Original article

Irrigation Practices and Intestinal Helminth Infections in Southern and Central Zones of Tigray

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Abstract

Background: Irrigation practices have impact on the distribution of schistosomiasis; so, identifying newly established schistosomiasis transmission foci allows for designing prevention and control strategy.

Objective: To establish schistosomiasis prevalence and intensity in relation to development of water bodies for irrigation.

Methods: A survey of stool specimens of 2000 school children using Kato thick smear method was carried out in Central and Southern Tigray between October 2001 and January 2002.

Results: Among the 1012 males and 998 females examined, 29% males and 27.5% females were found positive for one or more parasite. The prevalence of *S. mansoni* was 27% in longstanding irrigated, 10.8% in recently constructed irrigation schemes and 1.8% in the non-irrigated rural localities. In the urban setting, its prevalence was 15.5% in areas with water body nearby and 0.5% in areas with no water body nearby (P<0.0001). New *S. mansoni* infection foci were detected in Tumuga with a prevalence of 87%; Dibdibo (41%), Mariam Shewito (25%), Adiha (23%) and Lekia (9%).

Conclusion: The increasing risk of schistosomiasis mansoni in the irrigation sites is high. Hence, designing preventive and control strategies concurrent with the development of the irrigation projects will be required to reduce prevalence of schistosomiasis. [*Ethiop.J.Health Dev.* 2009;23(1):48-56]

Introduction

Parasitic worms adversely affect the health of humans in many parts of the world. Intestinal parasitic infections continue to be a public health problem globally, particularly among children in the developing countries (1). In many of the developing countries, the most prevalent and important helminths are those of the soil-transmitted nematodes. Chronic gut infection in humans commonly results from nematodes, particularly that of *Ascaris lumbricoides*, *Trichuris trichiura* and hookworms (*Ancylostoma duodenale* and *Necator americanus)* (2), and the blood flukes, schistosomes (3). Their distribution is influenced by sanitation, population movement, availability of water bodies, etc. For example, higher rates of ascariasis, trichuriasis and hookworm infection were constantly recorded among migrants from populations working in irrigation schemes in the Awash Valley than among nearby nomads or migrant populations employed in rain-fed agriculture in the semi-arid Setit Humora area (4). The fact that hookworm, *Ascaris* and *Trichuris* larvae and ova require humid environments as in irrigation schemes indicates the role of such schemes in the transmission of these intestinal parasites (5). Lemma (6) also observed that the continuing large-scale agricultural use of rivers, the construction of highways and population movement lead to the spread of schistosomiasis. Various studies have been conducted on all intestinal parasites or only on *Schistosoma mansoni* infection in Tigray (12, 22 and 23).

It is known that irrigation and the construction of dams with poor sanitary practice results in rapid spread of S. *mansoni*, since the aqueous environment provides suitable condition for intermediate snail host (7). Worldwide, in all endemic regions, the development of water resource plays an important role in the spread of schistosomiasis. For example, the introduction of irrigated agricultural scheme has been associated with introduction of *S. mansoni* in both upper and middle part of Awash valley (8).

In Ethiopia, the introduction of irrigated agricultural schemes has been shown to be associated with the introduction of *S. mansoni* in both upper and middle part of Awash Valley (8).

Currently, to reduce dependency on rain fed agriculture, construction of dams for irrigation is underway in Ethiopia. Tigray is one of the regions which have started a rural development program by an extensive construction of dams for irrigation. Although there is no national inventory of small dams in Ethiopia, there are more than 70 reservoirs in Tigray (Northern Ethiopia), ranging in reservoir water volume from 50,000 to 4,500,000 m^3 (25 & 26). The majority of the dams are situated near human settlements at an altitude range of 1700-2700m. Dams serve many different purposes for the community, such as domestic and agricultural water supply, irrigation and fish culture. As a potential very negative side-effect, dams may create conducive environment for breeding sites of malaria and schistosomiasis vectors. Although increased economic benefit of expansion of irrigated agriculture is being realized, its public health impact is not fully understood. The present investigation was undertaken to establish the prevalence and intensity of intestinal schistosome and other helminth infections in relation to development of water bodies for irrigation. The information generated in the current study would help to identify new schistosomiasis foci and it can also be used as a baseline

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data for mapping the distribution of schistosomiasis and future reference for designing and evaluating Schistosomiasis control strategies.

