, the primary school children and then to the community at large.

The survey was carried out for three consecutive days in each of the study areas. A planned schedule of observation was prepared to assess individual exposure to infection. Data was taken by tallying the number of individuals visiting the water points from 6am

to 6pm. The activity at the water contact point, the time spent in the water and the age and sex of the individuals were also recorded. Pictures were also taken to demonstrate the type of activity at the sites that are believed to act as transmission points of schistosomiasis.

### **Shoe wearing practice survey**

The third survey was that of the shoe wearing practice of the primary school pupils.

A surprise visit was carried out in one of the primary schools in the study area. During the activity the boys and girls were separated so as to later determine prevalence in relation to gender and a record of the ones with and without shoes was taken. The boys with or without shoes were recorded separately from the girls with or without shoes, so as to compare which sex and shoe wearing practice. This would help relate hookworm infection with sex. This practice was considered relevant especially for the transmission of hookworm among the school children.

### **2.7 Statistical Analysis**

Data were entered using excel (Microsoft corp.) and checked for range, consistency and integrity. Statistical analysis was performed with Statistical Package for Social Sciences SPSS 12.0.1, (SPSS Inc. Chicago IL, USA). Frequency analysis was used to calculate the positive cases with *Schistosoma mansoni* infection. Soil transmitted helminthes showed very few positive cases, and this made mathematical analysis difficult. Pearson's correlation was used to depict the relationship between the age of the primary school children and the schistosomiasis infection.

The egg count was log transformed to get the geometric mean egg count.

The status of infection in the study area was measured in terms of prevalence and intensity. Correlation statistics was used to compare the relationship between infection and age. The spatial and temporal variations of the vector and cercarial densities were also determined and the frequencies calculated.

## CHAPTER THREE

### 3.0 RESULTS

#### 3.1 Introduction

The prevalence of infection with schistosomiasis before treatment was 22.7% in Mukou, where out of 181 pupils examined, 41 were found to be positive. In Mianya it was 31.1%, where out of the 182 pupils examined 57 were found to be positive. The prevalence of infection with schistosomiasis after treatment was 6.99% in Mukou where out of 441 pupils that were diagnosed, 31 were found to be positive with schistosomiasis. In Mianya it was 8.73% where out of 378 pupils diagnosed, 33 were found to be positive with schistosomiasis.

Malacological survey revealed the presence of 3 species of freshwater snails, namely *Physca acuta*, *Biomphalaria pfeifferi*, and *Bulinus globosus*. The species of *P. acuta* collected were 38, *B. pfeifferi* was abundant and during the entire study period 573 snails were collected of which 12 were found to shed human cercariae. A total of 248 *B. globosus* were also collected.

The risk factor survey provided qualitative and quantitative data on hygiene and sanitation, water contact and shoe wearing practice of the school children. The results indicate that there is a relationship between these hygiene practices and conditions with the infection of soil transmitted helminthes in the two study areas.

#### 3.2 Results of the Parasitological Survey

##### 3.2.1 First survey

The total number of students whose stool samples were examined in Mukou, in the month of September was 181, as shown in table 2. The pupils who had intestinal schistosomiasis were 41 which translated to a prevalence of 22.7%. The girls had a prevalence of 45.7 compared to the boys who had a prevalence of 37.1. The age group of 10-14 recorded the highest prevalence of 51.4 during this first survey. One male student was found to have eggs of *Hymenelopsis nana*. The Tables 3 and 4 show the percentage of intensity threshold for Mukou according to age and sex. A comparison between age

and schistosomiasis infection was done, statistical analysis using Person's correlation at confidence level of 0.05 gave a relationship of (-0.12) between age and schistosomiasis infection indicating that with an increase in age there was a decrease in infection, as shown in figure 12. In Mianya primary, school as shown in table 1, a total of 182 pupils were examined of which 57 pupils were infected with schistosomiasis and that translated to a prevalence of 31.1%. Table 3 and 4 show the percentage of intensity for Mianya according to age and sex. A comparison between age and infection using Pearson's correlation at confidence level of 0.05 showed a relationship of -0.028, as shown in figure 12. This negative relationship indicates that with an increase in age there was a decrease in infection. Four pupils were diagnosed with *Hymenelopsis nana*, 4 were positive with *Ascaris lumbricoides* and 7 with Hookworm. 8 students were found to have multiple infections. Table 3 shows the percentage of intensity threshold for Mianya according to age and sex.

### 3.2.2 Second survey

The second laboratory diagnosis was specifically for standard three pupils. These pupils fall in the age groups of 5-9 and 10-14 years of age. Table 6 shows that in Mianya primary school a total of 55 school children were diagnosed, 24 were infected with schistosomiasis, which translated to a prevalence of 43.6%. Females had a prevalence of 54.2, which was higher than the males who had a prevalence of 45.8. The age group of 10-14 had the highest cases of infection as shown in figure 10. A comparison between age and schistosomiasis infection was done, using Person's correlation at 0.05 confidence level which gave a relationship of 0.435. The intensity of infection was light. There was 1 student with ascaris, two with hookworm and 1 with *H.nana*. There were only 2 pupils with multiple infection.

In Mukou 62 pupils were diagnosed and 40 were infected, the prevalence of infection was 64.5%. Comparing prevalence according to sex, the males had a prevalence of 57.5% compared to the females who had a prevalence of 42.5% within the age groups that of 10-14 years had the highest prevalence (refer to bale 6). It was noted that in both Mianya and Mukou *S.mansoni* was high in the 10-14 age group (refer to figure 10). A comparison between age and infection using Pearson's correlation at 0.05 confidence level showed a

relationship of -0.025, indicating negative correlation; as age increased there was a decrease in infection. Other infections diagnosed during this survey were hookworm, ascaris and *H.nana*.

### 3.2.3 Third Survey

The third laboratory survey was carried out in March immediately after which followed treatment. The prevalences here were used to determine whether there was an increase in infection from September 2006. Table 1 shows that in Mianya primary school 377 pupils were examined and 109 pupils were found to be positive with Schistosomiasis and these translated to a prevalence of 28.9%. It was observed that there was an increase in the population of the school, as it was a new year and also an increase in the number of pupils found to be positive with schistosomiasis as compared to the previous year. A comparison between age and infection using Pearson's correlation showed a relationship of 0.17 as shown in figure 12. There were 12 cases of Ascaris reported, 13 of Hookworm and 2 of *Hymenelopsis nana* and these had low prevalences. There were 11 cases of reported multiple infections. Table 3 shows the percentage of intensity threshold for mianya, according to age and sex.

Table 2 shows that in Mukou a total of 432 pupils were examined and 74 were infected with schistosomiasis. This translated to a prevalence of 17.1%. A comparison between age and infection using Pearson's correlation at 0.05 confidence level showed a relationship of 0.02, as shown in figure 12 there were 2 reported cases of ascaris with one pupil having more than 1000 eggs; there were 3 reported cases of *H.nana* and 1 multiple infections case.

### 3.2.4 Fourth survey

This survey was performed in May 8 weeks after treatment. It was done to check if the prevalences had gone down and if there were any new infections. In Mianya primary school 378 pupils were diagnosed, out of which 33 were found to be positive.

