Original article

Intestinal helminth infections among the current residents of the future Finchaa Sugar plantation area, Western Ethiopia

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Abstract: In a cross-sectional survey of helminth infections made in February 1995 in the future Finchaa Sugar Project area, Finchaa Valley, Western Ethiopia, *Ascaris lumbricoides* and hookworms were found to be the most prevalent reaching, on average, 28% and 20%, respectively, among the populations living in seven camps. *Schistosoma mansoni* also reached 22% and 30% in two of the camps. Other parasites which were present at lower prevalences were *Trichuris trichiura*, *Taenia saginata*, *Entrobius vermicularis*, *Fasciola hepatica*, and *Hymenolepis nana*. The geometric mean egg counts per gram of faeces (epg) of *A. lumbricoides*, *S. mansoni*, hookworms and *T. trichiura* were 977, 141, 126 and 65 respectively. Both prevalence and intensity of infection of the last four parasites were highest among those below 15 years of age except hookworm which appeared to be more prevalent among the teenagers. All ages combined, only *A. lumbricoides* was more prevalent among the females ($P<0.05$). The frequency distribution of *A. lumbricoides*, *S. mansoni*, and hookworm egg counts showed that the parasites are highly over-dispersed with the majority of the sample population producing none or few eggs, and a small portion producing relatively high numbers of eggs. Also, the ratios of variance: arithmetic mean egg counts were large for the young age groups indicating a high degree of aggregation of the parasites in the community and adding more evidence to the generally held view about the frequency distribution of helminth parasites in the human population. The possibility of increased transmission of the parasites due to irrigation development and their potential adverse effects on the population is discussed and possible control measures suggested.[*Ethiop. J. Health Dev.* 1997;11(3):219-228]

Introduction

Intestinal helminth infections are known to be persistently ubiquitous in the developing world especially in poorest communities where the sanitary conditions are a lot to be desired (1,2). Inspite of the availability of cheap and effective drugs for their control, worldwide prevalence rates of helminth parasitism have not changed since the turn of the century (3). In 1990 it was estimated that at least 1000 million are infected with geohelminths alone (4). The main reason for this persistent ubiquity is the fact that intestinal helminths frequently rank low in the list of priorities in public health programs because the effects of helminth infections on the human population cannot be measured unambiguously in terms of mortality figures (5). However, even if the mortality figures directly related to intestinal helminth infections may be low, the absolute numbers are still reported to be fairly high because of the high prevalences of infections in the developing countries (2,4). Current estimates suggest that hundreds of thousands of avoidable deaths occur each year due to helminthiasis (4). Furthermore, recent studies have convincingly demonstrated that helminth infections have detrimental effects on human nutrition (4,5); they indirectly rob of his energy and ambition; interfere with his nutrition; and ultimately make him more susceptible to other diseases (6). These findings and the availability of broad spectrum and effective anthelminthic drugs at

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chemotherapy (2,4,5). To optimize the cost-effectiveness of chemotherapy, it is now recommended to target it against the heavily infected individuals or sectors within the population (4,5,7-9). In affordable cost have led to renewed interest to control intestinal helminth infections through

order to do this, population-based measurement of the intensity of infection and identification of high risk groups are emphasized (7,8). More reliable estimation of the intensity of infection could be made using direct estimates of gastrointestinal nematodes worm burdens obtained by anthelminthic expulsion (10). However, since this procedure is logistically difficult as well as unpleasant in community applications (11-13) the intensity of infection is usually indirectly estimated through faecal egg counts using quantitative coprological techniques (13).

The distribution of heavily infected individuals in the population has been examined in a number of countries (11). The major geohelminths of man are known to be highly over-dispersed, the large bulk of the heavy infections occurring in a minority of individuals (14,15). However, although most literatures show that the large majority of these heavily infected individuals constitute the younger age group(s), there are conflicting reports on the sex and age patterns of infection (13). The issue is further complicated by provision of evidence in support of predisposition to heavy infection due to genetic and/or environmental factors (10,14,18,19). Hence, it is difficult to extrapolate results of studies conducted in other countries for designing national control strategies. One needs to establish the distribution of these heavily infected individuals in the population living under specific environmental and socio-cultural conditions in order to devise appropriate community control strategies.