Methods

Central Tigray encompasses ten districts (Weredas) and has 265 primary schools. The population of Central Tigray was 1,132,112 and of this 88.8% are subsistence farmers (Fig. 1). South Tigray is divided into eight districts and has 256 primary schools. The population of South Tigray was 938,808, of which 85% are subsistence farmers.

The study population was primary school children. They were selected because prevalence of infection in school-age children can be used as an index for assessing community prevalence (9) and they are likely to accept the inconvenience of providing stool specimens.

Sampling and sample size

Comparing the results of pre-irrigation health data (especially for the recently constructed reservoirs) would have been important to explain the impact but such data are not available in the region. Thus, 10 representative schools were purposely selected from each of Central and South Tigray zones (Fig. 1). The selection comprises 3 schools from longstanding, 2 schools from recently constructed irrigation schemes, 3 schools from non-irrigated, 1 school from urban center with river nearby and 1 school from urban center with no river nearby. Hundred students from each of the 20 schools were selected using systematic sampling by using a random start. The total sample size was 2000 school children. Data collection was undertaken from October 2001 to January 2002.

Parasitological examination

Students were supplied with a piece of paper to bring about 3gms of faeces. Specimens were collected on-the-spot. Teachers and school directors were assisting investigators in collecting the samples. Students who were not able to pass stool during sample collection were advised not to bring their friends stool, but to report that they could not pass stool. Those who reported were substituted by other students. In the field, the 2000 samples were processed by Kato thick smear (10) and transported to Mekelle University for microscopic examination. One slide was prepared for each sample and examined once by well trained expertise. All positive cases were treated. Those with *S. mansoni* were treated with Praziquantel 40 mg/kg body weight, single dose, while for others with helminthes (*A. lumbricoides* and *T. trichiura* and hookworm) infections were treated by Mebendazole 100mg BID for three days.

Intensity of infection was estimated from the number of eggs per gram of faeces (epg). Based on egg counts, cutoff values for classification of intensity of infection were used. Intensity of *S. mansoni* is classified into: light infection (1-99epg), moderate (100-399 epg) and heavy (greater than 400 epg). Similarly, the classification for *A. lumbricoides* is: light infection (1-4999epg), moderate (5000-49999epg) and heavy (greater than 50,000epg). Intensity of *T. trichiura* is: light infection (1-999epg), moderate (1000-9999 epg) and heavy (greater than 10,000epg). Classification of hookworm is: light infection (1-1999epg), moderate (2000-3999 epg) and heavy (greater than 4,000epg) (11). In the result section, only intensity of *S. mansoni* was presented because the intensity in all others was light infection.

Socioeconomic survey

Data of socioeconomic factors was collected using a structured questionnaire specifically developed for this purpose. All questions were closed-ended in structure. One of the questions was filled by observation. Data was collected by one of the researchers.

Data Analysis

Data was entered into and were analyzed using SPSS version 10.1 software package.

Results

Prevalence

A total of 1012 male and 988 female school children were examined. Out of these, 571 (295 males and 276 females) were positive for one or more helminths. On the whole, average intestinal helminth infection was 28.6% (range: 6% - 92%). Considering irrigation practices, the overall prevalence of intestinal helminth infection in long-standing irrigation areas was 38.5% (range: 14 – 92%); in the newly introduced irrigation schemes, it was 20.8% (range: 6-47%) and in non-irrigated areas, it was 15.7% (range: 9-26%). Furthermore, significant difference ($P<0.00001$) was observed between prevalence in the urban centers (40.8% range: 15-88%) and rural communities (26.1% range: 9.5-50%) (Table 1).