This translated to prevalence of 8.73% (refer to table 1), this indicates a decrease in overall prevalence as can be seen in figure 8.. A comparison between age and schistosomiasis infection was done, statistical analysis using Person's correlation gave a



relationship of  $-0.11$ , as shown in figure 12 and these depicted that with increase in age there was a decrease in infection. No soil transmitted helminthes were reported. In Mukou primary 441 pupils were diagnosed, out of which 31 were found to be positive with schistosomiasis infection. This translated to a prevalence of 6.99% (refer to table2) this indicates a decrease in the overall prevalence as can be seen in figure 9. A comparison between age and schistosomiasis infection was done, statistical analysis using Person's correlation at 0.05% confidence level gave a relationship of  $-0.06$  depicting that with an increase in age there was a decrease in infection as shown in figure 12. For both Mianya and Mukou intensities of *S.mansoni* had gone down considerably in may after the treatment as compared to the period before treatment, which was September and march as can be seen in figure 11. There was 1 reported case of *H.nana*, 1 Hookworm and 3 cases of ascaris. For the multiple infections there was one reported case of an 11 year old boy with 1 hookworm egg on a single slide and 1 *S.mansoni* egg on a single slide. Tables 1-6 below show the prevalence and intensities in Mianya and Mukou primary schools during the four surveys, table 5 being a key that represents the intensity threshold for *S.mansoni* infection.

Table 1: Schistosomiasis infection status in Mianya

	NO. OF STUDENTS	POSITIVE	OVERALL PREVALENCE	PERCENTAGE PREVALENCE BY SEX		PERCENTAGE PREVALENCE BY AGE GROUP (YRS)			
				FEMALE	MALE	5.0-9.0	10.0-14	15-19	20-24
SEPTEMBER	182	57	31.1	14.3	17	5.3	68.4	24.6	1.8
MARCH	377	109	28.9	15.3	13.5	23.9	60.6	14.7	0.9
MAY	378	33	8.7	3.4	5.2	36.4	54.5	9.1	0

Table 2: Schistosomiasis infection status in Mukou

	NO. OF STUDENTS	POSITIVE	OVERALL PREVALENCE	PERCENTAGE PREVALENCE BY SEX		PERCENTAGE PREVALENCE BY AGE GROUP (YRS)			
				FEMALE	MALE	5.0-9.0	10.0-14	15-19	20-24
SEPTEMBER	181	41	22.7	11.6	11	39	51.2	9.8	0
MARCH	432	74	17.1	7.6	10.2	6.8	64.9	28.4	0
MAY	441	31	7	3.1	3.8	6.5	77.4	16.1	0

Table 3: Percentage of intensity threshold for Mianya and Mukou according to and sex

Mianya			
SEX	LIGHT	MODERATE	HEAVY
MALE	52.8	60.7	44.4
FEMALE	47.2	39.3	55.6

Mukou			
SEX	LIGHT	MODERATE	HEAVY
MALE	61.3	35.9	19
FEMALE	38.7	61.4	81

Table 4: Percentage of intensity threshold for Mianya and Mukou according to age group

Mianya			
AGE GROUP	LIGHT	MODERATE	HEAVY
5.0-9.0	20.9	26.5	36.1
10.0-14.0	60	65.5	52.8
15.0-19.0	18.2	8	11.1
20.0-24.0	1.2	0	0

Mukou			
AGE GROUP	LIGHT	MODERATE	HEAVY
5.0-9.0	18.1	20	0
10.0-14.0	62.4	71.4	85.7
15.0-19.0	19.5	7.6	14.3
20.0-24.0	0	0	0

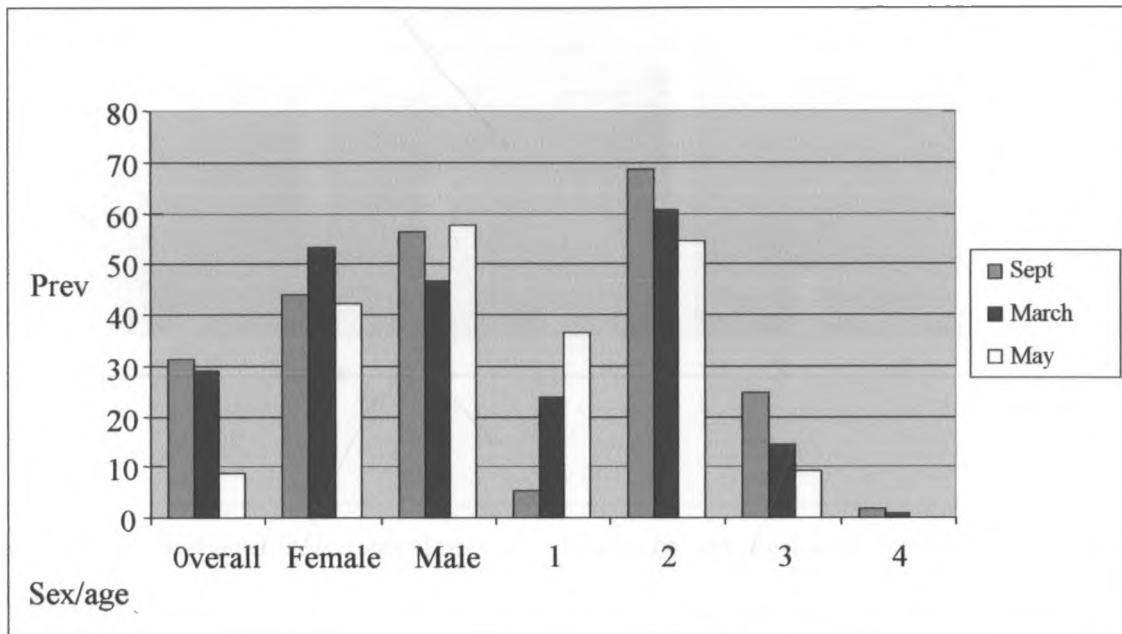
Table 5: Intensity threshold for schistosomiasis infection

Helminth	Intensity threshold		
	Light	Moderate	Heavy
<i>S. mansoni</i>	1-99egg	100-399	>400

Table 6: Schistosomiasis Prevalence in class 3

	NO. OF STUDENTS	POSITIVE	OVERALL PREVALENCE	PERCENTAGE PREVALENCE BY SEX		PERCENTAGE PREVALENCE BY AGE GROUP(YRS)	
				MALE	FEMALE	5.0-9.0	10.0-14
MIANYA	55	24	43.6	20	23	20.8	79.2
MUKOU	62	40	64.5	35.4	29.0	47.5	52.5

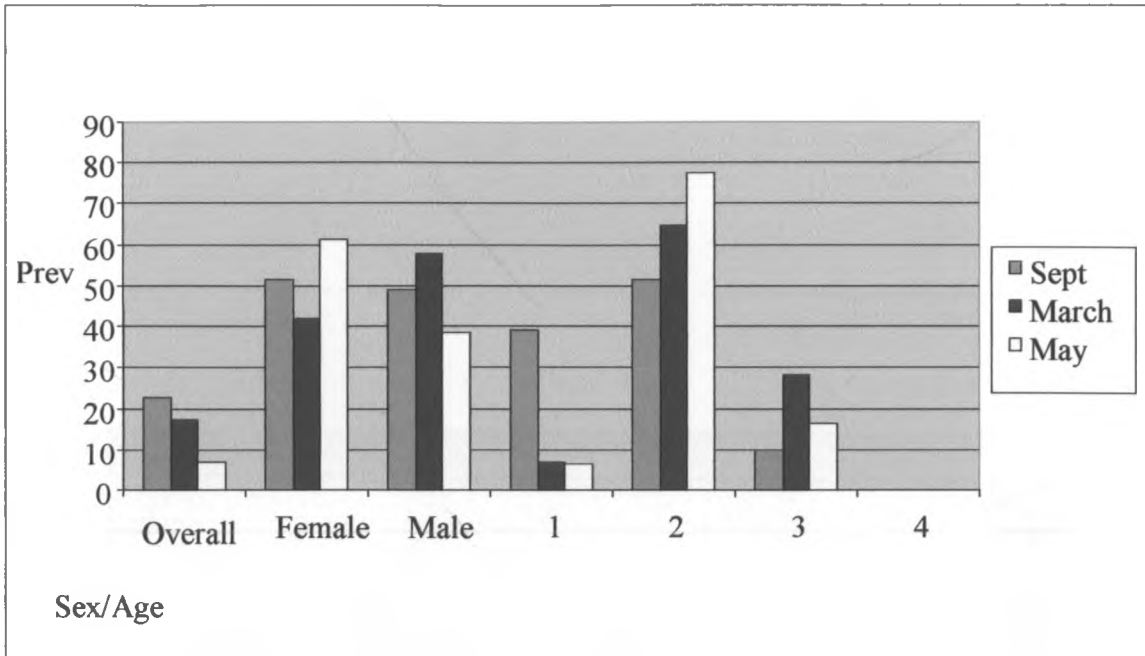
Figures 8-12 below graphically represent the above tables.



