ADDIS ABABA UNIVERSITY SCHOOL OF GRADUATE STUDIES
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THE IMPACT OF SNAIL CONTROL ON THE PREVALENCE AND INTENSITY OF SCHISTOSOMIASIS MANSONI IN FINCHAA AND WONJI-SHOA SUGAR ESTATES: POST-PILOT CONTROL STATUS

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ABBREVIATIONS AND ACRONYMS

ANOVA:	Analysis of Variance
EPG:	Eggs Per Gram of Feces
SD:	Standard Deviation
WHO:	World Health Organization
P-value:	Probability Value

ABSTRACT

Schistosoma mansoni is one of the main parasitic infections in Ethiopia which spreads due to water resource development and population migration. Although national schistosomiasis control program has not been established in the country, several pilot controls have been undertaken. Most of these pilot controls were based on endod application as a mollusccicide. This study was conducted from October 2008 to April 2009 to evaluate the impact of snail control on the prevalence and intensity of *S. mansoni* in Finchaa and Wonji-Shoa sugar estates, in the sustainability phase of schistosomiasis pilot control. The study included 302 school children from Finchaa and 333 school children from Wonji-Shoa sugar estates. Stool specimens were collected and examined microscopically using Kato-katz thick smear technique. The prevalence and mean intensity of *S. mansoni* infection were found to be 60.26% and 287.84 $\pm$ 613.37 in Finchaa and 57% and 147.39 $\pm$ 278.07 in Wonji-Shoa sugar estate respectively. In Finchaa sugar estate, the prevalence of schistosomiasis has not shown a significant difference with the prevalence in the post-intervention study ($P = 0.13$). But the mean intensity of infection has significantly increased among the school children ($P < 0.001$). In Wonji-Shoa sugar estate, on the other hand, both the prevalence and mean intensity of the disease has decreased when compared with previous study conducted in 1990 on school children in the estate ($P < 0.001$). But the disease still has high prevalence and moderate mean intensity of infection in both sugar estates. These results in line with comparison to similar works elsewhere and their implications are also discussed.

1. INTRODUCTION

Schistosomiasis, also called bilharziasis, is one of the neglected tropical diseases caused by blood flukes which belong to the genus *Schistosoma*. Schistosomiasis in humans is caused by three main species which are further classified by their clinical forms into urinary schistosomiasis caused by *Schistosoma haematobium* and intestinal schistosomiasis caused by *S. mansoni* and *S. japonicum* (Gryseels *et al.*, 2006; Wu and Halim, 2000). Similarly, other two *Schistosoma* species with limited geographical distribution, *S. intercalatum* and *S. mekongi*, also cause intestinal schistosomiasis (Gryseels *et al*., 2006). In addition, some schistosome parasites of other animals might also occasionally infect humans and others cause cercarial dermatitis, commonly called swimmer's itch (McManus and Loukas, 2008; Verbrugge *et al*., 2004).

From human parasitic infections, schistosomiasis is the second parasitic disease by affecting large number of people in the world. According to a meta-analysis study by Steinmann *et al*. (2006), it is estimated that 779 million people are at risk of schistosomiasis and 207 million people harbor the parasite. Among these estimates, 97% of the infections and 85% of the total population at risk are found in Africa. In addition, it is estimated that more than 280,000 deaths are caused annually in relation to schistosomiasis in Sub Sahara Africa (King *et al*., 2005). Similarly, the disease is believed to causes an estimate of 0.5% to 0.6% disability weights and a total of 4.5 million disability adjusted life years (DALYs) (WHO, 2002). But according to King *et al*. (2005), the disability weights associated with the disease is higher reaching up to 2 -15% and similarly the DALYs are also several folds higher.

Even if the transmission of schistosomiasis has been eliminated or significantly reduced in some countries, the disease is currently increasing associated with water resource developments in other areas (Bruun and Aagaard-Hansen, 2008; Steinmann *et al*., 2006; WHO, 2002). In many countries, such as Burkina Faso, Cameroon, Senegal, Zambia, Nigeria, Kenya, Cote d'Ivoire, Ethiopia and Puerto Rico, schistosomiasis has been introduced to previously non-endemic areas following water resource developments (Boelee and Madsen, 2006; Steinmann *et al*., 2006). In addition, from the total 779 million peoples at risk of schistosomiasis infection, 13.6% (106 million) live in close proximity to irrigation scheme and large dam reservoirs (Steinmann *et al*., 2006).

1.1 Life cycle of schistosome parasites

The life cycle of Schistosome parasites need definitive and intermediate hosts which are accompanied by freely swimming larval stages. Human beings get infection by the parasite of schistosomiasis when contacting with infested surface waters by the infective larval stages called cercariae. The cercariae consists a tail used for motility in the water and a head for attachment to host skin and glands containing proteolytic enzymes to facilitate penetration of human skin (Boelee and Madsen, 2006). During penetration of the skin, the tail is shaded and several other changes accompany the transformation into a new form called the schistosomule (Wu and Halim, 2000). These stages migrate through the body within the bloodstream to lung and liver for further development. In the liver, they develop in to sexually matured adults; pairs with an opposite sex and establish themselves to mesenteric veins during intestinal schistosomiasis (Wu and Halim, 2000; Utizinger *et al.*, 2007). In the case of *S. haematobium*, the adult parasites reside in peri-vesical venules of the urinary bladder (Utizinger *et al.*, 2007).

Paired adults produce several eggs in their life time; more than half of which are trapped inside tissues and these eggs are responsible for the pathology of the disease (Utizinger *et al.*, 2007; Gryseels *et al*., 2006). The eggs released out of the human body with feces (intestinal form) or urine (urinary form) hatch in fresh water in to the first larval form called miracidium. The miracidium swims and penetrates susceptible snail host (genus *Biomphalaria* for *S. mansoni*, *Bulinus* for *S. haematobium* and *Oncomelania* for *S. japonicum*). Then, the miracidium transform into many sporocysts and the sporocysts develop into several cercariae (Wu and Halim, 2000; Utizinger *et al.*, 2007). The cercariae migrate out of the snail and swim in the surrounding water searching for a definitive host. In the definitive host they become mature adults which in turn lay egg and continue its life cycle.

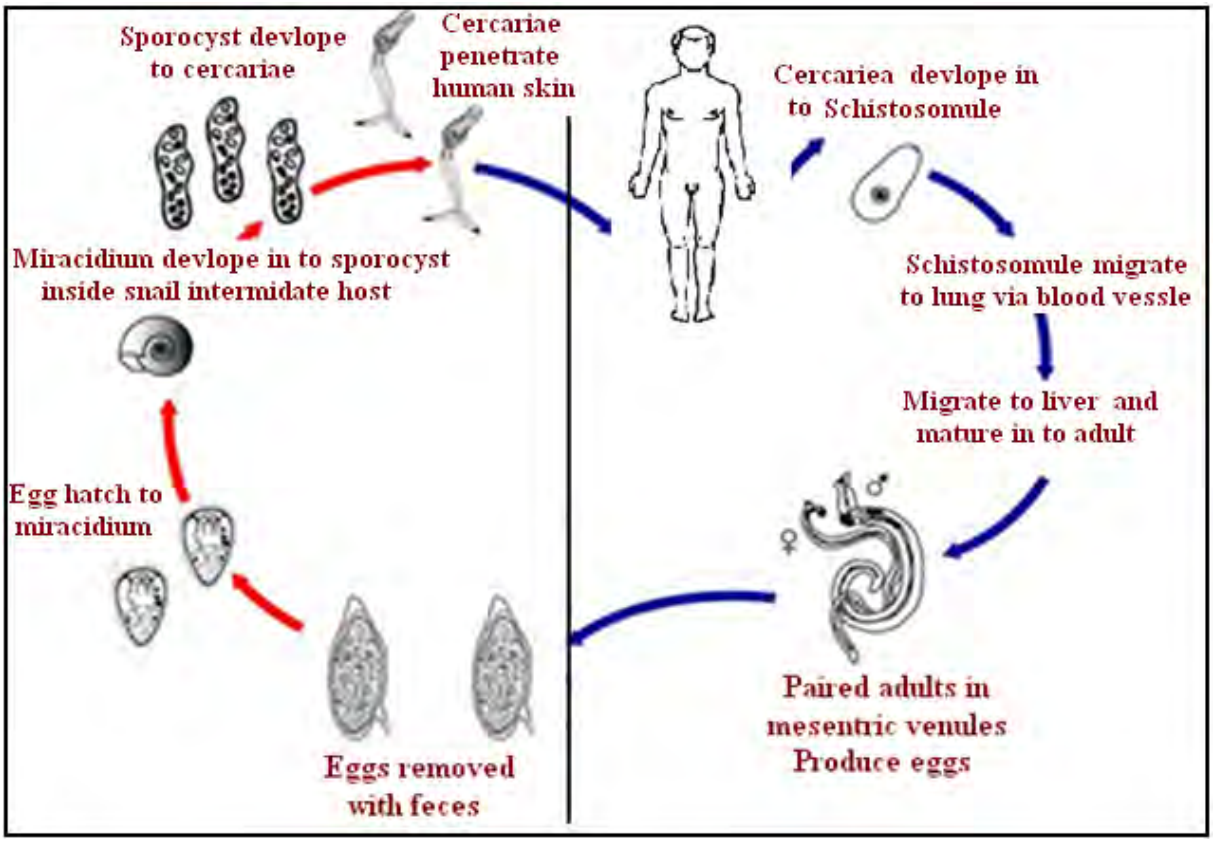


Figure 1: Life cycle of *Schistosoma mansoni*

(Modified from http://www.dpd.cdc.gov/dpdx/html/schistosomiasis.htm)

1.2 Disease manifestations in schistosome infection

Schistosomiasis is principally a chronic disease with acute disease manifestations mostly among first time infections such as in tourists and migrants. During acute pathology of schistosomiasis, penetration of cercariae can cause temporary urticarial rash in skin which may sometimes persist for days as papulo-pruriginous lesions (Gryseels *et al*., 2006). Similarly, the penetration of other animal schistosome cercariae causes allergic reaction as they die inside the skin. This allergic reaction is called cercarial dermatitis or swimmer's itch (McManus and Loukas, 2008; Verbrugge *et al*., 2004). The most common acute case of schistosomiasis is 'Katayama fever' which is a hypersensitivity reaction against the migrating schistosomule. It starts with fever, malaise, eosinophilia and non-productive cough and most patients recover spontaneously. But in some it may develop to a more series disease with hepatosplenomegaly, diarrhea, diffuse abdominal pain and widespread rash (Gryseels *et al*., 2006; Wu and Halim, 2000). Katayama fever caused due to *S. mansoni* and *S. haematobium* infections in endemic communities is rarely seen. But Katayama fever due to *S. japonicum* is relatively seen more often among peoples living in endemic communities (Gryseels *et al*., 2006).

On the other hand, chronic schistosomiasis is caused by repeated immunological reactions against the eggs and their antigens trapped in tissues (Utizinger *et al*., 2007; Gryseels *et al*., 2006). The chronic disease manifestation does not appear until large numbers of egg are trapped in tissues. Therefore, the disease shows its symptoms after several years of infection (Utizinger *et al*., 2007). During chronic infections with *S. mansoni and S. japonicum*, the eggs reaching the intestinal wall provoke immunological reaction as they migrate inside the tissue. These reactions cause mucosal granulomatous inflammations, micro-ulcerations and superficial bleedings

resulting in symptoms including intermittent abdominal pain and discomfort, loss of appetite and diarrhea with or without blood (Gryseels *et al*., 2006).