Of the 20 schools surveyed, 11 (55%) were positive for S. *mansoni* infection. The difference in the overall prevalence of *S. mansoni* infection with respect to irrigation was 17.5% in irrigated and 5.5% in non-irrigated areas ($P < 0.0001$) (Table 3). Further, the prevalence of *S. mansoni* infection was much higher (27%) in the longstanding irrigated locations than in the recently constructed irrigation schemes (10.7%) and 1.8% in the non-irrigated locations ($P < 0.0001$) (see Table 2). Similarly, urban centers with water body nearby had a much higher prevalence (15.5%) than urban centers with no water body nearby (0.5%).

Table 1: **Proportion of students positive for one or more intestinal helminth species in South and Central Tigray, 2002**

Setting	South Tigray			Central Tigray			Total (ST & CT)
	Male	Female	Total	Male	Female	Total	
Long-standing (Rural)dam	74/152 (48.7)[1]	76/148 (51.4)	150/300 (50)	40/150 (26.7)	41/150 (27.3)	81/300 (27)	231/600 (38.5)
Recent dam (Rural)	6/84 (7.1)	13/116 (11.2)	19/200 (9.5)	37/115 (32.2)	27/85 (31.8)	64/200 (32)	83/400 (20.8)
No irrigation (Rural)	21/163 (11.5)	28/137 (20.4)	49/300 (16.3)	26/151 (17.2)	19/149 (12.8)	45/300 (15)	94/600 (15.7)
Urban[2]	59/96 (61.5)	52/104 (50)	111/200 (55.5)	32/101 (31.7)	20/99 (20.2)	52/200 (26)	163/400 (40.8)
Total (Overall)	160/495 (32.3)	169/505 (33.5)	329/1000 (32.9)	135/517 (26.1)	107/483 (22.2)	242/1000 (24.2)	571/2000 (28.6)

Key:1= values in brackets are %; 2 =in 50% of the urban area studied there are rivers nearby; ST= south Tigray; CT= Central Tigray

Table 2: ***S. mansoni* distribution in school children with respect to different irrigation practices and sex in South and Central Tigray, 2002**

Settings	Male		Female		Total	
	No	%	No	%	No	%
LSI	77/303	25.5	83/297	27.9	160/600	27
RCI	27/200	13.6	16/200	8	43/400	10.7
NI	9/321	0.7	2/288	2.3	11/600	1.8
UW	17/98	11.7	14/102	13.5	31/200	15.5
UNW	1/100	1	0/100	0	1/200	0.5

Abbreviations: LSI= Long-standing irrigation, RCI= Recently constructed irrigation,
NI= Non-irrigated area, UW= Urban with water body near by,
UNW= Urban with no water body nearby

Table 3: **Primary schools in South and Central Tigray with children positive for S. *mansoni* infection , 2002**

Schools	Altitude	Zone	% infection n=100 (in each School)	Irrigation Practice
Tumuga	1450	ST	87	Long-standing
Meara	2050	ST	19	Long-standing
Gira Bered	2100	ST	2	Recently constructed dam
Dibdibo	1850	CT	41	Recently constructed dam
Adiha	1600	CT	25	Long-standing
Mariam Shewito	1900	CT	23	Long-standing
Agbe	1550	CT	7	Long-standing
Godowa	2510	CT	2	Non-irrigated
Lekia	1900	CT	9	Non-irrigated
Abi Adi	1700	CT	32	Urban
Abreha Atsbeha	2000	CT	1	Urban

Abbreviations: CT = Central Tigray, ST = South Tigray

The prevalence of *S. mansoni* infection with respect to age showed a peak in the age group 10-14 years old (15%) while the rate of infection in 5-9 years old was 8.4% and that for 15-19 years old was 11% (Table 4). Unlike in *S. mansoni* infection, the peak infection due to geo-helminths was in the age group 5-9 (14.8%) and 10-14 (14.7%) and the least affected group was the age group 15-19 (10%) ($P < 0.03$). The highest prevalence of geo-helminths (88%) was in Alamata, a small town in Southern Tigray.