**Figure 8: Schistosomiasis prevalence in Mianya by sex and age group for the entire study period**

**Key**

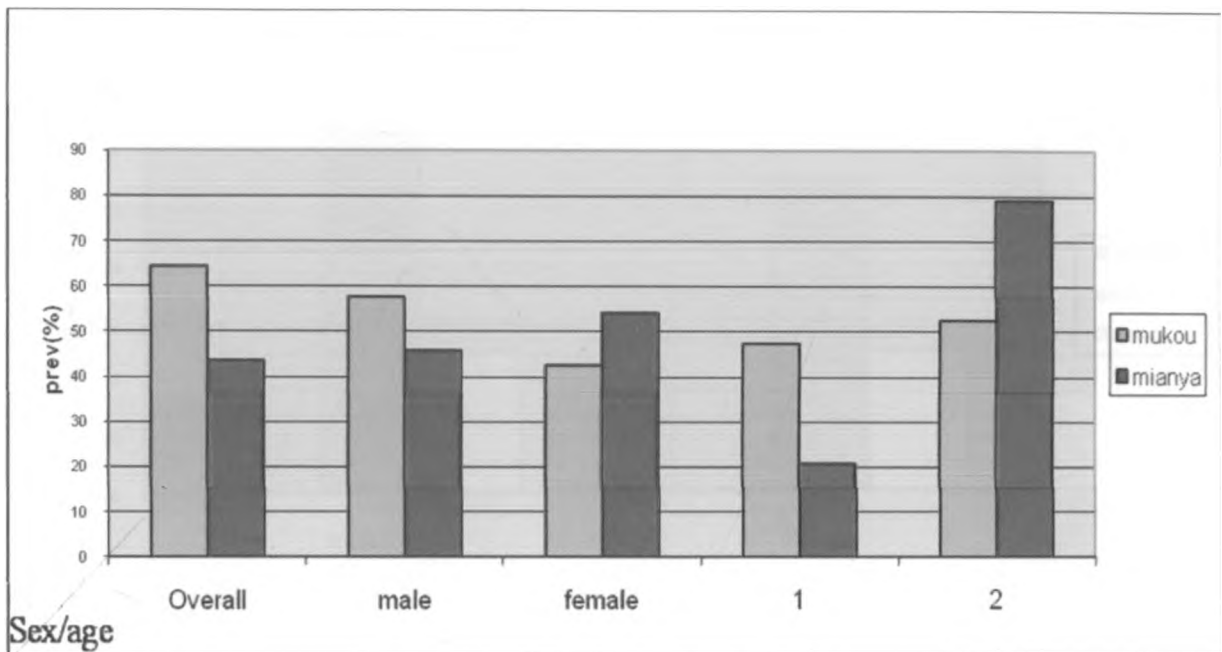
- 1 Represents ages 5-9 yrs
- 2 Represents ages 10-14 yrs
- 3 Represents ages 15-19 yrs
- 4 Represents ages 20-24 yrs



**Figure 9: Schistosomiasis prevalence in Mukou by sex and age group for the entire study period**

**Key**

- 1 Represents ages 5-9 yrs
- 2 Represents ages 10-14 yrs
- 3 Represents ages 15-19 yrs
- 4 Represents ages 20-24 yrs