The major complication during chronic infections of *S. mansoni* and *S. japonicum* is hepatic or hepatosplenic schistosomiasis (Wu and Halim, 2000). During early hepatic schistosomiasis, inflammatory reactions to the trapped eggs in periportal spaces of liver cause hepatomegaly with enlarged left lobe of liver and nodular splenomegaly (Gryseels *et al*., 2006). Repeated immunological reactions to the eggs lead to periportal fibrosis causing a more severe form of hepatic schistosomiasis. In this case, the periportal fibrosis leads to occlusion of the portal vein, portal hypertension, splenomegaly and gastrointestinal varices (Gryseels *et al*., 2006; Alam *et al*., 2009). In addition, the liver becomes hard and nodular; sometimes it may become enlarged (Wu and Halim, 2000). The most series and fatal complication of fibrosis during hepatic schistosomiasis is bleeding of the gastro-esophageal varices which results in anemia, cachexia, hypoalbuminaemia and growth retardation (Gryseels *et al*., 2006).

During chronic urinary schistosomiasis, the eggs trapped in tissues of the genito-urinary system provoke granulomatous inflammation, ulceration, and pseudopolyposis of the vesical and ureteral walls (Gryseels *et al*., 2006). The disease manifestations include haematuria (mainly at terminal urine), cystitis, dysuria, pollakisuria, proteinuria and abdominal pain (Alam *et al*., 2009; Gryseels *et al*., 2006). Chronic cases can eventually lead to bladder ulcer and calcification of bladder and lower ureters resulting in hydroureter, hydronephrosis, polyps and fistulae (Alam *et* al., 2009; Wu and Halim, 2000; Gryseels *et al*., 2006). In addition, more chronic cases might also lead to fatal complications such as parenchymal damage and kidney failure (Gryseels *et al*.,

2006). Urinary schistosomiasis is also widely associated with squamous cell carcinoma or bladder cancer (Alam *et al*., 2009). Similarly, it has been indicated that female genital schistosomiasis exacerbates the effect of human papilloma virus leading to spread of cervical cancer as well as increase the risk of HIV infection (Richens, 2004).

1.3 Global status of schistosomiasis

The occurrence of schistosomiasis has been reported from 76 countries in the tropical region of the world including Djibouti and Nepal where the reports are thought to be of imported cases (Steinmann *et al*., 2006; Gryseels *et al*., 2006). The disease is generally distributed in Africa, the Middle East, Southeast and Western Pacific Asia, South America and the Caribbean islands (Boelee and Madsen, 2006; Hotez *et al*., 2008; Steinmann *et al*., 2006; Zhou *et al*., 2007; WHO, 2002). Among the total 76 countries, ongoing transmission of schistosomiasis is reported from 67 countries and 46 of them are located in Africa (Boelee and Madsen, 2006; Steinmann *et al*., 2006).

S. mansoni is present in 54 countries across Africa, part of the Middle East, South America and the Caribbean (Bruun and Aagaard-Hansen, 2008). Among the 54 countries, 39 countries are present in Africa including Egypt, Tunisia and Morocco where the disease has been significantly reduced due to control efforts (Boelee and Madsen, 2006). In South America and the Caribbean *S. mansoni* is reported from 5 countries including Brazil, Venezuela, Suriname, Guadalupe and Dominican Republic with significant transmission (Hotez *et al*., 2008). In addition, cases of *S. mansoni* have also been reported from other Caribbean countries such as Puerto Rico,

Antigua, St Lucia, Martinique and Montserrat but the disease transmission has been significantly reduced (Steinmann *et al.*, 2006).

On the other hand, *S. haematobium* is distributed among 53 countries in Africa and the Middle East (Bruun and Aagaard-Hansen, 2008). Among the total countries reported for urinary schistosomiasis 44 of them are found in Africa (Boelee and Madsen, 2006). Whereas *S. japonicum* is found in some parts of China since the disease has been controlled in most of previously endemic provinces (Zhou *et al*., 2007; Wang *et al*., 2008). In addition, the disease is also found in Indonesia, Cambodia, the Philippines, Malaysia and Thailand (Leonardo *et al*., 2008; Steinmann *et al*., 2006; Bruun and Aagaard-Hansen, 2008). The other two schistosomiasis parasites, *S. mekongi* and *S. intercalatum*, are reported from 12 countries with limited distributions (Bruun and Aagaard-Hansen, 2008; Gryssels *et al*., 2006). *S. mekongi* is reported from Laos and Cambodia in Mekong river basin; while *S. intercalatum* is reported from 10 central African countries (Bruun and Aagaard-Hansen, 2008).

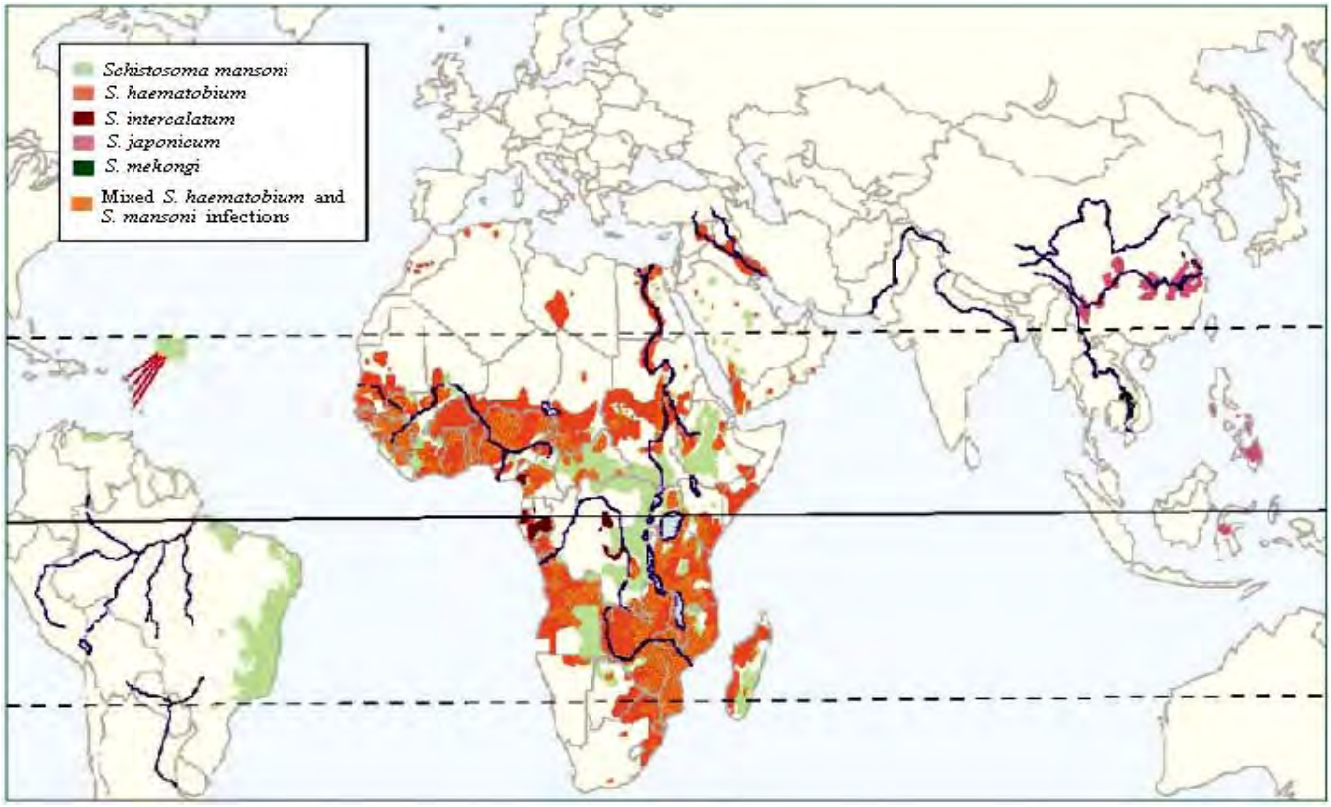


Figure 2: Global distribution of schistosomiasis (Modified from Gryseels *et al*., 2006)

In the control against schistosomiasis, Japan was the first country to eliminate the disease with the last human case of new infection in 1977 (Tanaka and Tsuji, 1997). Tunisia was the second country to achieve interruption of schistosomiasis transmission in the year 1984 (WHO, 2002). Currently, the transmission of schistosomiasis has been eliminated or significantly reduced in several countries including China, Brazil, Turkey, Malaysia, Lebanon, Egypt, Morocco, Venezuela, the Philippines and the Caribbean countries (Steinmann *et al*., 2006; WHO, 2002). The methods used in the control are large scale morbidity control, socio-economic developments and snail control by environmental modifications and molluscicides (Steinmann *et al*., 2006; Tanaka and Tsuji, 1997). In addition to these control methods, vaccines have also showed

promising results for control of schistosomiasis in the future (McManus and Loukas, 2008; Oliveira *et al*., 2008).

In the more recent control effort, in China, national schistosomiasis control program was implemented by a loan from the World Bank involving large scale morbidity control by chemotherapy and chemical control of snails and environmental modifications (Xianyi *et al*., 2005). As a result, the number of infected people was reduced from 1.7 million in the year 1992 to 828,000 in 2001 (Xianyi *et al*., 2005) and to 726,112 in 2004 (Zhou *et al*., 2007). In addition the control program has reached to eradicating the disease in five of previously high endemic provinces (Wu *et al*., 2005).

1.4 Schistosomiasis in Ethiopia

In Ethiopia, both intestinal schistosomiasis caused by *S. mansoni* and urinary schistosomiasis caused by *S. haematobium* are endemic and pose considerable public health problem (Kloos *et al*., 1988; Erko *et al*., 1997a; Ali *et al*., 2006). The first report of *S. mansoni* in Ethiopia dates back to 1934 along the banks of Lake Tana while *S. haematobium* was first reported from Gewani in Afar (WHO, 1987). In the country, *S. mansoni* is widely distributed where as the distribution of *S. haematobium* is restricted to some lowlands below 800m in Awash, Kurmuk (near the Sudan border) and Wabe Shebele areas (Erko *et al*., 1997a; Kloos *et al*., 1988).

The transmission of schistosomiasis in Ethiopia takes place in three main ecologies which are streams, lakes and irrigation schemes (Birrie *et al*., 1993a; Erko *et al*., 1997a). Streams are the

main transmission ecology since they are the main habitats for the snail intermediate hosts in the country. In addition, it has been shown that *S. mansoni* is mostly endemic in agricultural communities situated along streams (Birrie *et al*., 1993a; Kloos *et al*., 1988). Similarly, several researches have also indicated that irrigation schemes are becoming favorable site for transmission of schistosomiasis by favoring the growth of snail intermediate hosts (Bezuneh *et al*., 1995; Kloos *et al*., 1988).

In Ethiopia, there are four known snail intermediate hosts of human schistosomiasis, two *Biomphalaria* and two Bulinid species. The most important intermediate host for intestinal schistosomiasis is *Biomphalaria pfeifferi* (Kloos *et al*., 1988). *B. sudanica* also transmits intestinal schistosomiasis but its distribution is restricted to three localities in the rift valley: Lake Ziway, Lake Abaya and the interface of Tikur Wuha River and Lake Awassa (Erko *et al*., 2006). In urinary schistosomiasis, the two snail intermediate hosts are *Bulinus abyssinicus* and *Bu. africanus* (Kloos *et al*., 1988; Mamo and Redda, 1989). *Bu. abyssinicus* is the transmitting agent of *S. haematobium* in the Awash valley while in Kurmuk the snail intermediate host is *Bu. africanus*. In the lower Wabe Shebele valley where the transmission of the disease is not yet proved, *Bu. abyssinicus* is implicated in the transmission of *S. haematobium* based on the assumption that it serves as intermediate host in neighboring foci in Somalia (Kloos *et al*., 1988; Mamo and Redda, 1989; Erko *et al*., 1997a).