Table 4: **Prevalence of Intestinal Helminth Infections by zone and age in school children in South and Central Tigray, 2002**

Zone	Infection by Age															
	S. mansoni								**Geo-helminth**							
	5-9		10-14		15-19		Total		5-9		10-14		15-19		Total	
	No	%	No	%	No	%	No	%	No	%	No	%	No	%	No	%
CT	32	10.6	79	15.7	29	14.9	140	14	15	5	16	3.2	6	3.1	33/1000	3.3
ST	23	6.8	81	14.5	4	3.8	108	10.8	80	23.7	140	25.1	24	23.1	244/1000	24.4
Total	55	8.6	160	15.1	33	11	248	12.4	95	14.8	156	14.7	30	10	277/2000	13.9

CT= Central Tigray; ST= South Tigray

On the average, the prevalence of *S. mansoni* infections with respect to altitude showed highest prevalence in the lowlands and the least in the highlands (P<0.0001). Similarly, significantly high (P< 0.0001) prevalence was observed for *A. lumbricoides* and *T. trichiura* (result not shown).

It also was evident that *S. mansoni* prevalence was significantly associated with rural areas (P < 0.03), while *A. lumbricoides* and *T. trichiura* infections were more prevalent in the urban centers (P < 0.0001) (Table 5).

Information obtained on environmental conditions such as the condition of the floor of the house (cemented or not), availability of toilet and potable water and wearing of shoes by the students showed that none of the conditions were significantly associated with parasite prevalence (Table 6). Only 18.3% of the students examined had relatively better hygienic living conditions. However, even among these groups, 47.8% were harboring one or more parasite. The majority of the study subjects belonged to the category # 4 (Floor not cemented, no toilet and no safe water but wearing shoes) and the group had the highest parasite infection (59.1%).

Table 5: **Prevalence of parasitic infection with respect to altitude, urban and rural in school children in South and Central Tigray, 2002**

Parasite	**Altitude**						**Urban**		**Rural**	
	Highland >2500masl		**Medium** 2000 – 2500masl		**Lowland** <2000masl					
	No	%	No	%	No	%	No	%	No	%
S. m	2	1	21	3.5	223	18.6	32/400	8	214/1600	13.8
H. w	0	0	3	0.5	13	1.1	1/400	0.3	15/1600	0.9
T. t	1	0.5	13	2.2	50	4.2	34/400	8.5	30/1600	1.9
A. l	6	3	17	2.8	171	14.3	90/400	22.5	104/1600	6.5

Abbreviations: S.m = *S. mansoni*, Hw = Hookworm, A.l = *A. lumbricoides*, T.t = *T. trichiura,*

Table 6: **Proportion of school children harboring parasites within different socioeconomic and environmental conditions in South and Central Tigray, 2002**

Socioeconomic & environmental condition	Alamata		Maichew		Abyi Adi		Total	
	Examin (n)	Positive n (%)	Exami (n)	Positive n (%)	Examined (n)	Positive n (%)	Examined n (%)	Positive n (%)
Category 1	20	15(75)	4	1(25)	22	6 (27.3)	46 (18.25)	22 (47.82)
Category 2	1	1(100)	0	0	13	5 (38.5)	14 (5.56)	6 (42.86)
Category 3	16	14(87.5)	23	4(17.4)	3	0	42 (16.67)	18 (42.86)
Category 4	35	31(88.6)	12	5(41.7)	46	19 (41.3)	93 (36.9)	55 (59.14)
Category 5	10	9(90)	12	2(16.7)	6	2 (33.3)	28 (11.11)	13 (46.13)
Category 6	15	15(100)	0	0	10	5 (50)	25 (9.92)	20 (80)
Category 7	3	3(100)	1	1(100)	0	0	4 (1.59)	4 (100)
Total	100	88	52	13 (25)	100	37	252	138 (54.76)

Key: 1= Floor cement, shoe wearing, use toilet & potable water, 2= Floor cement, shoe wearing, no toilet & no potable water, 3= Floor not cemented, shoe wearing, use toilet & potable water, 4= Floor not cemented, shoe wearing, no toilet & no potable water, 5 = Floor not cemented, shoe wearing, no toilet & no potable water 6= Floor not cemented, not shoe wearing, no toilet but use potable water, and 7= Floor not cemented, not shoe wearing, no toilet & no potable water

Intensity of S. mansoni infection

The highest intensity of *S. mansoni* infection was in the irrigated sites followed by urban centers with nearby water bodies. Newly introduced irrigation projects were the next in intensity while the least intensity was in non-irrigated and urban centers with no nearby water body (P <0.0001) (Fig. 2). The overall data for both zones revealed that the peak prevalence for heavy *S. mansoni* infection was in the age group 10-14 (7.5%) followed by 15-19 (6.1%) and 5-9 1(0.3%) (P < 0.003) (Fig. 3a).