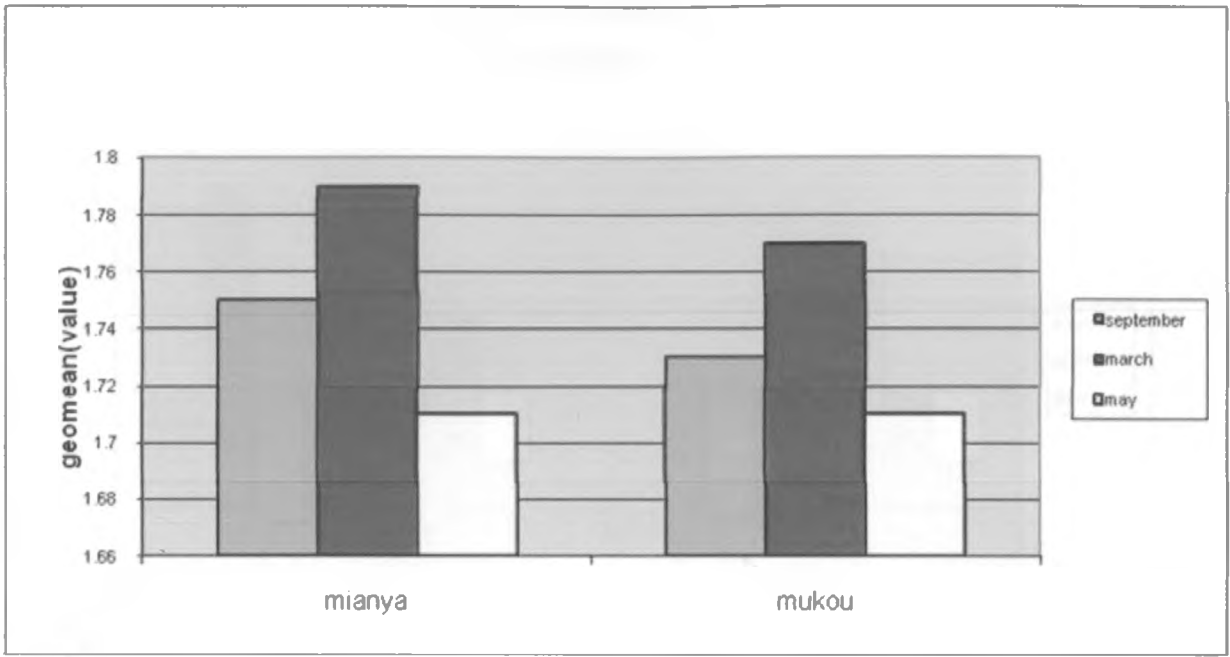


**Figure 10: Prevalence of Schistosomiasis in Mukou and Mianya school children by sex and age group**

**Key**

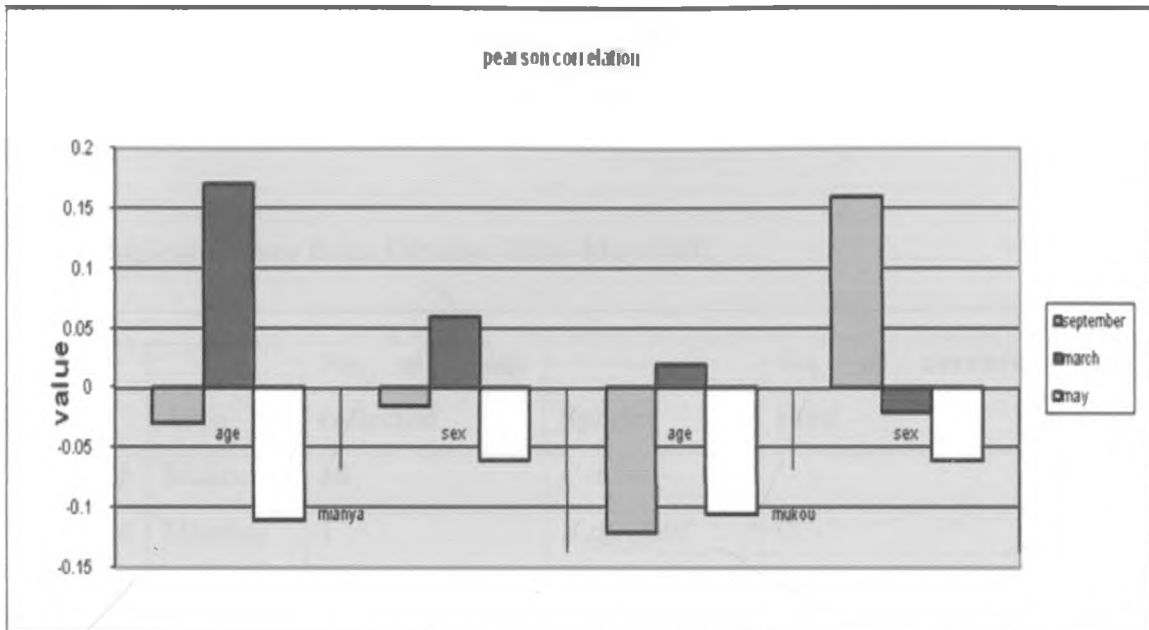
1 Represents ages 5-9 yrs

2 Represents ages 10-14 yrs



**Figure 11:** Intensities of *S.mansoni* in Mianya and Mukou as measured by the geometric mean egg counts.





**Figure 12: Pearson's correlation of age and sex versus prevalence**

Figure 12 above shows the comparison between age and infection using Pearson's correlation. The negative relationship indicates that with an increase in age, there was a decrease in infection and vice versa.

### 3.3 Malacology survey results

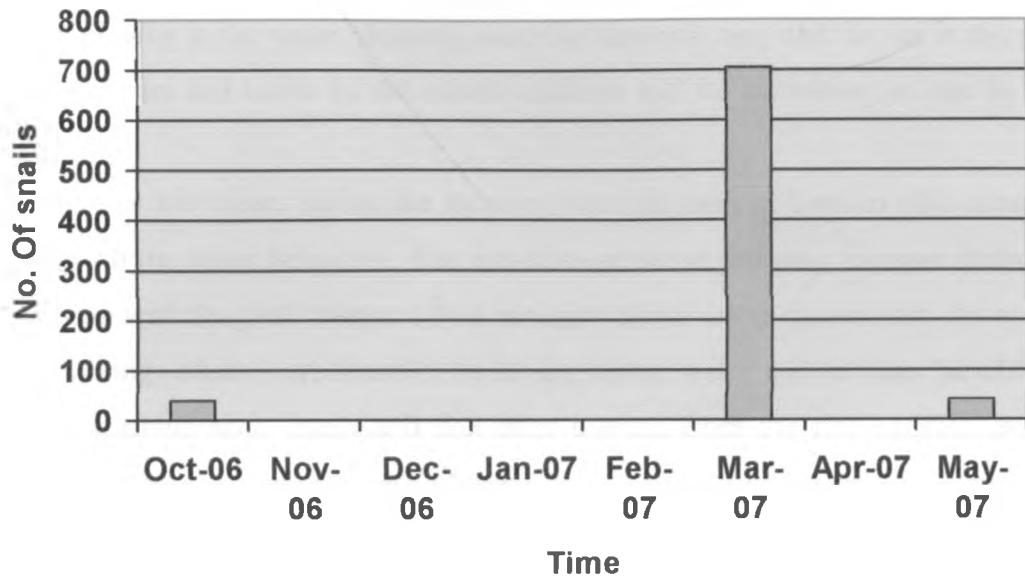
The first survey was done during the rainy season October 2006 and the total number of snails collected was 39; out of these 1 was identified as *Biomphalaria pfeifferi* and 38 as *Physca acuta*. In the month of March 705 snails of the genus *Biomphalaria* were collected in both the study areas. In the final month of May 40 snails of the genus *Biomphalaria* were collected.

The cercarial density was low; the single snail collected in the month of October did not shed any human or non human cercaria. In March four snails shed non- human cercaria and three human, in May no snail shed. Table 7 and figure 13 below show the findings of the survey. The Malacological survey showed that the vectors responsible for infection were not in abundance in the study area.

**Table 7**

**Malacological Survey from October 2006-May 2007**

<b>Date</b>	<b>Area</b>	<b>No. of snails collected</b>	<b>Species</b>	<b>No. of cercaria shed</b>
24.10.06	Mukou	38	<i>P.acuta</i>	-
26.10.06	Mianya	1	<i>B.pfeifferi</i>	0
02.03.07	Mianya	16	<i>B.pfeifferi</i>	4 non human
02.03.07	Mianya	110	<i>B.globosus</i>	-
07.03.07	Mianya	7	<i>B.pfeifferi</i>	0
07.03.07	Mianya	120	<i>B.globosus</i>	-
08.03.07	Ndorome	452	<i>B.pfeifferi</i>	3 human
08.03.07	Nyamindi	85	<i>B.pfeifferi</i>	9 human
20.05.07	Mukou	12	<i>B.pfeifferi</i>	0
20.05.07	Mukou	18	<i>B.globosus</i>	-



**Figure 13: Distribution of vector density in the study area**

### 3.4 Risk factor survey results

#### 3.4.1 Water contact results

In Mianya area during the one week survey, the average number of adults coming into contact with water was 63, and that of the children coming into contact with water was 1029 which gave a total of 1092. The ratio of children to adults coming into contact with water in this particular area is 16: 1, indicating that in the area the number of children coming into contact with water is higher than the number of adults. In Mukou area the total number of adults and children coming into contact with water was 259. Water contact activity was seen to be high from 6am in the morning to around 10 am then go down, and peak again at 1pm. In Mukou the highest average peak number of water contact was 43 between 7 and 8 am as can be seen in figure 15. In Mianya the activities were observed to be high as from 6am to 9am, with peak numbers of children coming

into contact with the water being 182. The peak activities were also observed to be high at around 3- 4pm when the peak water contact activity was 153 as can be seen in figure 14. Water contact activities are more or less the same in the study area and they include, children playing in the water, drawing water for domestic use, and for use in the schools, cleaning of feet and hands by the school children and for swimming as can be seen in figure 17.

The activities are higher during the morning with the ratio of boys to girls coming into contact with the water being 3:1. The activities go down and only increase during lunch break again with the girls' of ages 12-14 having a higher water contact than the boys.

In the evenings adults were found to be having higher water contact than the children as they are washing their hands and feet after coming from the rice paddies, and other domestic duties that require them to come into contact with the water. Figures 14-15 below show water contact counts and patterns observed during daily water contact surveys in the study areas. Due to logistical problems it was difficult to separate water contact pattern for children and adults in mukou area, therefore the total count was put together