S. mansoni is widely distributed in the country covering most of the places between 1300-2200m altitudes (Ali *et al*., 2006; Erko *et al*., 1997a; Kloos *et al*., 1988). The majority of the endemic places are located in the northern parts of the country in North Gondar (Jemaneh, 1997), Tigray

(Wolde-Michael and Kebede, 1996), Dembia plain (Jemaneh, 1998), Lake Tana area (Erko and Tedlla, 1993, Dagnew, 1993, Degu *et al*., 2002) and South Gondar (Jemaneh, 2000a). The disease is also further distributed in the northeast in Borkena river basin, Wolo (Assefa *et al*., 1998; Berhe *et al*., 2007a; Erko *et al*., 2002a) and in the northwest in middle Beles river valley, Metekel and Awi zone (Teklehaimanot and Fletcher, 1990). In the eastern part of the country the disease has been reported from the upper Awash valley in Metehara sugar estate (Abebe *et al*., 1995) and Wonji-Shoa sugar estate (Simonsen *et al*., 1990). In addition, the disease has been reported in some parts of the former provinces of Harergae (Lo *et al.*, 1989) and Bale (Wondimagenehu *et al*., 1997).

In the central part of Ethiopia, intestinal schistosomiasis has been reported from several communities in Lake Ziway (Birrie *et al*., 1993a; Legesse and Erko, 2007) and Lake Langano areas (Erko *et al*., 2001); and in some parts of the highlands at Addis Ababa (Birrie *et al*., 1996; Erko *et al*., 1996) and Akaki (Mamo *et al*., 1999). In the southern part, the disease was reported from Wondo Genet (Erko *et al*., 2002b), Lake Awassa (Mitku, 2008; Merid *et al*., 2001), Northern Omo (Berhe *et al*., 2007a,b) and Western part of Lake Abaya (Wolde-Michael *et al*., 1999). In the western part of Ethiopia, most of the endemic places are located along Nile valley, in Finchaa sugar estate, Agallu-Meti and Dalati-Sirba areas (between Benishangul-Gumuz and Oromia) (Erko *et al*., 2003; Gunderson *et al*., 1990, 1998). The disease has also been reported in the Southwest at Jimma (Mengistu *et al*., 2007). In addition, *S. mansoni* was also reported from some communities along Baro River with low prevalence rates (Jemaneh, 2000b).

S. haematobium is reported to be transmitted in Lower Awash valley in Dubti, Detabahir and Assaita (Jemaneh *et al*., 1993) and in the middle Awash valley from Ammibara and Gewani (Ayele *et al*., 2008; Hiel-Meskel *et al*., 1989). Beside the Awash valley, the disease is also transmitted in Kurmuk near the Sudan border in Benishangu-Gumuz regional state (Birhanu, 2008). In addition, the presence of urinary schistosomiasis in communities along the lower Wabe-Shebele River basin is also suspected but the transmission of the disease has not been proved (Ali *et al*., 2006; Erko *et al*., 1997a).

Despite the fact that schistosomiasis is high in prevalence and associated morbidity especially in children (Berhe *et al*., 2009); its control effort is restricted to pilot control trials (Erko *et al*., 1997a). Most of the control trials are based on initial mass chemotherapy and application of synthetic molluscicides like niclosamide or plant molluscicides (endod berries) and other snail control methods (Tekle-Haimanot and Goll, 1978; Haile-Meskel *et al*., 1989; Erko *et al*., 2002a; Erko *et al*., 2003; Gundersen *et al*., 1990). One of the pioneer works in pilot control trials was done in Adwa which used the application of endod in water bodies infested with snails (Goll *et al*., 1983). After that several control trials has been conducted in Borkena River basin (Kemise, Bati and Harbu) (Erko *et al*., 2002a), the Nile Valley (Gundersen *et al*., 1990), Middle Awash Valley (Hiel-Meskele *et al*., 1989) and Finchaa Sugar estate (Erko *et al*., 2003).

1.5 Justification of the study

Even if there were pilot control trials of intestinal schistosomiasis in Wonji-Shoa and Finchaa sugar estates, effect of the control programs and the current situation of schistosomiasis is not known. In addition, specific works concerning the schistosomiasis status and control strategies in both sugar estates are not also updated. Therefore, a study to evaluate the impact of the schistosomiasis control program that has been practiced in Wonji-Shoa and Finchaa sugar estates is important to know the current situation of the disease.

Statement of the Hypothesis: The prevalence and intensity of *S. mansoni* infection in Finchaa and Wonji-Shoa Sugar Estates was reduced in post-pilot control/sustainability phase mainly due to snail control measures.

2. OBJECTIVES OF THE STUDY

2.1 General Objective

The general objectives of this study were to assess the impact of schistosomiasis control on the prevalence and intensity of the disease in Finchaa and Wonji-Shoa sugar estates.

2.2 Specific Objective

- To determine the current prevalence and intensity of *S. mansoni* infection in Finchaa and Wonji-Shoa sugar estates

- To compare the current prevalence and intensity of schistosomiasis with post-intervention prevalence and intensity of the disease

- To evaluate the impact of schistosomiasis pilot control which was implemented in the mid-1990s

3. MATERIALS AND METHODS

3.1 Descriptions of the study areas

This study was conducted in Finchaa and Wonji-Shoa Sugar Estates from October 2008 to April 2009. Currently, both sugar estates are expanding their development of sugarcane plantations. This inevitably leads to attraction of more labor force to these schistosomiasis endemic places.

Finchaa Sugar Estate is located in Finchaa valley 332 km from Addis Ababa in East Welega Zone of the Oromia Region. The sugar estate is located between 9^0 30'N to 9^0 60' N latitudes and 37^0 10' to 37^0 30' E longitudes (Girma and Awulachew, 2007) and at about 1,350-1600 meters altitude (Chala, 2007). It is stretched in most part of the Finchaa River valley cultivating more than 8,500 hectare of irrigated land using sprinkle irrigation system which is worth more than 300 million US dollar (Birrie *et al*., 1997; Girma and Awulachew, 2007).

In the sugar estate, there were more than 6,200 permanent and temporary employees; they live with their families in different villages in the estates. The total number of people living in the different camps of the sugar estate reaches 20,000 (Girma and Awulachew, 2007). The residents live in 5 villages named alphabetically from Village A to E and one village called Agemsa which is located around the sugar factory plant. Polyclinic, high school, technical and vocational school and other main services are located in this village. In addition, each village contains smaller settlement areas commonly known as Camps. In each village, there was one elementary school and one health center. Beside the main village, most of the residents were laborers and their families who work in the sugarcane farms. This study was conducted in Finchaa Valley Elementary School found in Camp 7 of Village E.

The sprinkle irrigation system used in the sugarcane farms reduces the formation of snail habitats hence the risk of schistosomiasis is expected to be low. However, the transmission of the disease occurs in streams rather than the irrigation system and most of the schistosomiasis cases are aggregated in residents in Village E. The prevalence of the disease in the camp was 30% among the residents in 1994 (Birrie *et al*., 1997) and 78% among school children in Finchaa Valley Elementary School (Erko *et al*., 1997b). After schistosomiasis pilot control trial was initiated in the area, the prevalence of the disease decreased to 26% among the residents and to 56% among the school children of camp 7 after four years (Erko *et al*., 2003).

The other study site is Wonji-Shoa Sugar estate which is located in the upper Awash River valley. The sugar estate is 114 km from Addis Ababa in East Shewa Zone of the Oromia Region. The place is located within the geographical bounderies of 8^0 21' to 8^0 29' N latitudes and 39^0 12' to 39^0 18' E longitudes (Girma and Awulachew, 2007). In addition, the sugar estate is about 1,540m above sea level (Yifru *et al*., 2007). The sugar estate is currently cultivating more than 7,279 hectar of irrigated land using a furrow type irrigation system (Girma and Awulachew, 2007).

In the sugar estate more than 7,500 people are employed each year; including their families the total population in the sugar estate is more than 24,000 (Girma and Awulachew, 2007). The populations live in 13 camps scattered among the different parts of the sugar estate. Most of the residents in the camps were laborers who work in the nearby sugarcane farms. In the sugar estate, there was one hospital opened in the year 1961 and under it there were three polyclinic and 14 clinics both inside and outside the sugar estate. Inside the sugar estate there were two elementary schools; in addition other students also study in nearby towns like Awash Melkasa and Wonji.

The furrow irrigation system implemented in the sugar estate makes it a favorable place for supporting snail intermediate hosts as a result the risk of schistosomiasis is very high. In addition, schistosomiasis was introduced in to the estate as a result of the irrigation development (Simonsen *et al*., 1990; Tekle-Haimanote and Goll, 1978). First, intestinal schistosomiasis was reported in the sugar estate among 10 migrant laborers in the year 1964 and spreads more in the estate (Simonsen *et al*., 1990). As a result, control of schistosomiasis was initiated in 1971 by applying niclosamide and N-tritylmorpholine in the secondary and tertiary drainage canals (Tekle-Haimanote and Goll, 1978). Although there was mollusccicide application the total prevalence of the disease has increased from 9.24% to 13% after two years. Whereas, schistosomiasis confirmed to spread throughout the sugar estate after that with a prevalence reaching up to 82% among school children (Simonsen *et al*., 1990).

The pilot control of the schistosomiasis was started in 1994 by Wonji Hospital in collaboration with Aklilu Lemma Institute of Pathobiology, the Ethiopian Science and Technology Commission and Ethiopian Health and Nutrition Research Institute. The hospital opened a Bilharzia control unit with personals trained by Aklilu Lemma Institute of Pathobiology, on the preparation and use of endod berries as a mollusccicide. Starting from 1994 snail surveys and endod applications were conducted every year. In addition, mass and targeted chemotherapy were also given during schistosomiasis survey in 1997. Since then, the hospital has been undertaking periodic surveys on the disease as part of the monitoring mechanism. The results obtained in these surveys by are explained in this thesis under sections 4.4 and Appendix 5.

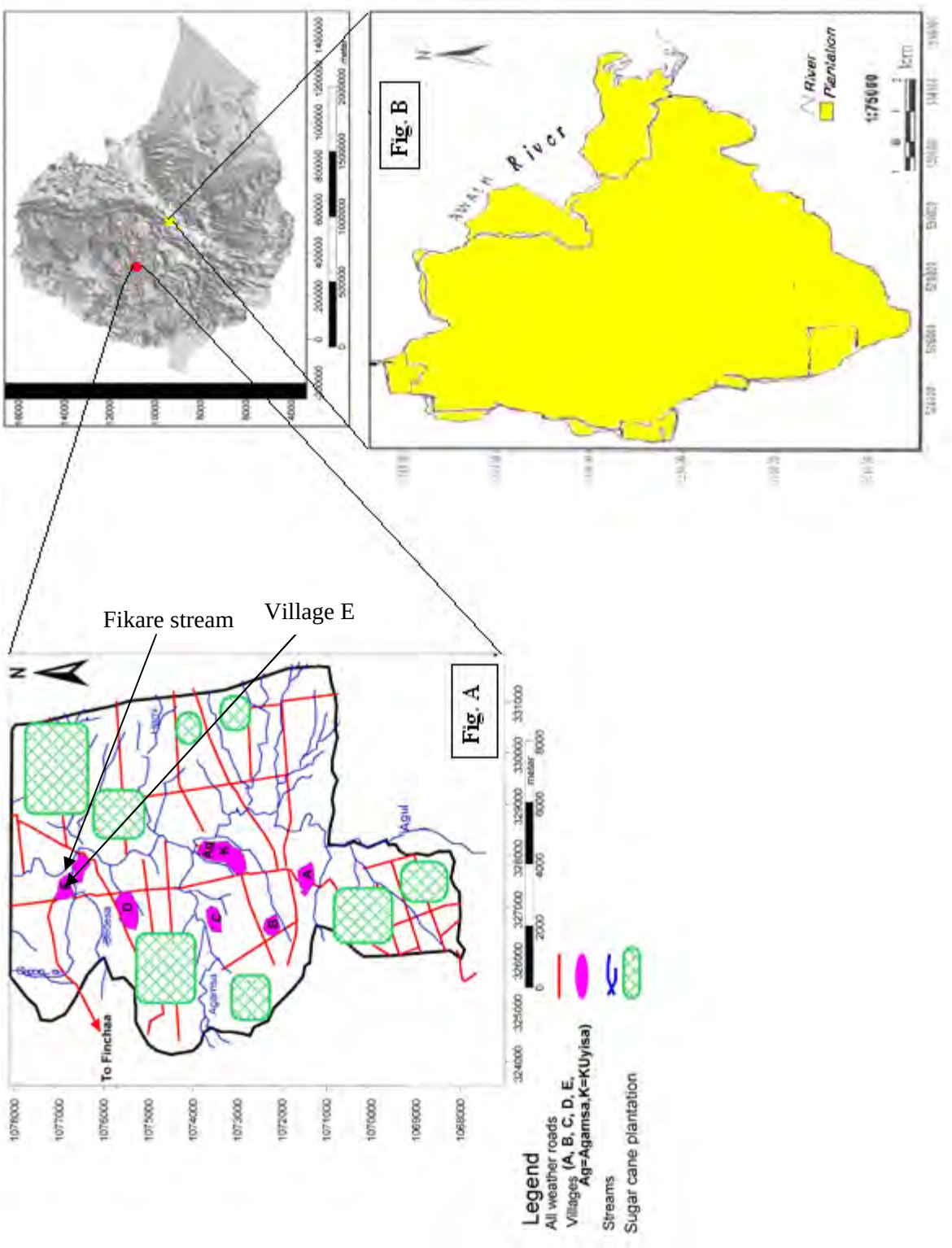


Figure 3: Map of the study sites (Modified from Admasu, 2007 and Chala, 2007)