A number of surveys on human helminth parasites in Ethiopia have been carried out (20-32). Hence, the species, prevalence and distribution of intestinal helminth parasites are well known for most parts of Ethiopia. However, little is known about the distribution of the worm burden and intensity of infection in the population. The main reason for the gap in knowledge about the intensity of infection in Ethiopia was largely due to lack of diagnostic field tools for quantitative determination of infection. With the adoption of the Kato's thick smear method (33) in 1979 for a large scale use in Ethiopia it became possible to quantify infection due to intestinal schistosomiasis among schoolchildren in Ethiopia and the populations of some communities (34). However, due to the longer time required to count the eggs under the microscope, this quantitative diagnostic method has not been extended to other intestinal helminths. Recently, quantitative examination of intestinal helminths among schoolchildren in the Kolfe Elementary School, Addis Ababa, revealed astounding intensities of infection due to *Ascaris* and *Trichuris* in children (30). Spurred by this finding it was decided to extend measurement of the intensity of infection to the whole population in order to determine the intensity and distribution of worm burden, as indirectly gauged by faecal egg counts, of intestinal helminths in the population. For this purpose, the labour population of the Finchaa Sugar Project Area, of Western Ethiopia was selected.

Methods

The study area and population: The study was conducted in the Finchaa Sugar Project Areas, Wellega Region, Western Ethiopia (Figure 1) in February 1995. The Project Area, lying in the Finchaa River valley envisage to cover about 20,000 ha of land to grow sugar cane using sprinkler irrigation system at a cost of over 300 Million USD (35). The previous State Farm area is now absorbed by the Project. Currently, intensive construction of irrigation networks and residential houses are underway and a sugar factory is soon to be erected.

The population, comprising workers of the previous State Farm, their families and new arrivals in search of job opportunities, already surpasses 10,000 people. When completed, it is expected that the Finchaa Sugar Project will

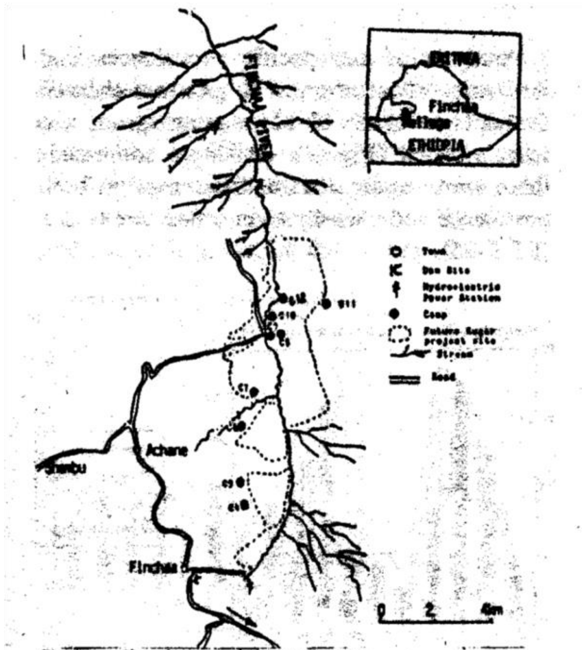

Figure 1: Sketch-map of the study area.

Figure 1: **Sketch-map of the study area.**

ultimately create jobs for over 7,000 workers who may in turn create an additional population of 25,000 people or more (35). Currently, the people are living in seven camps, each with a population of a little over 1000 except Camps 5 and 7 which have over 2000 people. Most of the houses are with thached-roof and are constructed without plan. Water is provided at few standpipes in each camp but the majority of the residents still depend, for almost all purposes, on the Finchaa River and a number of smaller streams flowing close to the camps. Only very few households have pit latrines and the sewerage system is still in its infancy. With the completion of the construction of the residential houses and the beginning of the Sugar Factory, installation of piped water supply and sanitary facilities is expected. However, it is not certain how many of the poor and unemployed families could benefit from the planned improvements of water supply and sanitary facilities.

Stool examination: The number of households in each camp was estimated based on the information provided by the local Sugar Project authorities. Based on the estimates, 10% of the households were selected by systematic random sampling technique. Once a household was selected all members were summoned for stool examination. For each individual a single slide was prepared using the Kato's thick smear method (with 41.7mg template (36)). The eggs of all intestinal helminths encountered under the microscope (using the 10 x eyepiece magnification) were counted using a multiple tally counter. For each parasite the number of eggs counted per slide was converted to eggs per gram of faeces by multiplying by a factor of 24.