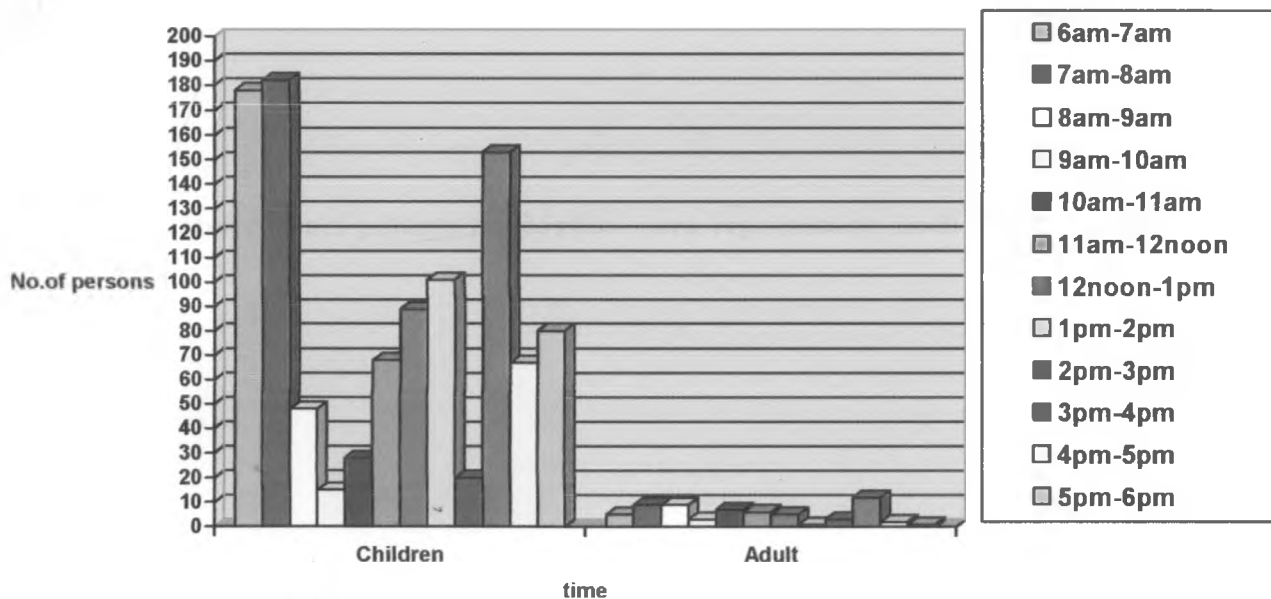
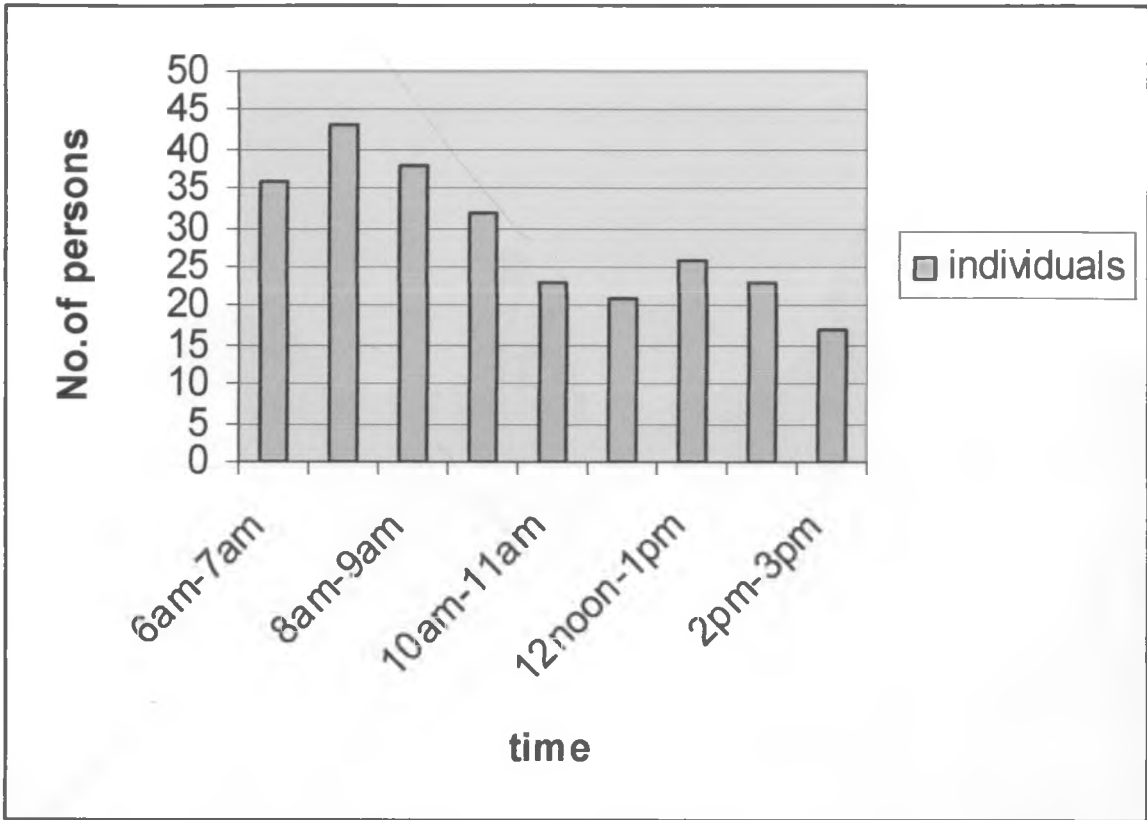


Figure 14: Water contact Pattern for Mianya area.



**Figure 15: Water contact pattern for Mukou Area representing both children and adults**



**Figure 16: Latrines in Mianya Primary School that are located right next to rice paddies**



**Figure 17: School children from Mukou primary School swimming in rice paddies and Canals**

### **3.4.2 Latrines and leaky tins survey**

In Mukou area 50 homesteads were sampled out of which, 48 houses had toilets that were already in use, and 2 houses were found not to have latrines. 16 houses had latrines that were out of use including the 2 houses that were found not to have latrines in use.

Of the 48 toilets that were in use, 2 were in good condition, 22 average, 4 bad, 18 poor and 2 in extremely bad condition.

In the primary school there were 8 toilets in good use and 6 were out of use, and 2 well constructed toilets for teachers however as shown in figure 17 these toilets have been constructed right next to the rice paddies. There were no leaky tins in use for the largest part of my study.

#### **Key used in grading the toilets**

Good- constructed using stone and iron sheets

Average – constructed using wood and iron sheets

Bad – made out of mud

Poor – made out of sack material

Very poor – made out sack material

In Mianya area 50 homesteads were sampled out of which 48 houses toilets that were in use 2 houses had had no toilets at all. 46 houses had at least two toilets that were out of use. Out of the 46 toilets that were in good use condition 4 Of them were average, 12 were bad, 12 were poor, and 22 were very poor.

In the primary school the nursery school children had 6 good toilets

### **3.4.3 Shoe wearing practice**

In the surprise visit that was carried out in Mianya Primary school on a single day, it was observed that 60 children had put on shoes on that day, of which 18 were boys and 42



were girls. The number of pupils without shoes was found to be 302, of which 158 were boys and 144 were girls

The ratio of pupils with shoes to those without was 1:5. The ratio of boys to girls with shoes is 3:7, indicating that more girls than boys put on shoes in the school. The ratio of boys to girls without shoes is 1:1, indicating that the number of boys without shoes is equal to the number of girls without. Tables 13-15 and figures 18 and 19 show the shoe wearing practices in Mianya primary schools.