Fig. A = Finchaa sugar estate **Fig. B** = Wonji-Shoa sugar estate

3.2 Study population

The study was conducted on school children in the two sugar estates. Most of the children are family members of the laborers who work in the sugar plantation farms. In Finchaa sugar estate, the study was conducted in Finchaa valley elementary school located in Camp 7 (Village E) and all of the students were from the same village. Camp 7 is the most affected village by intestinal schistosomiasis. Post intervention survey at the same school in 1998 has showed a prevalence of 56% for *S. mansoni* infection (Erko *et al*., 2003). The total population of students in the elementary school enrolled from grade 1 to grade 8 during the study was 750.

In Wonji sugar estate, the study was conducted in two schools, Hawass Melkasa and Tigle Leedget Elementary schools. The first school is located outside the sugar estate in Awash Melkasa town bordering the sugar estate. Students in this school were composed of children from the town and from a nearby village (camp O) of Wonji-Shoa sugar estate. All students attending this school from Camp O were included in the survey. The other school is located inside the sugar estate and all the students were from the different camps in the estate.

3.3 Sample size

Sample size is determined by using the following formula (Naing *et al.*, 2006) with a 95% (0.95) confidence interval.

$$n = \frac{Z^2 P(1-P)}{d^2}$$

n= Sample size

Z= Z statistic for a level of confidence = 1.96

P= Expected prevalence

d= Precision for 95% (0.95) = 0.05

In Finchaa sugar estate the prevalence of schistosomiasis has decreased from 76% to 56% within four years (1994-1998) of control trial (Erko *et al*., 2003). In 2008 (after 10 years) a reduction of 30% was taken in to account and the expected prevalence would be 26%. Using the above formula the total sample size would become 296.65 in Finchaa Valley elementary school. Systematic random sampling was used to choose among the school children in Finchaa Valley elementary school and total of 302 children were selected.

In Wonji-Shoa sugar estate, literatures were not available about the impact of the pilot control on the prevalence of the disease. Therefore, 10% reduction was considered from the 81.9% prevalence of *S. mansoni* reported by Simonsen *et al*. (1990). As a result, the expected prevalence would be 71.9%, approximately 72%. By using the formula stated by Naing *et al*. (2006) the sample size would be 309.79 in Wonji-Shoa sugar estate. A total of 333 school children were enrolled in the study from Tigle Leedget and Hawass Melkasa elementary schools. 231 of the school children were selected by systematic random sampling from Tigle Leedget Elementary School and constituted as the study subjects. The other 102 school children were Camp O students attending in Hawass Melkasa Elementary School.

3.4 Parasitological study

After explaining the purpose of the study to the guardian of the school children, applicator stick and plastic sheets were distributed for stool collection (approximately 1gm of stool). During stool sample collection, names, grades, ages, sex and name of villages of the children were recorded in a registration form (Appendix 4). Then, the stool samples were processed with Kato-katz technique (Appendix 1) and examined for helminth eggs on pre spot for treatment. The

slides were transported to the Medical Parasitology Unit laboratory at Aklilu Lemma Institute of Pathobiology, Addis Ababa University. The slides were quantitatively examined using a compound microscope (10X objective lens magnification power). During preparation of Kato-Katz smear a 41.7mg pore size template was used and the number of eggs counted per slide was multiplied by 24 to convert it into eggs per gram of feces (EPG).

During classifying intensity levels of intestinal schistosomiasis, classes of *S. mansoni* intensity levels recommended by WHO (2002) was used. It states that an EPG of 1-99 is considered light infection, 100-399 moderate infection and an EPG greater than or equal to 400 is considered heavy infection. In addition, the school children were classified in to three age groups (5-9, 10-14 and 15-19 years old) and their respective prevalence and intensity was studied.

3.5 Snail survey

During snail survey in Finchaa sugar estate the main human water contact site in Fikare stream was checked for *B. pfeifferi* snails using scoop, hand picking and visual inspection. In Wonji-Shoa sugar estate, the snail survey was done in irrigation canals previously known to be infested with *B. pfeifferi*. During the survey drag scoop, hand picking and visual inspection were used.

3.6 Data collection from Wonji Hospital and Finchaa sugar estate polyclinic

In Finchaa sugar estate, data from the polyclinic were taken from the record and sanitation offices. From the record office, the annual cases of *S. mansoni* infection and schistosomiasis control activities up to 2007/08 were extracted from annual reports. From the sanitation office the last schistosomiasis control activity (2008/09) was explained orally by staff of the sanitation

office. On the other hand, in Wonji-Shoa sugar estate all data were collected from the Bilharzia control unit of Wonji Hospital. These data include the annual cases of *S. mansoni* infection from the hospital, results of the 1997, 2004 and 2008 epidemiological surveys, results of annual snail survey and amount of endod applied in the irrigation canals each year.

3.7 Data analysis

The results of the microscopic examination was entered to a Microsoft excel application 2007 and imported to a statistics software, SPSS version 15, for analysis. An independent t-test was done to compare the mean intensity and prevalence of schistosomiasis among male and female study subjects. One way ANOVA was also done to compare the differences in prevalence and intensity among age groups of the school children. In addition, one sample t-test was done to compare the prevalence and mean intensities of the disease with other previous studies. In all of the statistical analysis 95% (0.95) confidence interval was used and P-values less than or equal to 0.05 were considered statistically significant.

3.8 Ethical considerations

- The study was conducted in the three elementary school with a permission granted from the school teachers and directors (guardians of the school children).
- The study obtained ethical clearance from the ethical committee of Faculty of Science, Addis Ababa University, Department of Biology.
- All children found positive for schistosomiasis in Wonji-Shoa and Finchaa Sugar Estates were treated with praziquantel.

4. RESULTS

4.1 Demographic data

From the total of 302 school children selected from Finchaa Valley elementary school 154 (50.99%) were males and 148 (49.01%) were females. The mean age of the study population was 11.19 ± 2.49 (Mean ± SD). Similarly, the mean age of male and female school children was 11.23 ± 2.53 and 11.15 ± 2.46 respectively (P = 0.77).

In Wonji-Shoa sugar estate, from the total number of school children, 333, enrolled in the study 167 (50.15%) were females and 166 (49.85%) were males. The mean age of the study population was 11.09 ± 2.37; among male and female, the mean age was 10.95 ± 2.36 and 11.15 ± 2.46 respectively (P = 0.3). Among the 102 Camp O children attending in Hawass Melkasa Elementary School, 54 (52.94%) were males and 48 (47.06%) were females. The mean age of the study population in this school was 10.87 ± 2.59; the mean age among male school children was 11.18 ± 2.89 and 10.52 ± 2.19 among females (P = 0.2). On the other hand, among the 231 school children in Tigle Leedget Elementary School, 112 (48.48%) were males and 119 (51.52%) were females. The mean age of the children enrolled in the study from this school was 11.18 ± 2.27. In addition the mean age among male and female school children was 10.95 ± 2.36 and 11.22 ± 2.38 respectively (P = 0.03).

4.2 Data from Finchaa Sugar Estate Polyclinic records

Most of the schistosomiasis cases in the polyclinic are reported from residents of camp 7 since the camp is the most affected by intestinal schistosomiasis. The polyclinic annual report

indicated that the number of schistosomiasis cases has decreased. There were 103 cases of *S. mansoni* in the year 2003/04 which is 0.29% of all patients in the polyclinic. In the year 2007/08 cases of schistosomiasis were only 22 (0.05% of all cases). The polyclinic annual report of schistosomiasis in Finchaa Sugar Estate for the past 5 years is shown in Table 1. In addition, monthly reported cases of *S. mansoni* from the Finchaa polyclinic reports and 6 years annual report are given in Appendix 2.

Table 1: *Schistosoma mansoni* cases in Finchaa Sugar Estate Polyclinic, 2003-2008

YEAR	Total Patients	No of Positive for *S. mansoni* infection (%)
2003/04	46,697	130 (0.29%)
2004/05	42,497	47 (0.11%)
2005/06	43,673	20 (0.05%)
2006/07	44,946	28 (0.06%)
2007/08	47,674	22 (0.05%)

After termination of schistosomiasis control program in 1998 the polyclinic continued to maintain the control activities- endod application and clearance of Fikare stream. According to the yearly report of the Polyclinic, in Camp 7 of the sugar estate vegetation clearance and molluscicides (endod) application was done along Fikare stream up to the year 2006. After that de-vegetation and clearance of the stream was done in 2008 according to the polyclinic officials.

4.3 Parasitological and snail survey in Finchaa Sugar Estate

Among the 302 school children examined from Finchaa Valley Elementary School, 182 (60.26%) children excreted eggs of *S. mansoni* during the study period. The mean intensity of infection was found to be 287.84 ± 613.37 EPG (Mean ± SD) with a maximum intensity of 5304 EPG among male and 2424 in female school children.

Based on the WHO category of *S. mansoni* intensity levels (Section 3.4) among the total infected individuals, 59 (32.42%), 54 (29.67%) and 69 (37.91%) were heavily, moderately and lightly infected respectively. Among the positive male school children, 45 (42.06%) were categorized under heavy infection of intestinal schistosomiasis. In addition, 30 (28.04%) were moderately infected and 32 (29.90%) were lightly infected. From the positive female school children 14 (18.67%), 24 (32%) and 37(49.33%) was found to be highly, moderately and lightly infected.

The school children were classified in to three age groups (Section 3.4); based on this classification, the prevalence and mean intensity of *S. mansoni* was found to be higher among children with in the age group of 10-14 years old (Table 2). But the prevalence of *S. mansoni* was not statistically significant from the prevalence of the disease among children 15-19 years old (P= 0.60) as well as 5-9 years old (P= 0.13). Similarly, the difference between the prevalence of schistosomiasis in 5-9 and 15-19 years old children (Table 2) was not significant (P= 0.56).

On the other hand, the mean intensity of *S. mansoni* infection among 10-14 years old children was 317.42 ± 653.78 EPG (Table 2). The intensity in this age group was significantly higher than the mean intensity among 15-19 years old school children ($P < 0.001$) but not significantly

different from the mean intensity of 5-9 years old children (P = 0.91). In addition, the mean intensity of schistosomiasis among the 5-9 years old children was also significantly higher than the mean intensity in children 15-19 years old (P = 0.014).