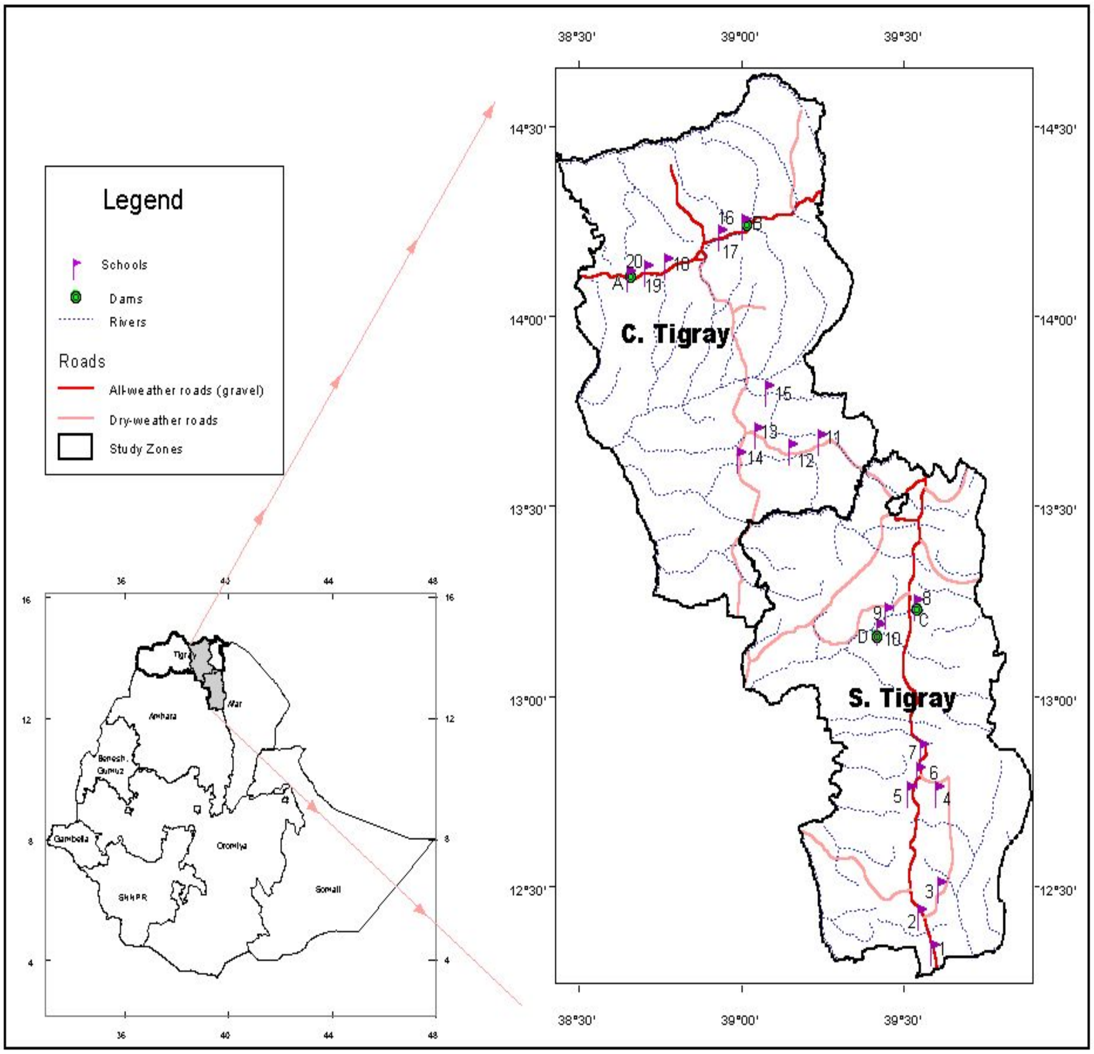

Figure 1: **Map of the Study Area**

Key: **Primary Schools**

South Tigray

1) Tumuga
2) Adget Fana (Alamata)
3) Gerjelle
4) Genettie
5) Mekan
6) Hizba (Maichew)
7) Birhan Lekatit
8) Ara
9) Meara
10) Gira Bered
11) Central Tigray
12) Aynimbirkekiy
13) Godewa
14) Agbe
15) Abyi Adi
16) Adiha
17) Dibdibo
18) Mariam Shewito
19) Leki'a
20) Abreha Atsbeha (Axum)
21) Dura