Statistical analysis: the data were coded and entered into a computer using the dBase IV version 2.0. and analyzed using SPSS statistical package. The intensity of infection, (estimated as $\exp[\sum \log c)/n]$, where n is the number of individuals examined and c is the faecal egg count (epg) for each individual), was expressed as the geometric mean of egg counts on the positive subjects. The variance: mean (arithmetic) ratios were calculated as a measure of aggregation of parasites within sex and age classes. The prevalences and intensities were compared with X^2 tests and with Student's t-tests, respectively.

Results

The size, age and sex composition of the sample population are presented in Table 1. Males and females are equally represented except for a slight under representation of males in the 15-19 years age group. Altogether, 1321 persons (662 males and 659 females) were examined in the seven camps.

Table 1: **The age and sex distribution of the sample population.**

Age group	Male	Female	Total
0 - 4	104	93	197
5 - 9	140	146	286
10 - 14	117	104	221
15 - 19	29	42	71
20 - 24	52	59	111
25 - 29	36	82	118
30 - 34	55	48	103
35 - 39	46	47	93
40 - 44	36	18	54
45 - 49	26	14	40
50+	21	6	27
Total	662	659	1321*

* The ages of five persons missing

The intestinal helminths diagnosed were *Schistosoma mansoni*, *Ascaris lumbricoides*, Hookworm species, *Trichuris trichiura*, *Hymenolepis nana*, *Taenia saginata*, *Fasciola hepatica* and *Enterobius vermicularis*. However, only the results of the first four parasites are presented here since the rest occurred in very low prevalence rates.

Table 2: **Prevalence of intestinal helminths among the population in the Finchaa Sugar Project area, Western Ethiopia, 1994**.

Camp	Pop*	No. Exam.	Percent positive**				Geometric mean EPG			
			Sm	Al	Ho	Tt	Sm	Al	Ho	Tt
6	162	44	2	34	2	2	24	777	120	72
7	3699	432	30	27	33	2	198	883	143	107
8	765	187	8	23	13	3	62	1102	68	27
9	1193	200	22	40	4	2	122	908	265	215
10	961	104	4	14	21	6	69	1338	64	56
11	978	204	11	26	17	4	66	1123	148	66
12	542	145	1	30	18	14	72	1074	125	51
Total	8210	1326	16	28	20	4.5	142	968	125	64
M	-	667	17.7	25	21	3.6	140	887	117	59
F	-	659	15	31	19	4.6	146	1040	135	69

* - Total population according to local census in 1993

S.M - *Schistosoma mansoni,* Tt = *Trichuuris trichiura*

A.l - *Ascaris lumbricoides*

Ho. - Hookworms,

*** - intestinal helminths which are not shown here because of their extremely low prevalences are: Hymenolepis nana, Fasciola hepatica, Taenia saginata and Enterobius vermicularis*

All camps combined, the average prevalences of *A. lumbricoides*, hookworms and *S. mansoni* were 28%, 20% and 16%, respectively, (Table 2) while the corresponding geometric mean egg counts per gram of faeces were 968, 125 and 142, respectively. However, *S. mansoni* was highest in prevalence (30%) and intensity of infection (198 epg) in Camp 7 followed by Camp 9(22% and 122epg) while *A. lumbricoides* was over 20% in six of the camps, reaching 40% in Camp 9. The intensity of infection of *Ascaris* was however, highest (1338 epg) in Camp 10 where the prevalence was lowest (14%) indicating that the few infected persons could have high worm burdens. Hookworms were most prevalent in Camp 7(33%) followed by Camp 10(21%) but the intensity of infection was highest (265 epg) in Camp 9 where the prevalence was lowest (4%), again showing that the few infected persons could have heavy worm burdens.

Analysis of age-specific prevalences and intensities of infection of *S. mansoni* showed that children in the 10-14 years age-group are most affected (Fig. 2). All ages combined, there were no significant differences in both prevalence and intensity of infection due to sex (P>0-05).