Table 2: Age specific prevalence and intensity of *Schistosoma mansoni* among school children in Finchaa Valley Elementary School, Finchaa Sugar Estate, October 2008

Age Category	Prevalence (%)	Mean Intensity (EPG) ± SD
5-9	53.25%	307.01 ± 641.61
10-14	63.44%	317.42 ± 653.78
15-19	58.97%	129.42 ± 194.73
Total	60.26%	287.84 ± 613.37

In addition, the prevalence and mean intensity of intestinal schistosomiasis was found to be higher among males than in females. The prevalence was 69.48% (107/154) among male study subjects which is higher than the prevalence in females, 50.68% (75/148). The difference in prevalence between the sexes was found to be statistically significant (P< 0.001). In addition the mean intensity of the disease in male (444.31 ± 783.17 EPG) was also found to be significantly higher than the mean intensity among female (125.03 ± 282.18) school children (P < 0.001).

During the snail survey in Fikare stream, Finchaa sugar estate, *B. pfeifferi* or any other snail species were not found.

Schistosomiasis control in Finchaa Sugar Estate

To compare the prevalence and mean intensity of *S. mansoni* infection, the post intervention data was taken which indicates a prevalence of 56% and mean intensity of 114 EPG among school children in Finchaa Valley elementary school in the year 1998 (Table 3). In the present study the prevalence of schistosomiasis in the same school was found to be 60.26% and mean intensity of 287.84 EPG. The prevalence of the disease (60.26%) was found to be higher than the post-intervention prevalence (56%) but the difference was not statistically significant (P=0.13). On the other hand the present mean intensity of infection (287.84 EPG) was found significantly higher than the mean intensity of the disease (114 EPG) in the post-intervention study (P< 0.001).

Similarly, the prevalence and mean intensity of *S. mansoni* in males and females was also compared with the 1998 post-intervention study. The present prevalence of intestinal schistosomiasis in both sexes was found to be higher than that of the 1998 prevalence data but the differences were not statistically significant in both cases (Table 3). In addition, the mean intensity of infection in females was higher than the 1998 post-intervention data but the difference was not statistically significant (P= 0.16). Among the male children, the mean intensity of infection in the present study showed a statistically significant increase from the post intervention study in 1998 (P < 0.001) (Table 3).

Table 3: Comparison of mean intensity and prevalence of *Schistosoma mansoni* infection among students of Finchaa Valley Elementary School, Finchaa Sugar Estate, October 1998 and October 2008

Sex	Prevalence/ Intensity	Year of Study		P-value [a]
		October, 2008	October, 1998 [b]	
Male	**Prevalence**	69.49% (107/154)	63.00% (78/124)	P= 0.08
	Intensity	444.31	125	P< 0.001
Female	**Prevalence**	50.68% (75/148)	44.00% (32/73)	P= 0.11
	Intensity	125.03	92	P= 0.16
Total	**Prevalence**	60.26% (182/302)	56.00% (110/197)	P= 0.13
	Intensity	287.84	114	P< 0.001

[a] = Any P value less than or equal to 0.05 has statistically significant difference.
[b] = All data obtained for the 1998 post-intervention study were taken from Erko *et al*. (2003).

4.4 Data from Wonji-Shoa Sugar Estate Hospital records

The annual report of the hospital cases of intestinal schistosomiasis has shown to decrease due to the pilot control trial. According to the hospital annual report the cases of intestinal schistosomiasis before implementation of pilot control ranges from 660 to 1780 (Appendix 3). After the control programs the number of cases has reduced to less than 350. The past five year annual case of intestinal schistosomiasis in Wonji Hospital is stated in Table 4. In addition the

annual cases of intestinal schistosomiasis for the past 20 years in the hospital are written in appendix 3.

Table 4: Cases of intestinal schistosomiasis reported in Wonji Hospital, Wonji-Shoa Sugar Estate, 2003-2008

YEAR	Total Patients	Number of Positive for *S. mansoni* infection (%)
2003/04	17550	257 (1.46%)
2004/05	20783	340 (1.64%)
2005/06	11808	235 (1.99%)
2006/07	18557	234 (1.26%)
2007/08	18829	245 (1.30%)

In the sugar estate, schistosomiasis control strategies are based on endod application, periodic drying of canals and vegetation clearance. Targeted and mass chemotherapy were also administered during stool surveys in May 1997 and 2004. A similar survey was also conducted in May 2008 and these data are presented in this section of the thesis. In the control of schistosomiasis, endod application in irrigation canals is the main control measure. Endod has been applied each year from 2000-2008 in the irrigation canals (Appendix 5).

The snail control in Wonji-Shoa sugar estate has also been accompanied by annual snail surveys in the irrigation canals. Several dead and alive *B. pfeifferi* snails were collected each year since the initiation of the pilot control in 1994. In last year's (2008) snail survey 68 alive *Biomphalaria* snails were collected and 10 (14.71%) of them shedding cercariae. In the year 2007, 4.33% (24) of the total alive snails (554) were found infected. It has also been indicated that the number of *Biomphalaria* snails as well as the irrigation canals infested with the snails are reducing. The number of infected and total alive *B. pfeifferi* snails collected in the irrigation canals of the sugar estate are shown in Figure 4.

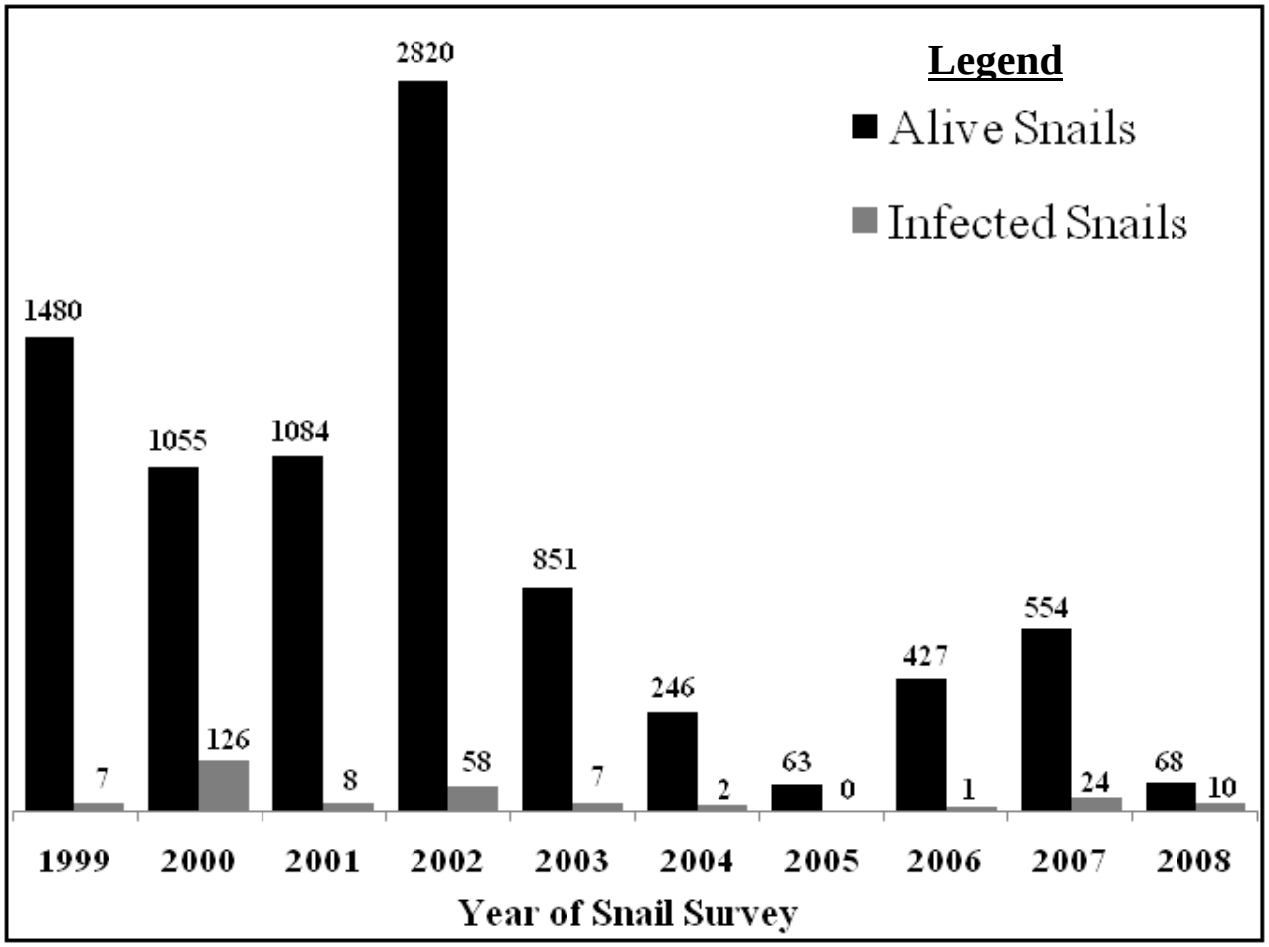


Figure 4: Number of alive and infected *Biomphalaria pfeifferi* snail collected in irrigation canals of Wonji-Shoa Sugar Estate, 1999-2008

Epidemiological surveys from Wonji Hospital

In Wonji Hospital, schistosomiasis survey was conducted using random sampling techniques among residents of all age groups and sex. The collected stools were processed using Kato-Katz technique (Appendix 1) in May 1997 and May 2008. Therefore, the data obtained in the two epidemiological surveys are reliable and can be used to assess the effect of schistosomiasis pilot control in the sugar estate.

During the epidemiological survey in May 1997, 606 people were screened for intestinal schistosomiasis from all the 13 camps in the sugar estate and 222 (36.60%) were positive with prevalence ranging from 6.5% to 57.1% among different camps. Similarly, a study in May 2008 among 400 people from 8 of the 13 camps in the sugar estate reported a total prevalence of 15% with a prevalence ranging from 0% to 28.0%. In the 1997 schistosomiasis survey the total prevalence of the disease among the 8 camps studied in the 2008 study was 42.11% (176/418). Therefore, the total prevalence of the disease has decreased significantly from 42.11% in May 1997 to 15.00% in May 2008 ($P< 0.001$).

4.5 Parasitological and snail surveys in Wonji-Shoa Sugar Estate

Among the total of 333 children included in the study from the two elementary schools, intestinal schistosomiasis was found in 191 individuals (57%). The prevalence of schistosomiasis among Camp O children attending Hawass Melkasa Elementary School was 67.65% (69/102). On the other hand, the prevalence of schistosomiasis among children in Tigle Leedget Elementary School was found to be 52.81% (122/231).

The overall mean intensity of intestinal schistosomiasis in children from both schools was 147.39 ± 278.07 (Mean ± SD). Among the children in Hawass Melkasa Elementary School, the mean intensity of infection was 267.76 ± 384.07 with the highest egg count of 1512 EPG in females and 1416 EPG in males. Similarly, the mean intensity of the disease among children in Tigle Leedget Elementary School was 94.23 ± 193.84 with the highest intensity of 1392 EPG in males and 969 EPG in females.

According to the WHO classification of intensity of intestinal schistosomiasis (Section 3.4), 38 (19.89%), 67 (35.08%) and 86 (45.03%) were heavily, moderately and lightly infected out of 191 positive children respectively. Among males, 41.58% were light infections, 39.6% were moderate and the rest 18.81% were heavy infections. Whereas, among the positive females 48.89% were lightly infected; 30% were moderately infected and the remaining 21.11% were heavily infected. Similarly, in Hawass Melkasa Elementary School 26.47%, 41.18% and 32.35% were heavily, moderately and lightly infected respectively. In addition, among the positive children in Tigle Leedget Elementary School, 14.92% were heavily infected, 38.01% were moderately infected and 46.27% were lightly infected (Table 5).