Dams: A) May Nugus (Dura) B) Dibdibo C) Gum Selasa (Ara) D) Adi Kenafiz (Gira Bered)

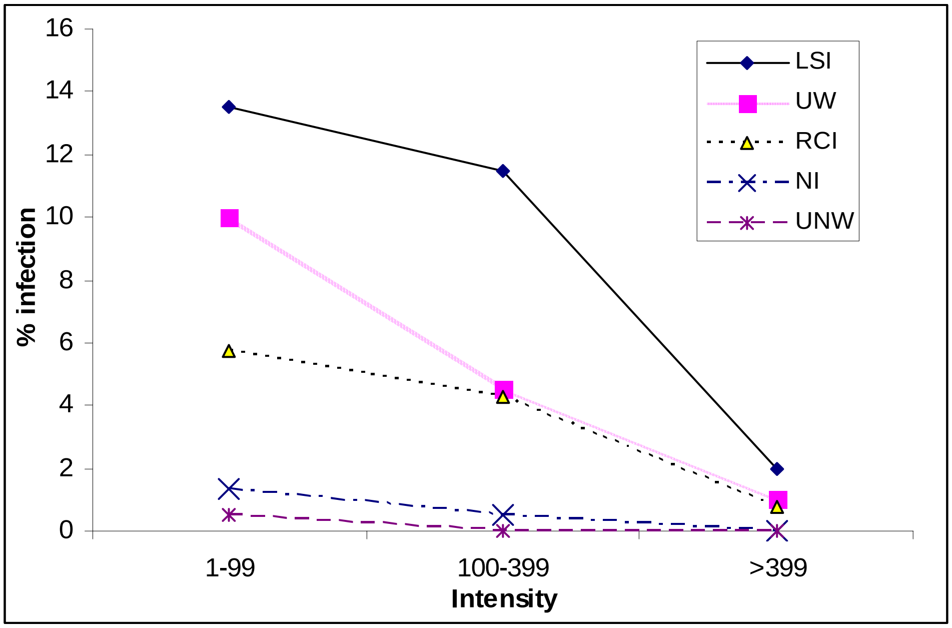

Figure 2: **Prevalence of *S. mansoni* infection shown by intensity levels**
Key: Light infection = 1-99epg, Moderate infection = 100-399epg and Heavy infection = > 399epg, LSI = Long-standing irrigation, RCI = Recently constructed irrigation, NI = Non-irrigated area, (UW) = urban with water body nearby, (UNW) = Urban with no water body nearby