**Table 8**

**Shoe wearing Practice in Mianya**

No. of Pupils in shoes				No. Of Pupils without		
Class	Boys	Girls	Total	Boys	Girls	Total
8	0	7	7	14	6	20
7	3	6	9	10	11	21
6	3	5	8	16	19	35
5	1	4	5	14	19	33
4	0	3	3	17	16	33
3	4	0	4	26	27	53
2	4	3	7	26	19	45
1	3	14	17	35	27	62

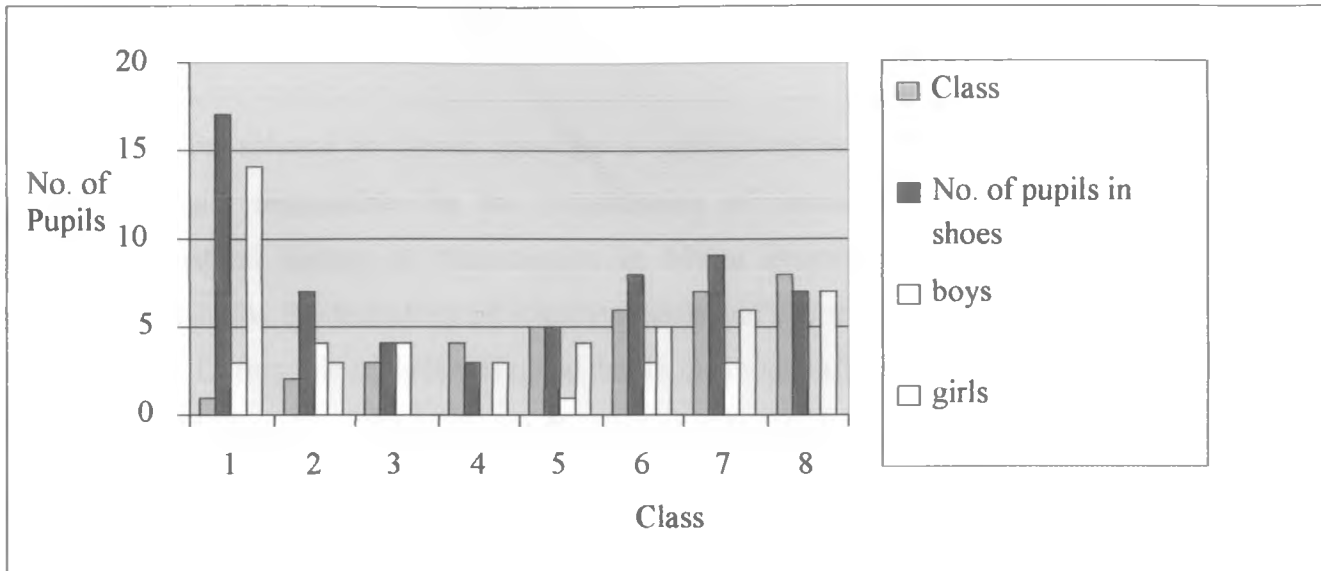


Figure 18: Graph showing number of pupils in shoes

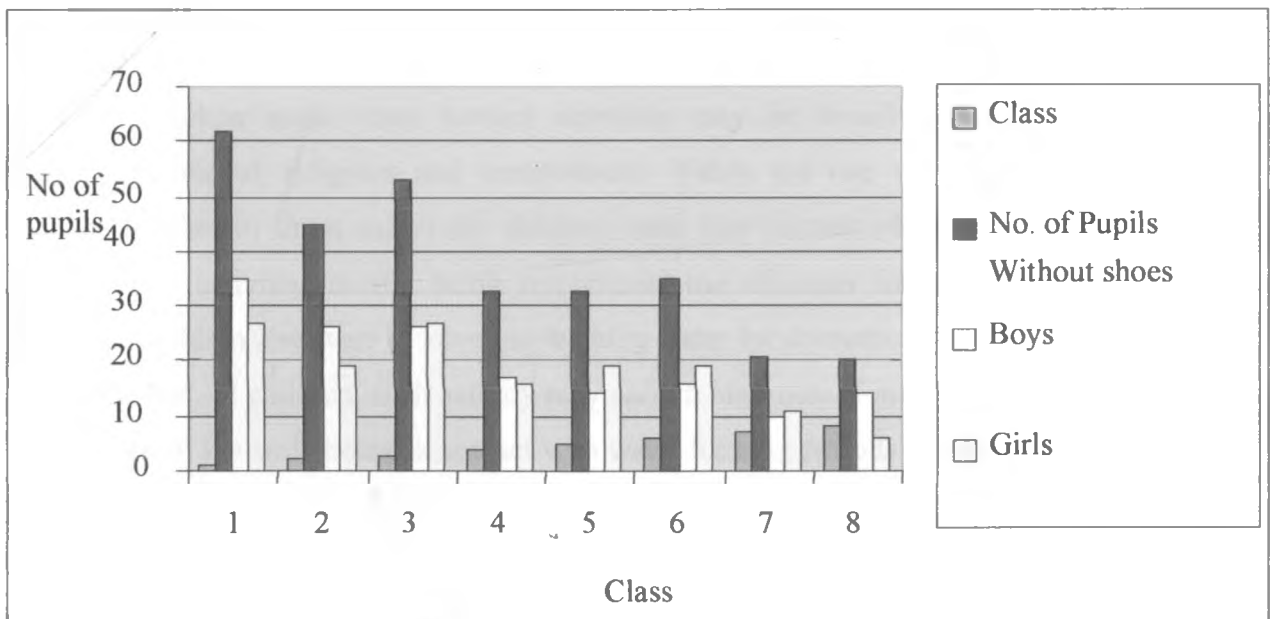


Figure 19: Graph showing number of pupils without shoes

## CHAPTER FOUR

### 4.0 GENRAL DISCUSSION

#### 4.1 Introduction

The rice irrigation scheme in Mwea provides a suitable niche for the survival of *Biomphalaria* snails responsible for the transmission of intestinal schistosomiasis. Therefore the natural history of transmission in Mwea irrigation scheme plays a fundamental role in the Epidemiology of schistosomiasis and soil transmitted helminthes in the study area. During this study it was noted that in the month of May when the vector density was low (Figure 13), the prevalence of infection was also low. But further studies need to be carried out to demonstrate the relationship between vector density and schistosomiasis prevalence in the area.

#### 4.2 Risk factors associated with *S.mansoni* and STH infections.

Knowledge of the pattern of exposure to infection is essential to an understanding of the epidemiology and successful control of an infectious disease and, in recent years, increasingly complex studies of water contact have been made in endemic areas. In Mianya and Mukou areas water contact activities may be broadly classified into domestic, recreational, religious and occupational. Within the one week observation period, the number of times (tally) the children came into contact with the water was 1029 with their activities mostly being recreational use of water for swimming and playing. The children also were involved in fetching water for domestic use and cleaning of hands and feet. In children, such activity may carry a high risk of infection as it often involves much of the body being in contact with water for long periods of time. Subjects of all ages were observed to wash themselves in surface water, an activity in which the risk of infection may be modified by the cercaricidal action of soaps, but during the observations the children were not seen to use any soap. In this case therefore there would be no modification of the cercaricidal action of soap.

It was relatively easy to obtain the general picture of the pattern of water contact behavior in the two communities, but the complexity of water contact behavior and transmission

systems make it a challenge to draw a quantitative assessment of the exposure to infection of individuals or groups of subjects since cercariae densities vary with site, season and time of day.

Contact with cercariae is also likely to vary with duration of water contact, type of activity and the surface area of the body in contact with water. Adequately planned schedules of observation may allow for variation in human behavior, but the analysis of such data to assess individual exposure to infection and the importance of different activities is difficult and involves assumptions which can lead to ambiguity in interpretation (Dalton and Pole, 1978; Barbour, 1985).

Water contact is the most important exposure to infection as far as schistosomiasis is concerned. Apart from schistosomiasis the children were also examined for soil transmitted helminthes; hookworms, ascaris, trichuris and *Hymenelopsis nana*.

Though the prevalence's of the soil transmitted helminthes were not as high as of schistosomiasis, it is important to discuss the risk factors associated with these infections. The sanitation situation in the study area is seen as one of the factors contributing to the transmission of soil transmitted helminthes. In the villages some houses were found not to have any latrines at all while others were found to have latrines of very poor condition. In the primary schools Mukou and Mianya were found to have good latrines, but in Mianya it was noted that the latrines were full and were leaking into the rice paddies. Figure 16 shows that the latrines have been constructed next to the rice paddies and the effluents spill into the canals that feed the paddies. It was also noted that the children and the villagers use this canal water for most of their domestic needs. Soil transmitted helminthes are common in areas with poor sanitation.