Table 5: Distribution of cases of intestinal schistosomiasis by classes of intensity in Wonji-Shoa Sugar Estate, April 2009

School Name	Sex	Level of Intensity of *S. mansoni* intensity			
		Light	Moderate	Heavy	Total
Hawass Melkasa Elementary School	**Male**	11 (32.35%)	14 (41.18%)	9 (26.47%)	34
	Female	8 (22.86%)	12 (34.28%)	15 (42.86%)	35
	Total	19 (27.54%)	26 (37.68%)	24 (34.78%)	69
Tigle Leedget Elementary School	**Male**	31 (46.27%)	26 (38.81%)	10 (14.92%)	67
	Female	36 (65.46%)	15 (27.27%)	4 (7.27%)	55
	Total	67 (54.92%)	41 (33.61%)	14 (11.47%)	122
Total	**Male**	42 (41.58%)	40 (39.60%)	19 (18.81%)	101
	Female	44 (48.89%)	27 (30.00%)	19 (21.11%)	90
	Total	86 (45.03%)	67 (35.08%)	38 (19.89%)	191

The prevalence among male and female school children in Wonji-Shoa sugar estate was 60.84% and 53.89%, respectively. The difference in the prevalence between male and female was not found statistically significant (P= 0.201). In Hawass Melkasa Elementary School children, the prevalence of *S. mansoni* among male and female study subjects was 62.96% (34/54) and 72.92% (35/48) respectively; but the difference was not found statistically significant (P= 0.286). On the other hand, among the children in Tigle Leedget Elementary School, prevalence of the disease among males was 59.82% and in females it was 46.22% (P = 0.039).

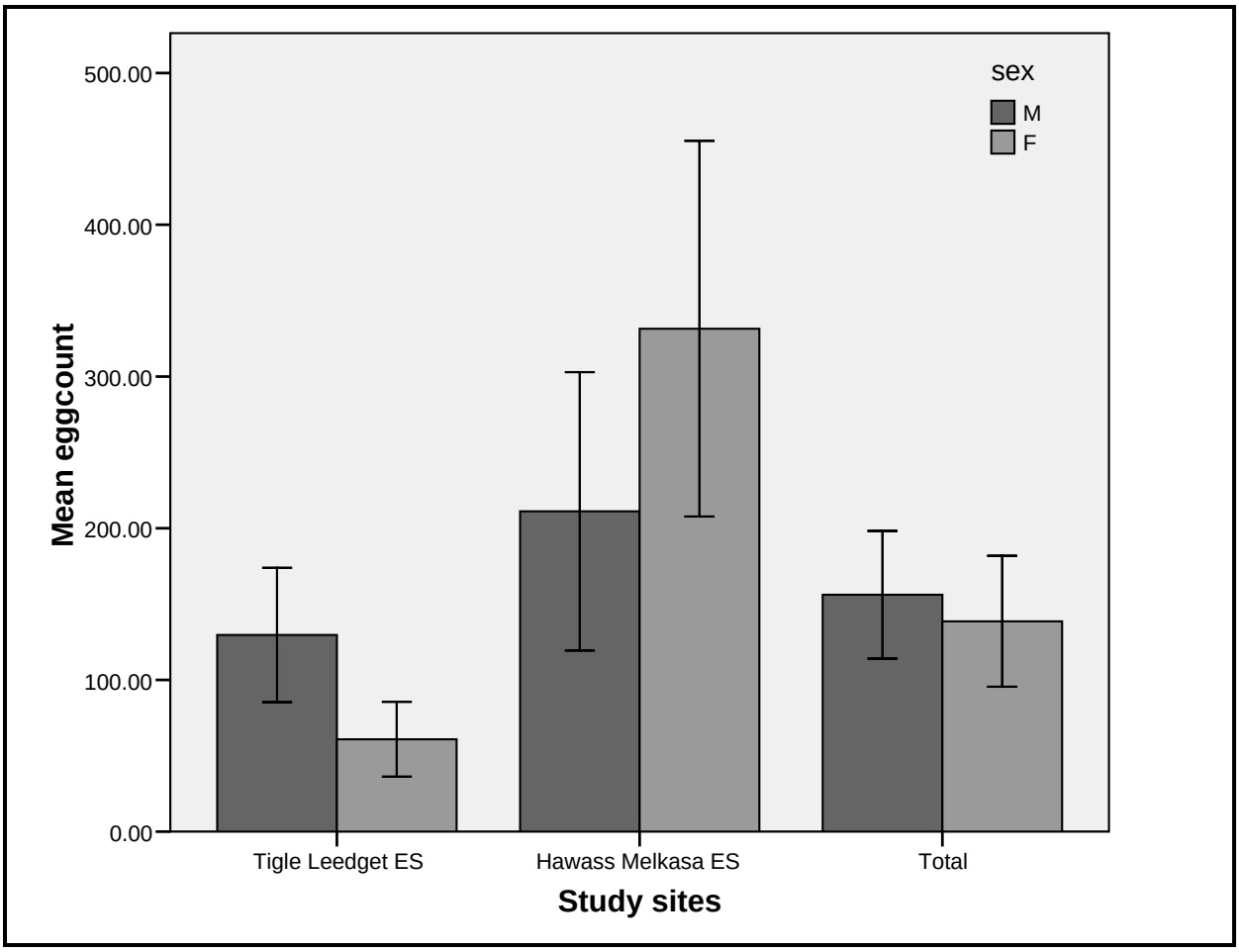
Table 6: The prevalence of intestinal schistosomiasis among male and female school children in Wonji-Shoa sugar estate, April 2009

School Name	Prevalence of *Schistosoma mansoni* (Number of infected/ Total Examined)		P-value [a]
	Male	Female	
Hawass Melkasa ES	62.96% (34/54)	72.92% (35/48)	P = 0.286
Tigle Leedget ES	59.82% (67/112)	46.22% (55/119)	P = 0.039
Total	60.84% (101/166)	53.89% (90/167)	P = 0.201

[a] = Any P-value less than or equal to 0.05 is statistically significant

ES = Elementary school

In addition, the mean intensity of infection among the school children in males was higher than the mean intensity in females but the difference was not found significant (P= 0.567). The mean intensity of infection among male school children was 156.14 $\pm$ 274.33 (Mean $\pm$ SD) and among females it was 138.68 $\pm$ 282.30. On the other hand, in Tigle Leedget Elementary School, the mean intensity of infection among males was 129.64 $\pm$ 236.17. It was significantly higher than the mean intensity among female school children, 60.91 $\pm$ 135.86 (P= 0.008). In addition, among the school children in Hawass Melkasa Elementary School, the mean intensity among females was higher than the mean intensity in males. In females the mean intensity was 331.5 $\pm$ 426.42 where as among males it was 211.11 $\pm$ 336.01 but the difference was not found statistically significant (P= 0.120).



ES = Elementary School M = Male F = Female

Figure 5: Mean intensity (EPG) of *Schistosoma mansoni* infection among school children in Wonji-Shoa Sugar Estate, April 2009

Similarly, the prevalence and intensity of intestinal schistosomiasis has also been studied among age groups (Table 7). The prevalence of the disease was found to be higher among 5-9 years old children (59.04%). But the difference was not significantly different from the prevalence among 10-14 years old (P= 0.940) as well as from children 15-19 years old (P= 0.961). Similarly, the prevalence among children 15-19 years old (56.25%) was not also significantly different from the prevalence in 10-14 years old children (P= 0.998).

On the other hand, the mean intensity of infection was found to be higher among 10-14 years old children (Table 7). The mean intensity in this age group was 160.73 ± 305.93; but the difference was not statistically significant from the mean intensity among children 15-19 years old (P= 0.941). Similarly, it was not significantly different from the mean intensity among 5-9 years old children (P= 0.394). In addition, the mean intensity in children 15-19 years old was higher than the mean intensity among 5-9 years old but the difference was not statistically significant (P= 0.868).

Table 7: Age specific prevalence and intensity of intestinal schistosomiasis among school children in Wonji-Shoa Sugar Estate from two elementary schools, April 2009

Age Category	Prevalence (%)	Mean Intensity (EPG) ± SD
5-9	59.34% (49/83)	113.93 ± 208.54
10-14	56.88% (124/218)	160.37 ± 305.93
15-19	56.25% (18/32)	143.25 ± 234.77
Total	57% (191/333)	147.39 ± 278.07

In Wonji-Shoa sugar estate, snail survey in irrigation canals indicated the absence of *B. pfeifferi*. But numerous *Physa acuta* snails were recovered and observed in the canals. In addition, other snails found in the canals include members of the genus *Bulinus* and *Melanoides*.

Comparison of *S. mansoni* prevalence and intensity with other studies

In Wonji-Shoa Sugar Estate, parasitological data are available in the hospital and the surveys were conducted on the whole population. Therefore, there is a shortage of available data on the prevalence and intensity of schistosomiasis for the school children. The available data that can be used for comparison is a schistosomiasis survey done by Simonsen *et al*. (1990). In this study, intestinal schistosomiasis was studied among 326 school children who were 5-14 years old. The prevalence was found to be 81.9% (83.12% among male school children and 80.72% among females) and the mean intensity of infection 377 EPG (Simonsen *et al*., 1990). In addition, the study has also obtained the prevalence and intensity of *S. mansoni* for three age categories which are 5-7, 8-11 and 12-14 years old (Table 8).

For comparison of the prevalence and intensity of the disease, the data among the study groups was calculated by taking the specific age group mentioned in Simonsen *et al*. (1990) into considerations. As a result, the prevalence among 5-14 years old school children was 57.48% (60.26% among male children and 54.67% among females). The mean intensity of infection among the school children was 147.83 $\pm$ 282.89. In addition, the prevalence and mean intensity of infection among the three age groups mentioned by Simonsen *et al*. (1990) were calculated. The prevalence and mean intensity of the disease among children 5-7 years old was 52.94% and 129.88 $\pm$ 284.86 respectively. Whereas the prevalence and mean intensity was 59.69% and 141.99 $\pm$ 259.87 among 8-11 years old children and among 12-14 years old children the prevalence was 53.76% and mean intensity 163.1 $\pm$ 327.12.

The prevalence and intensity of *S. mansoni* decreased significantly in April 2009 as compared to that of 1989 study among the school children (Table 8). Among male school children, the

prevalence decreased significantly from 83.12% to 60.26% (P< 0.001). Similarly, the prevalence has also decreased among female children (P< 0.001). In addition, a significant decrease has also found between the prevalence and intensity of *S. mansoni* among the three age groups except in the prevalence among children 5-7 years old (Table 8). In this age group, the prevalence has decreased from 72.4% to 52.94% but the decrease was not statistically significant (P = 0.138). Tables 9 indicates the prevalence and mean intensity of *S. mansoni* infection among school children in Wonji-Shoa Sugar Estate in 1989 and 2009 with their P-values when compared with one sample student t-test (SPSS version 15 statistical software).