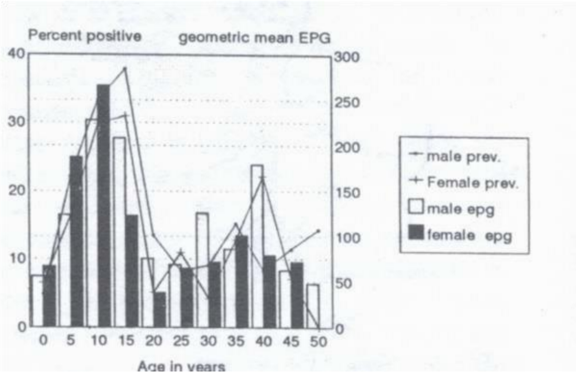

Figure 2: **Prevalence and intensity of infection of *S. mansoni* by sex and age**

Analysis of prevalence and intensity of infection of *A. lumbricoides* showed that children 0-9 years of age are most affected with heavier load among the under-fives (fig. 3). All ages combined, more females than males appear to be infected (P<0.05) but the intensity of infection was not significantly different (P>0.05).

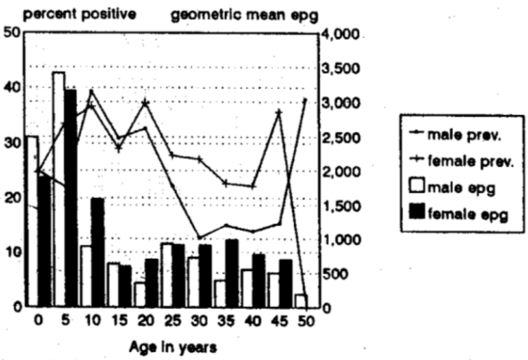

Figure 3: **Prevalence and intensity of *A. lumbricoides* infection by sex and age**

Hookworms were more or less equally distributed among all age-groups and sexes. A rise in prevalence and intensity of infection among the 45-50 years (Fig. 4) is due to the small number examined in that age-group. All ages combined, there were no significant differences in infection due to sex (P>0.05).

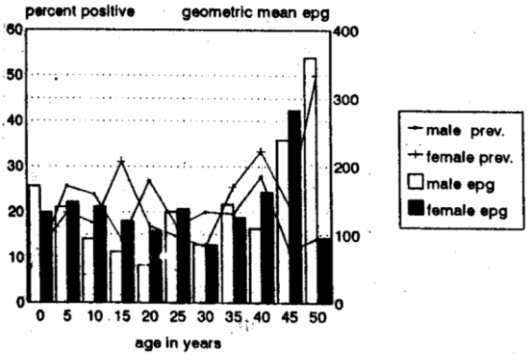

Figure 4: **Prevalence and intensity of hookworms infection by sex and age**

The prevalences of heavy infections for both *S. mansoni* and *A. lumbricoides* were very low in the population; only 5% and 6% of the infected population harboured moderate to heavy worm loads of *S. mansoni* and *A. lumbricoides*, respectively (Table 3). That of hookworms was not analyzed since the diagnostic technique is not absolutely reliable for quantification of hookworm eggs.

Table 3: **Classification of intensity of infection of *S. mansoni* and *A. lumbricoides* in the Finchaa Sugar Project Areas, western Ethiopia, 1995.**

Egg range	All Camps	
	No. exam.	%
S. mansoni		
Negative (0 egg)	1109	84
Low (<200 EPG)	143	11
Moderate (201-800 EPG)	52	4
Heavy (>800 EPG)	21	1
Total	1325*	100
A. lumbricoides		
Negative (0 egg)	956	72
Low (<5000 EPG)	290	22
Moderate (5001 - 20,000 EPG)	58	4
Heavy (>20,000 EPG)	21	2
Total	1325*	100

* one person each missing

The frequency distribution of egg counts showed that *A. lumbricoides*, *S. mansoni* and hookworms are overdispersed with the majority of the sample population producing none or few eggs and that only a small number of individuals are excreting more than 150 epgs (figures 2-4). Analysis of variance: mean ratios as a measure of the degree of aggregation (13), showed large ratios within age-groups and sexes (Table 4), suggesting a high degree of aggregation of egg counts in the infected population. *A. lumbricoides* appears to be more aggregated among the 0-9 years, especially females, while *S. mansoni* is more aggregated among the 5-14 years, especially males and hookworms among the 10-19 years of age. All ages combined, *A. lumbricoides* was more aggregated in the female while *S. mansoni* and hookworms appear to be more aggregated in the males (Table 4).

Discussion

Ascariasis and hookworm infection are the predominant and widespread intestinal parasitic problems in the camps of the Finchaa Sugar Project. The wide distribution of these two helminth parasites may be related to the favourability of the environmental conditions such as dampness created by the irrigation activities in progress, for their development, survival and transmission. It may also reflect the defecating habits of the population in the immediate vicinity of homes due to inadequate sanitary facilities in the camps. It is, however, of interest that *T. Trichiura*, which has a similar life cycle and mode of transmission with *A lambricoides,* occurred in low prevalence and intensity of infection (data not presented).