Trichuris infection is common in areas of high rainfall, high humidity, dense shade and poor sanitation and contaminated soil, as is the case in most of Mwea irrigation scheme. Trichuris infection is often associated with Ascaris. The greatest prevalence is in children of primary school age who pollute the soil around the house, and who develop heavy worm burdens (Crompton et al., 1985). Ascaris eggs best develop in shady damp soil, as it is in Mwea. The damp soil that supports rice farming in Mwea is favorable for hookworm, ascaris and Trichuris egg development. While in the paddies rice farmers

have little or no access to toilets and these increases the chances of defecating in the soil hence increasing chances of transmission.

As for hookworm the only reservoir of infection is man and the proportion of hookworm infection depends upon an adequate source of infection in the human population, the deposition of eggs in a favorable environment for extrinsic development of the parasite, appropriate conditions of the soil (Moisture and warmth) to allow larvae to develop and suitable conditions for the infective larvae to penetrate the skin. So in addition to poor sanitation as the case is in Mwea, the soils also provide a suitable environment for the survival of soil transmitted helminthes eggs. The mean relative humidity in Mwea is 79.6% and 95.2% (KARI, Mwea field station 2003).

The lack of facilities such as tap water also increase the risk of transmission of helminthes the school children have no place to wash their hands after visiting the toilets and those who use canal water to wash their hands also risk infection with Schistosomiasis.

#### **4.3 Prevalence and Intensity of *S.mansoni* in the school children**

In Mianya primary school the prevalence of Schistosomiasis infection during the entire study period was greater in males than in females, while in Mukou it was greater in females than in males except for the month of March. In standard 3, this is the age group of 5-9; 10-14, the overall prevalence of infection of Schistosomiasis was greater in males than in females. When comparing between the prevalence of infection and the age of the school children using the Pearson's correlation analysis: Figure 12 shows a negative relationship in prevalence of infection and age in both schools. From these results we can deduce that with increase in age there is a decrease in infection. The age group of 10-14 in Mukou had a higher ratio of heavy worm intensities as compared to Mianya, but Mianya had a higher ratio of moderate worm intensity as compared to Mukou. In many foci the prevalence of infection is greater in males than females, e.g. the Nile delta (Farooq *et al.*, 1978), the Philippines (Pesigan *et al.*, 1958) and northern Nigeria (Paugh and Gilles, 1978). Female pupils in both Mianya and Mukou had a higher ratio of heavy worm intensity as compared to the male pupils. Sometimes as in the Gambia, the

intensity and prevalence of infection have been found to be similar in the two sexes despite apparent differences in exposure to infection (Wilkins *et al.*, 1984a). In most cases the prevalence is higher in females, as in Mende communities in Sierra Leone where fishing is a female occupation (White *et al.*, 1982).

The relationship of infection to other personal attributes has received less attention but a large study in the Nile delta showed that fishermen, boatmen, farmers and farm workers, all groups with a high occupational contact with water, had a high prevalence of infection, as did Muslims in comparison with Christians (Farooq *et al.*, 1966). In Machakos district of Kenya, *S.mansoni* egg counts have been shown to be lower in wealthier households in those with better farms (Nordbeck *et al.*, 1982). Adult immigrants into endemic areas are a group of particular interest. A study in Brazil (Kloetzel and Da Silva, 1967) has shown that the relationship between immigrants' length of residence in an endemic area and infection in subjects born in the area, suggesting that length of exposure and infection rather than a factor related to age, such as water contact, should be seen as determining the pattern. This study shows that there is indeed a relationship between infection and different age groups among the school children and this can be attributed to the water contact behavior. In the age group of 5-9 and 10-14 in both schools, prevalence of infection with schistosomiasis is at its highest, with prevalences as high as 43.6% being recorded in Mianya area, and 64.5 in Mukou area. This is an active age group especially in water contact activities, be they domestic or for leisure, e.g. swimming. Apparently when comparing the relationship between age and prevalence of infection, the Pearson's correlation value was -0.025 at the confidence level of 0.05, indicating a negative correlation; as age increased there was a decrease in infection.

#### **4.4 Infection and Re-infection pattern of Schistosomiasis in the School children**

The Ministry of Health of Kenya in conjunction with the Ministry of Education and The Eastern and Southern Africa Center for International Parasite Control (ESACIPAC), a branch of The Kenya Medical Research Institute (KEMRI), has been providing free antehelminthic treatment to all primary schools in Mwea. The programme started in 2004 and is on going. Initially the prevalence was as high as 70% and after treatment the

prevalence was projected to drop to as low as 19%. The treatment has an impact of reducing the prevalence of infection. But after a few months of treatment the prevalence shot up again. This can either be largely attributed to reinfection, because citing drug resistance is still very controversial, although more research needs to be done to ascertain this.

Of all the primary schools in Kirinyaga district that are under the treatment programme, Mianya has had the highest prevalence of infection. Before the initial mass treatment, in 2004 the prevalence was 71.1% and after the treatment it dropped to 19.8%. This indicates that the drug Praziquantel was able to reduce the worm burden in the primary school children. The 19.8% prevalence that was recorded 8 weeks after the treatment was probably due to the juvenile parasites that had since matured. In 2005 the prevalence level was at around 30% compared to the previous year of 70%. The prevalence in 2005 reduced drastically from around 30% to around 5.3%. These figures show that treatment has an effect in reducing the prevalence level. In 2006 the prevalence levels rose to around 60% and then reduced drastically to 16% after treatment. This pattern of infection and reinfection has been evident since treatment started.

The prevalence of soil transmitted helminthes has been low over the years; this probably indicates a success in the treatment programme as compared to Schistosomiasis.

#### **4.5 Other studies done in the area**

A study carried out on the Pattern of *Schistosoma mansoni* infection after intervention in Mwea irrigation scheme in Kenya, showed high prevalence of reinfection among the primary school children. Muthami and others (Muthami *et al.*, 1995) state that in endemic areas, children have the highest prevalence and intensity of infection due to their more extensive contact with water relative to adults. Chemotherapy helps to control the disease, but population immigration, untreated pregnant women and very young children, and the selectiveness of control strategies make reinfection inevitable (Muthami *et al.*, 1995). Individuals aged 5-19 years showed an increasing trend of reinfection compared to individuals aged 30-59 years, with more than 50% of subjects in the 5-19 year old age group being reinfected by 12 months of follow up. The rather unusual occurrence of peak intensity of infection among 5-9 year old children from Mwea irrigation scheme in

Kirinyaga district suggests that they get exposed at an earlier age than in other endemic areas.

Other studies carried out in the district have shown prevalence of as high as 73% and 94% among primary school children (Mutahi and Thiongo 2005).

A study conducted by The Eastern and Southern Africa center for International Parasite Control demonstrated that intestinal Schistosomiasis is prevalent in Mwea. The prevalence among 2300 children in 5 schools in the district, before treatment was 47.4% for *S. mansoni* and 16.7% for *N. americanus*, 1.6% for *A. lumbricoides* and 0.8% for *T. trichura*. Prevalence of infection was seen to increase with age especially for *S. mansoni* and *N. americanus*. Prevalence of *S. mansoni* was the highest for the age group of 11-15 years of age, and then decreased slightly at 15-19 years of age. *Trichuris trichura* and *A. lumbricoides* infections remained low in all age groups. The overall cure rate was 100% for *A. lumbricoides* (from 44 to 0), 18.2% for *Trichuris trichura*, 96.0% for *N. americanus* (1-16/396) and 92.6% for *S. mansoni* (1-167/1154) (Kihara *et al* 2007).