Table 8: Comparison of the prevalence and intensity of intestinal schistosomiasis among 5-14 years old school children, Wonji-Shoa Sugar Estate, April 1989 and April 2009

Sex/Age Category		Prevalence/Intensity	April 1989 [a]	April 2009	P-value [c]
Sex	**Male**	**Prevalence**	83.12%	60.26%	P < 0.001
	Female	**Prevalence**	80.72%	54.67%	P < 0.001
Age Category [b]	**≤ 7**	**Prevalence**	72.4%	52.94%	P = 0.138
		Intensity	297	129.88	P = 0.028
	8-11	**Prevalence**	87.3%	59.69%	P < 0.001
		Intensity	433	141.99	P < 0.001
	12-14	**Prevalence**	84.1%	53.76%	P < 0.001
		Intensity	376	163.10	P < 0.001
Total		**Prevalence**	81.90%	57.48%	P < 0.001
		Intensity	377	147.83	P < 0.001

[a] = Data Obtained from Simonsen *et al*., 1990
[b] = Age Category is based on the classification of Simonsen *et al*. (1990)
[c] = P-value less than or equal to 0.05 have statistically significant differences

5. DISCUSSION

Intestinal schistosomiasis has been known to be endemic in Finchaa and Wonji-Shoa sugar estates (Birrie *et al*., 1993b; Teklehaimanote and Goll, 1978; Kloos *et al*., 1988). Intestinal schistosomiasis has been introduced and spread as a result of the irrigation development in Wonji-Shoa sugar estate (Kloos *et al*., 1988; Simonsen *et al*., 1990). In Finchaa sugar estate, the disease has increased as result of population migration associated with irrigation development (Erko *et al*., 1997a). As a result, schistosomiasis pilot control has been implemented in the two sugar estates in the mid 1990's. The main aim of the study was to evaluate the effect of schistosomiasis control, the post-pilot control activities, on the prevalence and intensity of the diseases in the sugar estates. In this study, the prevalence of the disease was found to be 57% among school children in Wonji-Shoa sugar estate with a mean intensity of 147.39. On the other hand, the prevalence of the disease among school children in the schistosomiasis affected camp of Finchaa sugar estate (Camp 7) was 60.62% and the mean intensity 287.84.

WHO (2002) classifies the prevalence of schistosomiasis into three categories i.e., a prevalence rate > 50% as category I (high prevalence), 10%-50% as category II (moderate prevalence) and a prevalence of lower than 10% as category III (low prevalence). Since the prevalence was greater than 50% in both sugar estates the disease is categorized under category I (high prevalence). In addition, both mean intensities in the study sites are categorized under moderate schistosomiasis infection based on WHO classification of *S. mansoni* intensity levels (WHO, 2002).

The prevalence in Finchaa and the mean intensity in both sugar estates were found to be higher among 10-14 years old children. On the other hand, the prevalence in Wonji was found to be

high among 5-9 years old children. But the differences were not found to be statistically significant in all cases except the mean intensity among children 15-19 years old in Finchaa Valley Elementary school. This could be due to a similar water activity patterns among the school children such as swimming, bathing and playing which are the most likely risk factors associated with schistosomiasis infection (Erko *et al*., 1997a; Kloos, 1993).

Moreover, the prevalence and intensity of schistosomiasis in Finchaa Valley Elementary school children was significantly higher among males (69.48% and 444.31 $\pm$ 783.17 EPG) than in female children (50.68% and 125.03 $\pm$ 282.18 EPG). The result is also similar to the other study conducted in the same school by Erko *et al*. (2003) which reported that the prevalence and mean intensity of the disease was 63.00% and 125 EPG among male school children and 44% and 92 EPG among females. Similarly, studies conducted in Harar (Lo *et al*., 1989), Adwa (Legesse, 2008), Gorgora (Degu *et al*., 2002), Wondo Genet (Erko *et al*., 2002b), North Gondar (Jemaneh, 1997) and other several studies conducted elsewhere in Ethiopia also indicate similar results. The main reason accounted for this high infection of male school children was attributable to more out door and water related activities among boys than girls (Tadesse, 2005; Erko *et al*., 1997a, Kloos *et al*., 1988, Legesse, 2008).

In addition, a review on human behavior and schistosomiasis by Kloss *et al.* (1993) indicated that schistosomiasis intensity and prevalence increased with increasing exposure to infected water bodies. A study on re-infection patterns among Finchaa valley elementary school children also indicated that, male children are more engaged in bathing and playing in water than the females (Erko *et al*., 1997b). The present finding also shows that the majority of positive male

children (42.06%) were heavily infected while the majority of the positive females (49.33%) were lightly infected.

On the other hand, in Wonji-Shoa sugar estate the prevalence and intensity of schistosomiasis among male school children was higher but the differences were not significant. Similar to this result, Simonsen *et al*. (1990) has also reported a minor difference between the prevalence of *S. mansoni* among male (83.12%) and female (80.72%) school children in the same sugar estate. Therefore, the similarity in schistosomiasis infection among male and female might be a common phenomenon among school children of Wonji-Shoa sugar estate. Moreover, mass chemotherapy in some camps and targeted chemotherapy in others was administered by Wonji Hospital during epidemiological surveys in the years 2004 and 2008. Since several studies indicate that chemotherapy of schistosomiasis reduces egg outputs during re-infections (Colley and Secor, 2004; Gunderson *et al*., 1998), the chemotherapy by the hospital might affect the outcome of this result. In support of this, higher proportion (45.03% or 86) of the total positive individuals (191) were light infections, with mean intensity less than 100 EPG, which is most probably due to the effect of these chemotherapy.

Schistosomiasis pilot control initiated in the year 1994 with mass chemotherapy and application of molluscicides (endod) brought a decreased in the prevalence and intensity of the disease within four years. The prevalence decreased from 78% to 56% and the mean intensity from 283 EPG to 114 EPG among the school children of Finchaa Valley elementary school (Erko *et al*., 2003). The control activities was taken over and continued by the sugar estate using endod application and environmental modifications like vegetation clearance. But, the last control activity using endod application was done in 2005/06; after that vegetation clearance was done

after two years in 2008/09. In addition, the post-pilot control activities have not included chemotherapy as a control strategy.

In the sugar estate, the prevalence of intestinal schistosomiasis has shown a minor increase from 56% in the post-intervention (Erko *et al*., 2003) to 60.62% (present time/post-pilot control status) but the difference was not significant. Similarly, the prevalence has shown a minor increase with no significant difference in both sexes (Table 3). On the other hand, the mean intensity of schistosomiasis has shown a significant increase from 114 EPG (Erko *et al*., 2003) to 287.84 EPG among the school children. Similarly, the mean intensity has increased among male and female school children.

The reason for the increase in prevalence and mean intensity may be due to lack of morbidity control method (mass chemotherapy) in the post-pilot control activities. Morbidity control by mass chemotherapy was done only once at the beginning of the pilot control trial in the year 1994 (Erko *et al*., 2003). But, in the post-pilot control activities, which were done by the sugar estate mass chemotherapy or schistosomiasis survey were not used in the control methods. Many studies have indicated that treatment of schistosomiasis has an effect on reducing the egg output during re-infections hence reduce the prevalence as well as the intensity (Colley and Secor, 2004). In addition, public health education specific to schistosomiasis has not been given in the post-pilot control activities. Similarly, the control activities that have not been practiced for two years (2005/06 to 2008/09) might also result in higher risk of schistosomiasis infection. As a result of these main factors, the prevalence and intensity of *S. mansoni* infection has increased in

the sugar estate from the post-intervention status of the disease (Erko *et al*., 2003) during the pilot control trial.

In Wonji-Shoa sugar estate schistosomiasis pilot control was initiated jointly by Wonji hospital, Aklilu Lemma Institute of Pathobiology, Ethiopian Health and Nutrition Research Institute and the Ethiopian Science and Technology Commission. The control methods include snail control, targeted and mass chemotherapy; the control activities were continued by the sugar estate. As a result, the overall prevalence of intestinal schistosomiasis among villagers in 8 of the camps decreased from 42.11% to 15% after 10 years of control activity. This is a commendable accomplishment of the schistosomiasis control in the sugar estate. In addition, both the prevalence and intensity of schistosomiasis in this study decreased significantly among the school children as compared to the prevalence and intensity of infection reported by Simonson *et al*. (1990). The prevalence has decreased with more than 20% and the intensity more than 200 EPG per person from the 1989 study by Simonson *et al*. (1990) (Table 8).

The main reason for the decrease in the prevalence and intensity of *S. mansoni* is the continuity of schistosomiasis control by the sugar estate after the pilot control. In the post-pilot control activities, continuous *Biomphalaria* snail survey and endod application in canals found to be infested with the snails were done each year. In support of the molluscicides preparation, the sugar estate has its own endod plantation farms which cultivate endod (*Phytolacca dodecandra* (endod) variety: type 44). The type 44 has been indicated to be one of the most active and potent types of endod in its molluscciciding capacity (Wolde-Yohannes, 2007). Similarly, vegetation clearance of irrigation canals was also part of the control activity. In addition, the schistosomiasis

surveys accompanied with mass and targeted chemotherapy have also an impact on the reduction of both the prevalence and intensity. As a result of these reasons, the disease has decreased in the sugar estate.

Even if the prevalence and intensity schistosomiasis decreased among the school children and the villagers in the sugar estate; the risk of infection is still present as evidenced by the presence of infected snails in the canals. In the last two years for instance, the percentage of cercariae shedding snails was 4.33% (24/544) in 2007 and 14.71% (10/65) in 2008. Similarly several live and dead *B. pfeifferi* snails were collected every year in the irrigation canals since the pilot control was initiated. Therefore, the risk of *S. mansoni* infection is still present in the sugar estate.

Generally, there are some achievements in the control of *S. mansoni* infection in both sugar estates but the disease is still high in prevalence. According to WHO, for a sustainable control and reduction of schistosomiasis, mass chemotherapy should be implemented once a year among school children in highly endemic areas (Colley and Secor, 2004; WHO, 2002). Many countries have achieved a significant morbidity reduction or transmission interruption or else disease elimination using mass chemotherapy as a primary tool (Steinmann *et al*., 2006; WHO, 2002). For example, China has reached to eliminate the disease from endemic provinces after 10 years of control program (Wu *et al*., 2005); which is the same years as the control of schistosomiasis implemented in both sugar estate. But in Finchaa sugar estate there was no mass chemotherapy given for the school children except in 1994. In Wonji-Shoa sugar estate, on the other hand, mass chemotherapy was practiced only during epidemiological surveys not annually. Therefore, the

luck of annual mass chemotherapy in the control strategies in both sugar estates is also accountable for the presence of high prevalence of schistosomiasis despite implementation of other control methods.

6. CONCLUSIONS AND RECOMMENDATIONS

This study indicates that schistosomiasis is still a major health problem in the two sugar estates with high prevalence. Although the prevalence and intensity of *S. mansoni* has decreased in Wonji-Shoa sugar estate, the disease is still highly prevalent among the school children. Even if *Biomphalaria* snail intermediate host has not been recovered in both sugar estates, a single snail can maintain the transmission of schistosomiasis since the snails are hermaphrodites. Therefore, the control activities must include available control measures to eradicate schistosomiasis from the sugar estate or bring the disease below the level of public health importance.

In addition to the snail control activities practiced currently the control methods should also contain the following activities:

- As recommended by WHO, morbidity control programs are mandatory among school children since the prevalence of the disease is high (> 50%) in both sugar estates

- Schistosomiasis survey in the community (among villagers) should also be done more often accompanied with targeted chemotherapy for positive individuals especially in Finchaa Sugar Estate

- Public health education is also necessary on the transmission of schistosomiasis in communities as well as in schools

- Community participation is necessary for a sustainable control of schistosomiasis. Therefore, control programs should be designed in such a way that can participate the communities living in the sugar estates

- Socioeconomic developments of the labors in the sugar estates and their families are also necessary for reducing the risk of schistosomiasis infection

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APPENDICES

Appendix 1: Kato-Katz technique Procedure

Materials needed

Applicator sticks	Screen, 60-105 mesh
Template with a hole of 6 mm on a 1.5 mm thick (41.7 mg)	Spatula, plastic
Microscope slides	Forceps
Toilet paper or absorbent tissue	Plastic sheet
Flat-bottom jar with lid	Hydrophilic cellophane

Glycerol-malachite green solution (1 ml of 3% aqueous malachite green 100 ml of glycerol and 100 ml of distilled water)

- The cellophane must be socked in the glycerol-malachite green solution for at least 16 hours before use.

Laboratory Procedure

1. Place a small amount of stool on newspaper or scrap paper or plastic sheet and press the small screen on top so that some of the feces are sieved through the screen and accumulate on top.