It is difficult to compare the prevalences and intensity of infections of *A. lumbricoides* and hookworms in this population with those reported from other parts of Ethiopia since almost all of the previous studies were qualitative and most were limited to school- children (20-32). However, compared to few population-based studies which used qualitative techniques (24, 25, 27-29), our findings indicate that the overall prevalences of both

Table 4: **Variance to mean ratios for *Ascaris lumbricoides* hookworms and *S. Mansoni* egg counts within sex and age classes in Finchaa Sugar Project Area.**

Agegroup(yrs)	*Ascaris*			Hookworms			*S. mansoni*		
	M	F	T	M	F	T	M	F	T
0 - 4	26263	68933	53264	439	414	420	54	27	35
5 - 9	13471	67593	53368	479	278	394	161	7937	6448
10 - 14	17508	11902	14787	940	253	673	7085	2655	5353
15 - 19	7615	15377	10758	160	843	757	605	179	452
20 - 24	1245	11702	10696	19	259	204	478	5	452
25 - 29	21096	11454	18031	314	199	223	8	81	66
30 - 34	3824	3790	3619	37	509	257	38	-	40
35 - 39	3088	12162	11640	354	295	305	435	567	466
40+	2715	18898	14484	647	244	502	65	9	47
Total	8654	47452	37016	558	343	456	5495	4703	5086

parasites are quite high in the project area. This raises a serious concern since these parasites have been associated with decreased work capacity and productivity in both children and adults, increased maternal and foetal morbidity and mortality, premature delivery and low birth weights, and increased susceptibility to other infections (1,2,5,6). Evidence abounds to show that intestinal helminths, especially *Ascaris,* seriously impair the mental and physical development of children (37) through depletion of micronutrients required for growth and development. Hookworm infection causes iron deficiency anaemia both in adults and children; pregnant women are particularly susceptible as iron demands are increased to meet the physiological requirements of the growing foetus and maternal tissue (38). Anaemia is always associated with a diminished capacity for sustained work and exercise. Hence, with the present overall prevalences of hookworms and schistosomiasis mansoni in the Finchaa Sugar Project area, both of which cause anaemia, the health and the productivity of adults whose livelihood and contribution to the economy depend on hard physical work will be severely impaired.

For helminth parasite populations the intensity is the central statistics determining both the morbidity of infection and the dynamics of transmission (8). The most convenient means of estimating the intensity of infection is to quantify the density of eggs in faeces on the assumption that this is directly proportional to the number of worms in the intestine (37, 38). The significance of the results of the present study is the fact that it has indicated the distribution of intensity of infection, as gauged by faecal egg count, of helminth parasites in the study population. The intensity of infection of intestinal helminthic infections in general and their epidemiological characteristics in the adult population in particular have not been well studied in Ethiopia. Only recently did Dagnew et al (39) attempt to determine the intensity of *A. lumbricoides* in a small rural village in northwest Ethiopia using the Stoll's dilution technique. From our study it is evident that infections with intestinal helminths are persistent throughout adult life. However, as indicated by the geometric mean egg counts, the variance: and mean ratios, the infection is aggregated in the younger agegroups, *A. lumbricoides* in the 0-9 years, *S. mansoni* in the 5-14 years and hookworms in the 10-19 years of age. These results add evidence to the findings of the frequency distributions that the major geohelminths of humans are over- dispersed in their distribution in the population, i.e., only a minority of individuals in the population excrete large amounts of eggs (13-15, 32). Hence, chemotherapy-based control programme in the Finchaa Sugar Project Area should focus on these high risk age-groups. Special attention should be paid to the screening and treatment of the labour force and the child-bearing female population since helminths in general, and schistosomiasis and hookworms in particular, cause iron deficiency anaemia leading to impaired health and reduced productivity. Deciding on which strategy (mass, selective or targeted) to use and at what interval to deliver the chemotherapy remains to be a challenge. In Nigeria, mass chemotherapy has been reported to be cost-effective as regards lowering the intensity of *A. lumbricoides* in a high endemicity area (40, 41). However, Guyatt et al. (42), after analysing the cost-effectiveness of several control programmes, have shown that child-targeted treatment can be more cost-effective than population treatment in reducing the number of diseases, especially if repeated at a two yearly interval by covering at least 90% of the children.