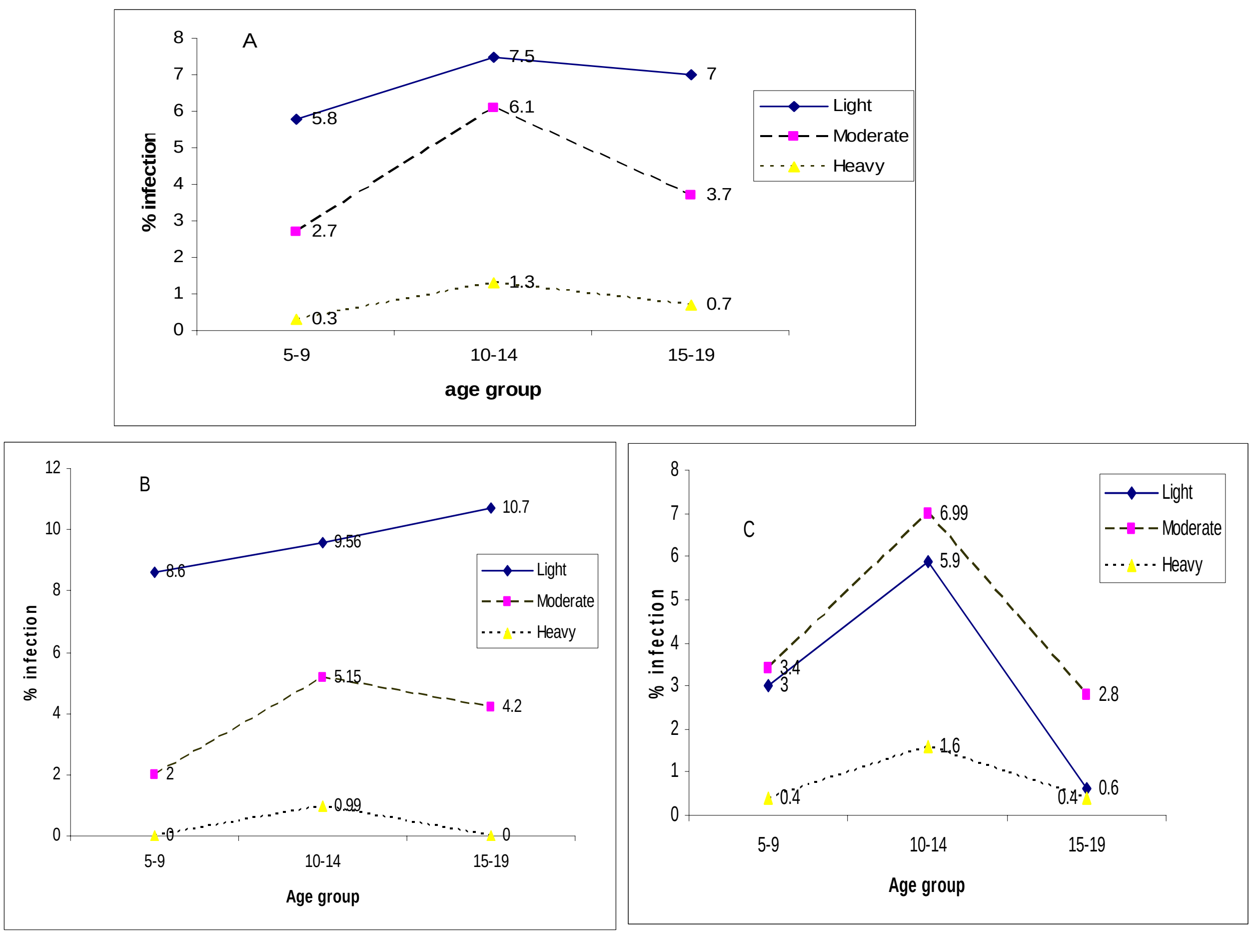

Figure 3: **Prevalence of *S. mansoni* infection shown by intensity levels and age**
Key: Light infection = 1-99epg, Moderate infection = 100-300epg and Heavy infection = > 399epg, (A) = Overall, (B) = Central Tigray, (C) = South Tigray

Discussion

The overall prevalence of intestinal helminthic infections in rural and urban centers that have water bodies nearby is a reflection of the high *S. mansoni* prevalence in areas with water and the prevailing favorable condition of moist and warm temperature for geo-helminths in the study sites. The finding that geo-helminth infections are more prevalent in the age groups 5-9 and 10-14 years in both study areas, ST and CT, is an indication that younger children are more exposed since they usually play in the open fields and eat food without washing hands. Thus, as age increases the prevalence of geo-helminth infection decreases possibly due to improved personal hygiene and reduced contact with soil. These findings are in agreement with that reported by (12) from Tigray.

In spite of the fact that South and Central Tigray have similar climatic conditions and other factors such as occupation, agricultural practices, human waste disposal and food habits, the finding that geo-helminth infection prevalence was significantly higher in South Tigray than in Central Tigray may be explained by the contribution of highest prevalence in Alamata in South Tigray. In Alamata, most plantations around human residences are frequently watered creating moist condition in an environment of hot temperature, thus making conditions for preservation of infective helminth eggs favorable.