#### **4.6 Conclusion and Proposed Future Studies**

The situation of Schistosomiasis in Mwea region is wanting, and is also likely to worsen with the expansion of areas under rice cultivation and continual predisposal to risk factors associated with transmission. There is an increase of small scale rice growing, along river valleys and streams next to the schemes. This automatically increases the risk of spreading the infection to new areas. The study involved parasitological surveys in two communities with different geographical settings. One of the schools is placed in the Mwea Township while the other is placed in the village, yet there was no major difference in the transmission, reinfection or water contact patterns. Both schools displayed similarities in the epidemiology of schistosomiasis and STH.

The situation of soil transmitted helminthes is not as bad as that of Schistosomiasis and the prevalence of the same are at manageable and controllable levels.

World Health Association (WHA) resolution 54.19 promotes an innovative public health approach in which Schistosomiasis control is combined with that of soil-transmitted helminthes. The WHO Expert Committee has recommended the practical aspects of its implementation.



Combined control of Schistosomiasis and soil transmitted helminthes tackles two diseases at the same time and thus saves on costs and time. This committee also suggested that in specific areas other helminthic infections, such as food borne trematode and cestode infections, be considered for control according to the same approach. Treatment with any of the anthelmintic drugs on the WHO essential drug list (Albendazole, Levamisole, Mebendazole, or Pyrantel – for soil transmitted helminthes, and Praziquantel for all species of schistosome) is safe, even when given to uninfected people.

The rising and falling levels of the prevalence of infection with Schistosomiasis and soil transmitted helminthes and control of the same is not a short-term undertaking. Deworming must become a regular feature of a child's schooling and, control programs must be embedded in the country's infrastructure, health services and ongoing public health programs.

During this study the objectives were successfully met, whereby the main one was to study the infection and reinfection pattern of Schistosomiasis and STH in school children after 3 years of therapeutic intervention and the factors affecting transmission. This main objective was narrowed down to; studying the prevalence and intensity of Schistosomiasis and STH in the school going children, where by the study determined the prevalence and intensity of soil transmitted helminthes and schistosomiasis among the school children before and after treatment with deworming drugs.

The study was also able to demonstrate the spatial and temporal variations in vector and cercarial density. Here the study managed to sample the number of infective snail and cercariae in the study area. Concerning this objective and using the findings, this study highly recommends that an all year round study on the same be done so as to capture the seasonality of infection. The study also recommends that a series of mark-recapture sampling should be carried out when studying the snail population. The mark recapture programme would provide data on snail survival rate-and probably investigate snail movement and this could be linked to spread of infection

Finally this study was able to investigate the risk factors associated with *Schistosoma mansoni* and STH infection, of which it was able to display the behavioral and

predisposing factors that contribute to high infection levels. The study was able to establish that water contact behavior in the area played a major role in the transmission of schistosomiasis, and poor sanitation played a major role in the transmission of soil transmitted helminthes. In addition to the continuing yearly treatment programme done in the primary schools, this study highly recommends that the Mwea rice irrigation workers should also have easy access to regular treatment for schistosomiasis. Praziquantel can be made available to them as part of broader community based drug delivery programs or outreach services, or simply demand through the most peripheral levels of the primary health care system (community health workers or drug distributors). The current low cost of praziquantel opens up real possibilities for cost-recovery and sustainable access.

Many control operations implemented through a single disease control mechanism are simply beyond the financial and human resource of the great majority of endemic countries (WHO 2001). This study promotes and recommends further the combined treatment approach.

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**Appendix 2 Malacological survey sampling form**

**Snail Sampling for Mukou October 2006**

Snail sampling form for Mukou						
Date .....						
Investigators.....						
Village.....			School...Mukou.....Water source.....			
Time of sampling.....Dry/Rain.....Water temperature.....						
GIS Record: Elev..... Latitude..... Longitude.....						
Site description			Vegetation			
		Present =	Absent =	Sand =		
River						
Stream						
Canal						
Furrow						
Paddy	Rice					
	No. Collected	No.shed				
B.Pfeifferi						
B.tropicus						
B.globosus						
B.africanus						
L.natalensis						
M.tuberculata						
Others... ..						
Water/environment characteristics						
Soil Type						

PH						
Salinity						
Magnesium						
Calcium						
Humidity						
Velocity						
Use by domestic animals.....Yes =1 No =2						

### Appendix 3 Results of the Parasitological survey in Mukou September 2006

Total Number of pupils (N=181)		
Parasite	Number of positive pupils	Prevalence (%)
Ascaris	0	0
Trichuris	0	0
Hookworm	0	0
Schistosomiasis	41	22.7
Others	1	0.5

### Appendix 4 Results of the Parasitological survey in Mianya September 2006

Total Number of pupils (N=182)		
Parasite	Number of positive pupils	Prevalence (%)
Ascaris	4	2.2
Trichuris	0	0
Hookworm	7	3.8
Schistosomiasis	57	31.1
Others	4	2.1

#### Appendix 5 Results of the Parasitological survey in Mianya March 2007

<b>Total Number of pupils (N=377)</b>		
<b>Parasite</b>	<b>Number of positive pupils</b>	<b>Prevalence (%)</b>
Ascaris	12	3.2
Trichuris	0	0
Hookworm	13	3.44
Schistosomiasis	109	28.9
Others	2	0.53

#### Appendix 6 Results of the Parasitological survey in Mukou March 2007

<b>Total Number of pupils (N=432)</b>		
<b>Parasite</b>	<b>Number of positive pupils</b>	<b>Prevalence (%)</b>
Ascaris	2	0.2
Trichuris	0	0
Hookworm	5	1.2
Schistosomiasis	74	17.1
Others	3	0.6

#### Appendix 7 Results of the Parasitological survey in Mukou May 2007

<b>Total Number of pupils(N=441)</b>		
<b>Parasite</b>	<b>Number of positive pupils</b>	<b>Prevalence (%)</b>
Ascaris	3	0.67
Trichuris	0	0
Hookworm	1	0.22
Schistosomiasis	31	6.96
Others	1	0.22

#### Appendix 8 Results of the Parasitological survey in Mianya May 2007

<b>Total Number of pupils (N=378)</b>		
<b>Parasite</b>	<b>Number of positive pupils</b>	<b>Prevalence (%)</b>
Ascaris	0	0
Trichuris	0	0
Hookworm	0	0
Schistosomiasis	33	8.73
Others	0	0

### Appendix 9 Results of the Parasitological survey in Mianya class 3

Total Number of pupils(n=55)		
Parasite	Number of positive pupils	Prevalence (%)
Ascaris	1	0
Trichuris	0	0
Hookworm	2	3.6
Schistosomiasis	24	43.6
Others	0	0

### Appendix 10 Results of the Parasitological survey in Mukou class 3

Total Number of pupils (n=62)		
Parasite	Number of positive pupils	Prevalence (%)
Ascaris	0	0
Trichuris	0	0
Hookworm	0	0
Schistosomiasis	40	64.5
Others	0	0



**endix 11 Intensity threshold for schistosomiasis and STH infections**

ninth	Intensity threshold		
	Light	Moderate	Heavy
<i>nbricoides</i>	1-4999epg	5000-49999epg	≥50,000
<i>chura</i>	1-999epg	1000-9999epg	≥10,000
kworm	1-1999epg	2000-3999epg	≥4,000
<i>msoni</i>	1-99epg	100-399	≥400

**Appendix 11 Intensity threshold for schistosomiasis and STH infections**

Helminth	Intensity threshold		
	Light	Moderate	Heavy
<i>A.lumbricoides</i>	1-4999epg	5000-49999epg	≥50,000
<i>T.trichura</i>	1-999epg	1000-9999epg	≥10,000
Hookworm	1-1999epg	2000-3999epg	≥4,000
<i>S.mansoni</i>	1-99epg	100-399	≥400