The long-term reduction of soil-transmitted geohelminths is greatly dependent on the safe disposal of human faeces because of the problem of re-infection. Improvement in sanitation, such as by the provision of latrines, is likely to result in a progressive decline in the abundance of the parasites in the host population (43). Feachem et al. (44) suggest that helminth infections are more sensitive to improvements in sanitation facilities than are other intestinal organisms. Although the prevalence of soil-transmitted helminths has been reported to be influenced less by water supply (43,44), provision of piped water supply (private or communal) for all households should not be forgotten since this has been proved to be useful in the control of faecally-transmitted parasites (45). Last but not least, all measures must be accompanied with basic hygienic education, especially in schools.

Quantitative assessment of hookworm burden relies on faecal egg counts but epg are subject to individual variation and density- dependent depression of fecundity (46-52). Egg output is a poor indicator of worm burden but does pin-point very heavy and light infections. Recently, a more sensitive diagnostic technique, known as the Agyina (53) method, has been developed for more accurate assessment of hookworm burden and this needs to be adopted in future hookworm research in Ethiopia. Unless preventive measures, such as provision of sanitary facilities, are implemented the problem of hookworm infection may be exacerbated with the development of large scale irrigated agriculture and agglomeration of population in the Finchaa Sugar Project area since the parasites are also known to flourish in agricultural areas, especially in plantation agriculture, with excess water resources which play an important role in their transmission and maintenance (46). For example, both schistosomiasis and ancylostomiasis have been important diseases in areas of Egypt which, without irrigation, would be much too dry for the survival of the parasites (46).

Since no species identification was performed, it is not known which species of hookworms is (are) responsible for the infection in the study area. It has been reported that both *Ancylostoma duodenale* and *Necator americanus* are sympatric in lowlands where the soil types are sandyclayloam and sandy-loam (51). The project area is located at an altitude of 1200 metres above sea level with a clay-loam soil type (51). Hence, it is likely that either both species of hookworms or *A. duodenale,* which is more of a lowland parasite in Ethiopia (32), may be present in the Finchaa Valley. Future studies should include species identification since *A. duodenale* causes more harm to the host (51, 52). Not least, *A. duodenale* can infect humans equally successfully by percutaneous, oral, transmamary and perhaps transplacental routes (52).

At present intestinal schistosomiasis appears to be limited to few camps in the project area. The occurrence of the disease among school- children and labourers of the previous State Farm in the Finchaa Valley was reported in 1990 (54). At that time, the prevalences of schistosomiasis in camps 7, 8, 9 and 10 were 29.5%, 6.5%, 16.7% and 3%, respectively. The current prevalences for the same camps are 30%, 8%, 22% and 11%, respectively, showing a rapid increase in some of the camps in about five years. Hence, if the necessary precautions are not taken, the situation may get out of control with the development of irrigated sugar cane production which will create perennial water pockets that favour increased propagation of host snails and parasite transmission. Schistosomiasis has now undergone unprecedented increase in the Wonji and Metehara Sugar Estates, Southeastern Ethiopia, from only a rare disease in the early 1960s (55, 56). Irrigation-based agriculture is labourintensive and calls for the concentration of people; this in turn leads to heavy use and pollution of canals and ditches and as a result, “man-made schistosomiasis” spreads in the labour population (31, 55). The development of irrigation schemes is the main cause of the spread of schistosomiasis in Africa (31); they offer good breeding grounds for intermediate host snails. Hence, to control morbidity and curb the problem of schistosomiasis from increasing in magnitude in the future Finchaa Sugar Project area, mass chemotherapy and snail control using Endod (*Phytolacca dodecandra*) berries should be started in the endemic camps (where prevalence in humans is 10% or above) before the development of the irrigation scheme is in full swing. In the rest of the camps, indirect case detection and treatment and regular monitoring of snails and their infection should be started.

Control measures should include periodic mass de-worming of children using broad spectrum anthehlminthics, such as Albendazole which has been proven to have high efficacy on both *Ascaris* and hookworms (2, 5). A recent study at the Kolfe Elementary School in Addis Ababa has shown that a 6-monthly de-worming programme significantly reduces both prevalence and intensity of infection of geohelminth parasites (unpublished data).

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