Contrary to the report of a study elsewhere (13), the prevalence of *A. lumbricoides* and *T. trichiura*, was significantly higher in the urban than in the rural settings. These findings are consistent with that in Kombolcha town (South Wollo) (14) and Addis Ababa and Debre Zeit (15). This may be attributed to the high population density and the poor sanitation prevailing in the urban centers.

The high prevalence of the major nematode parasites and *S. mansoni* in the lower altitudes can be accounted for by the relatively high temperature and moisture conditions favorable for larval development.

Lack of difference in parasite prevalence among students that do and do not have access to safe water, latrines, cemented floor and shoes or not being in the urban residences, implies that to reduce worm burden in a community, the quality of the socioeconomic indicators and their accessibility to the population must be much higher than what was determined in this study.

The pattern of schistosomiasis prevalence in Tigray where it was highest in the longstanding irrigated areas followed by the urban communities with water nearby, and next in the recently constructed irrigated sites followed by the non-irrigated sites, and in urban communities with no water nearby was similar to that reported from Methara Sugar State in Estern Shoa (16).

The high prevalence of *S. mansoni* infection in older dams, when compared with new dams less than 5 years old in an earlier study in Tigray (12) was confirmed by our study. This may be explained by the fact that adequate period of time is necessary for the establishment of schistosomiasis endemicity in a locality. Our finding has shown that the condition for established schistosomiasis endemicity has been fulfilled in the irrigation schemes in Tigray and hence, the danger of irrigation projects creating an ideal environment for the introduction and spread of the infection is real.

The situation in Gerjelle, which is an area with longstanding irrigation practices but with no *S. mansoni* positive individuals among the school children was an exception. The more likely means of spreading snails in irrigation schemes is by canal intake water flow from streams and rivers. Besides, it is often suggested that aquatic organisms can be introduced into new water bodies by water birds that can carry resting eggs as they fly from one water body to the other (24). Thus, we cannot say it is risk free because the snail intermediate hosts can be introduced into new water bodies by these birds.

The source of parasites could be infected persons that visit from endemic nearby foci.

The peak prevalence and intensity registered for *S. mansoni* infection in the age group 10-14 followed by the age group 15-19 years and, the lowest in the age group 5-9, was in agreement with earlier reports different parts of Ethiopia (17,18), including Tigray (12). The low infection rate in the age group 5-9 years might be attributed to the low water contact behavior of children of this age.

The significantly higher prevalence of *S. mansoni* in the rural than in the urban communities can be accounted for by the availability of more water bodies in the rural areas where irrigation schemes are present. The relationship between intensity of schistosomiasis infection and proximity of the location to water bodies has been reported from other locations in Ethiopia (13).

Our study has presented evidence for the endemicity of schistosomiasis mansoni in five localities (Adiha, Tumuga, Diobdibo, Lekia and Mariam Shewito) that have not been reported before. It is only Dibdibo (with 41% prevalence) dam, which is located near Dibdibo Primary School, that is among the recently constructed dams, while the other schools were among the longstanding irrigation users. This shows the need for careful surveys of an area for schistosomiasis endemicity before considering it free of the disease.

Longitudinal studies had indicated that prevalence of schistosome infection increases with the age of the irrigated area. In Ethiopia this was documented in

Methara (19, 16) and Wonji-Shoa Sugar Estates (20). Studies from Egypt had also shown an increased prevalence from 0.05% to 60% within less than five years following introduction of an irrigation scheme into a region (21).

Thus, the increased prevalence rate of *S. mansoni* infection with the increased introduction of irrigation schemes will be of great public health concern unless appropriate control measures are designed. It is possible, with increased development of irrigation, schistosomiasis might further increase in prevalence and intensity in the near future. Therefore, designing schistosomiasis prevention and control strategies concurrent with the development of the irrigation projects will be required to limit the spread of schistosomiasis.

Periodic de-warming of school children and, if possible, the whole community, is recommended. To further reduce the overall worm burden, construction of latrines and supply of safe water, inculcation of proper behavior in the proper use of the available facilities through education are necessary.

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