2. Scrape the flat-sided spatula across the upper surface of the screen to collect the sieved feces

3. Place template with a hole (41.7 mg holding capacity) on the centre of a microscope slide and add feces from the spatula so that the hole is completely filled. Use the side of the spatula pass over the template to remove excess feces from the edge of the hole.

4. Remove the template carefully so that the cylinder of feces is left on the slide.

5. Cover the fecal material with the pre-soaked cellophane with glycerol and malachite green.

6. Invert the microscope slide and firmly press the fecal sample against the hydrophilic cellophane strip on another microscope slide. The fecal material will be spread evenly between the microscope slide and the cellophane.

7. Carefully remove slide by gently sliding it sideways to avoid separating the cellophane strip or lifting it off. Place the slide on the bench with the cellophane upwards. Water evaporates while glycerol clears the feces.

8. Examine the slide preparations after 24 hours for schistosome eggs. Eggs may be recognizable for up to several months.

9. Count the number of eggs per slide and multiply by 24 while using a 41.7 mg template to convert it to eggs per gram of feces (EPG).

Appendix 2: Intestinal schistosomiasis cases reported in Finchaa Sugar Estate Polyclinic

Monthly reported cases of intestinal schistosomiasis in Finchaa Sugar Estate Polyclinic from 2004/05 to 2007/08

Month	**REPORT YEAR**			
	2004/05	**2005/06**	**2006/07**	**2007/08**
July	6	0	0	0
August	11	1	1	0
September	9	2	9	4
October	2	0	3	0
November	0	0	0	12
December	0	3	4	2
January	1	1	1	1
February	2	2	1	0
March	2	0	3	1
April	1	1	5	0
May	0	10	1	0
June	13	0	0	2
Total	**47**	**20**	**28**	**22**

Annual report of intestinal schistosomiasis cases in Finchaa Sugar Estate Polyclinic, 2002/03-2007/08

YEAR	Total Patients	No of Patients	Percentage
2002/03	43,445	78	0.18%
2003/04	46,697	130	0.29%
2004/05	42,497	47	0.11%
2005/06	43,673	20	0.05%
2006/07	44,946	28	0.06%
2007/08	47,674	22	0.05%

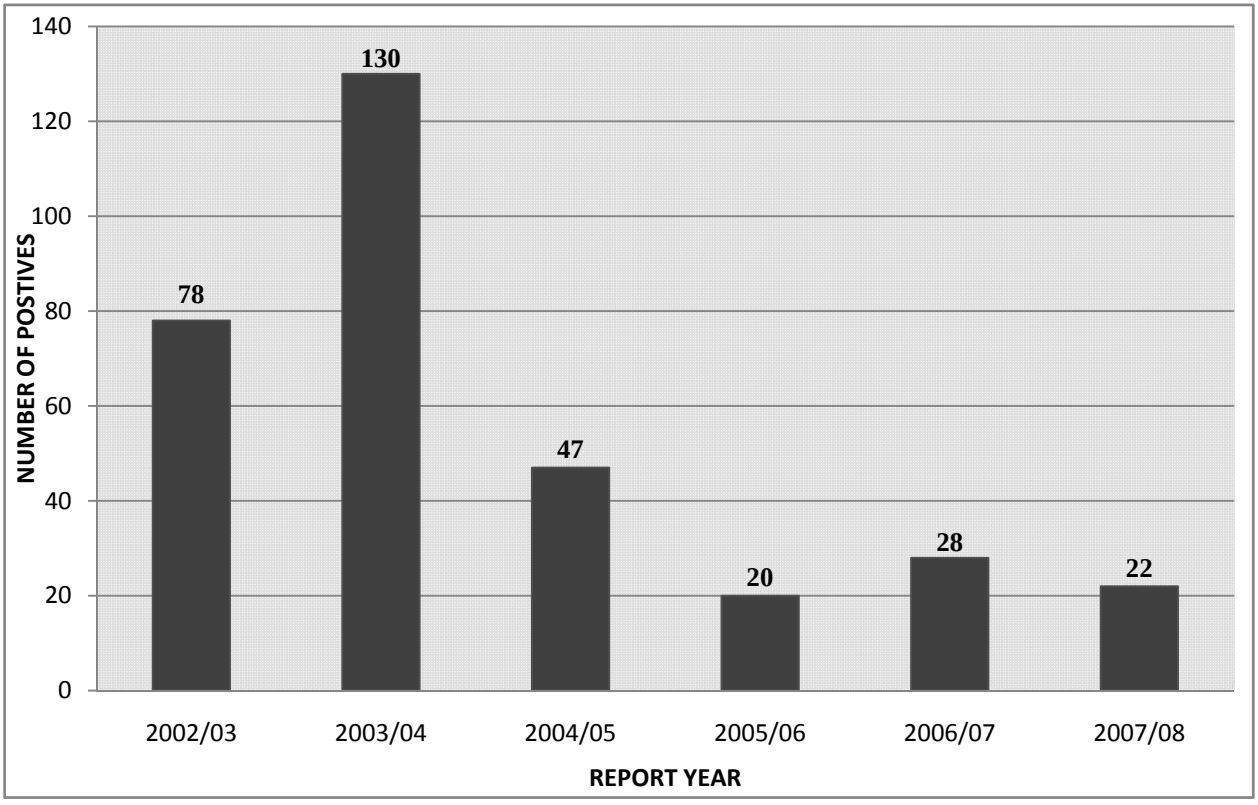


Figure 6: Patients positive for intestinal schistosomiasis in Finchaa Sugar Estates Polyclinic, 2002/03-2007/08

Appendix 3: Intestinal schistosomiasis cases reported in Wonji Hospital

Intestinal schistosomiasis cases reported in Wonji Hospital from 1988/89 to 2007/08

Year	No Examined	Positives	Percentage
1988/89	10988	806	7.34%
1989/90	10745	733	6.82%
1990/91	10541	662	6.28%
1991/92	10930	818	7.48%
1992/93	14251	1780	12.49%
1993/94	14858	1270	8.55%
1994/95	14251	868	6.09%
1995/96	14062	1108	7.88%
1996/97	13526	577	4.27%
1997/98	18089	413	2.28%
1998/99	20446	468	2.29%
1999/2000	19425	461	2.37%
2000/01	23524	766	3.26%
2001/02	20094	287	1.43%
2002/03	19580	361	1.84%
2003/04	17550	257	1.46%
2004/05	20783	340	1.64%
2005/06	11808	235	1.99%
2006/07	18557	234	1.26%
2007/08	18829	245	1.30%

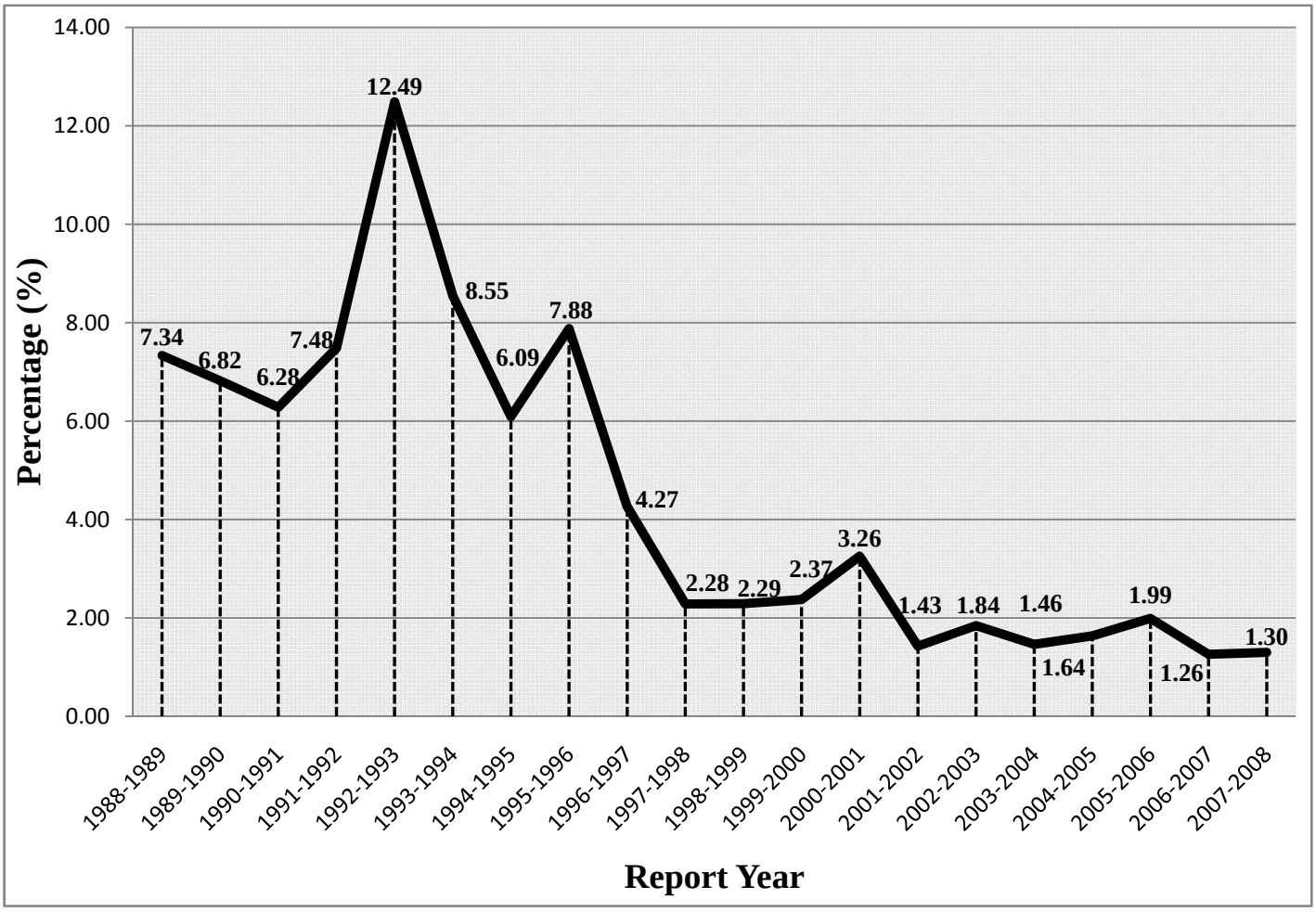


Figure 7: The percentage of *S. mansoni* cases from total patients in Wonji Hospital, Wonji-Shoa sugar estate, 1988/89-2007/08

Appendix 4: Student registration form during sample collection

No	NAME	Age	Sex	Grade	Camp No	Egg Count

Appendix 5: *Biomphalaria pfeifferi* snail survey and endod spray yearly activity report of Wonji Hospital form 1995-2008

The number of alive and dead snails collected and the amount of Endod sprayed in the irrigation canals of Wonji-Shoa sugar estate

Year	Total Number of Snails Collected		Amount of Endod Sprayed
	Alive Snails	Dead Snails	
1995	2737	2171	-
1996	6759	2523	-
1997	1435	1683	22 kg
1998	2945	1384	6 kg
1999	1480	1111	-
2000	1055	1261	35 kg
2001	1084	1184	62 kg
2002	2820	1666	194 kg
2003	851	18344	325 kg
2004	246	4791	135 kg
2005	63	1132	391 kg
2006	427	2099	202 kg
2007	554	2293	156 kg
2008	68	1222	20 kg

DECLARATIONS

I, Getnet Melaku Mekonnen, confirm that this thesis is my original work and has not been presented for any degree in any other university and that all sources of materials used for the thesis have been duly acknowledged.

Name: Getnet Melaku Mekonnen

Signature: _____

Date of submission: _____

This work has been done under our supervision

Name: Berhanu Erko (Assoc. Prof.)

Signature: _____

Date: _____

Name: Mengistu Legesse (Asst. Prof.)

Signature: _____

Date: _____

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