A Cross Sectional Assessment on Distribution of Snail and Risk Factors of *Schistosoma Mansoni* Infection in Proximity to Water Contact Points in Gorgora Town, Western Dembia District, Northwest Ethiopia.

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Abstract

Background: Schistosomiasis is one of the great neglected tropical diseases with socio-economic and health problem worldwide. In Ethiopia numerous studies reported *S. mansoni* is high among school-age and preschool age children. Though intensive prevalence studies are conducted the snail distribution and infectivity status and human infection rate dynamics in Ethiopian context remains poorly understood. Thus the purpose of the current study was to assess distribution of snail and risk factors of *Schistosoma mansoni* infection in proximity to water contact points in Gorgora town, Western Dembia District, Northwest Ethiopia.

Method: A Community based cross-sectional study was conducted in Gorgora Town from March to May 2020. A total of 385 study participants were selected by systematic random sampling technique. Stool sample was collected and examined by Kato-Katz technique. Malacological survey was done from sampling sites showing signs of human activity near Lake Tana shoreline. Live snails collected in plastic bucket containing water and weed were transported within four hours to the University of Gondar, Medical parasitology laboratory for identification and determination of infection. Data was entered with EPI Data version 4.4.2.1. Data analysis was carried out using SPSS version 20.0 and STATA version 15.0. p-value ≤ 0.05 was reported as statistically significant. Spatial distribution analysis was done using ArcGIS system for Geographical Information System (GIS).

Result: The overall prevalence of *S. mansoni* infection was 36.6% (CI: 32-41.9) with intensity of 30.5%, 27.0% and 42.6% for light, moderate, and heavy, respectively. Among the different fresh water snails collected on the basis of shell morphology 546(%) were *Biomphalaria pfeifferi*, 310(28.1%) were *Bulinus* spp, 101(9.1%) were *Lymnaea*, and 147(13.3%) were *Bivalve*. Schistosome infection in *Biomphalaria* spp. was 0.0%. Swimming frequency and proximity to water body were observed to be the most associated risk factor to *S. mansoni* infection.

Conclusion: The study showed that *S. mansoni* is an ongoing health problem in Gorgora. Different fresh water snails with a potential of transmitting diseases of human and veterinary importance that requires attention had been identified. Longitudinal and molecular study on *Biomphalaria pfeifferi* infection rate as well as susceptibility to schistosome infection is recommended.

Background

Schistosomiasis is one of the great neglected and unconquered tropical diseases caused by the digenetic trematode *Schistosoma* (1). It is an important socio economic and public health problem worldwide that is mostly prevalent in many developing countries where poor sanitation and low access to safe drinking water is predominant (2). *Schistosoma haematobium*, *Schistosoma japonicum*, and *Schistosoma mansoni* are the three main species infecting humans and *S. mekongi* and *S. intercalatum* are restricted in certain geographical locations. *Schistosoma mansoni* and *S. haematobium* which causes intestinal and urinary schistosomiasis respectively, are the causes of African schistosomiasis(2, 3). Transmission

of schistosomiasis involves the release of ova from infected hosts' faces or urine depending on the species, hatching of ova that release miracidia which ends up in the infection of appropriate intermediate snail host. Human infection involves skin penetration by cercaria when coming in contact with water containing Schistosoma-infected snails. Inside the human host, cercaria develop into sexually mature ova-laying worms in the hepatic portal system (4).

Freshwater snails play a salient role in the ecology of fresh-water; serving as food for numerous other animals and feeds on vast amounts of algae and detritus. Whereas estimated 350 snail species play significant role in public and veterinary health, many species of freshwater snail belonging to the family Planorbidae serve as intermediate hosts for a number of infections such as angiostrongyliasis, clonorchiasis, fascioliasis, fasciolopsiasis, opisthorchiasis, paragonimiasis and the most common, schistosomiasis in Africa, Asia and the Americas(5, 6). Human *Schistosoma* parasites species are transmitted by a responsible intermediate hosts: *Biomphalaria*, *Bulinus*, and *Oncomelania* for *S. mansoni*, *S. haematobium*, and *S. japonicum*, respectively(7, 8).

Schistosomiasis mostly affects poor and rural communities, particularly agricultural and fishing populations. Women doing domestic chores in infested water, such as washing clothes, are also at risk and can develop female genital schistosomiasis. Inadequate hygiene and contact with infected water make children especially vulnerable to infection(11).

Mass drug administration with Praziquantel (PZQ) is the cornerstone in schistosomiasis control strategies in which extensive reliance on just one drug is scaling up and this leads to emergence of resistance due to selective pressure(12, 13). Recent reports on the possible development of resistance and treatment failure to PZQ have generated much more unrest.

In Ethiopia, while *S. mansoni* is wide spread, *S. haematobium* is restricted to few areas. Although there are ample literatures on the distribution and infection status of schistosomiasis in Ethiopia, there is a need to conduct study on the distribution and infection status of snail intermediate hosts (3). Therefore, the availability of this information is important in designing effective disease control measures such as molluscicidal chemicals.

Methods

A Community based cross-sectional study was conducted from May 2020 to March 2021 in selected Schistosoma endemic village in Gorgora Town of Western Dembia District Northwest, Ethiopia. Gorgora is a small road side town on the shore of Lake Tana, 818 Km away from Addis Ababa. The average temperature ranges from 29 °C to 31 °C. Annual rainfall ranges from 900 mm to 1038 mm, with Altitude of 1800 m to 1900 m above sea level and located at 10° 17'N latitude and 37° 26'E longitude. The population is estimated to be 2,500 with 2.89 km square area (16)

The parasitological examination sample size was determined by using the single population proportion formula with the following assumptions: prevalence (p) of 50% to increase sample size, 95% confidence

level, 5% margin of error, and a sample estimation correction formula was considered. Moreover, a 10% non-response rate was added and the final sample size (n) was = 385.

A multi-stage sampling procedure was utilized to select study participants. At the first stage, village was selected randomly by simple random sampling from three villages. At the second sampling stage, numbers of households included in each village was determined by proportional allocation according to the total number of households found in each village/kebeles. Then, systematic sampling method was employed to select the households. The sampling interval was calculated by dividing the total households to the number of households to be included in the sample for each village. The initial household was randomly selected by lottery method and the next households was selected at that interval. Whenever more than one eligible was found in the same selected household, only one of them was chosen using the lottery method. In case no eligible candidate was identified in a selected household, the next household was selected keeping the interval constant afterwards. In addition, a person in the selected households was enrolled based on inclusion criteria. Then each data collector conducted a house-to house survey. Each water point and study households was Geo-referenced using Garmin64.

Data collection and laboratory methods

Malacological survey

All sites which showed signs of human activity near the shoreline were selected for snail collection. Intermediate snail hosts was surveyed both in the lake and in the stream at human water contact sites. In the likely habitats, observations was also made on physical characteristics such as vegetation abundance, turbidity, the nature of the substrate and stones. In addition, the meantime water contact activities were also surveyed(4).Snails were collected by scooping, hand picking using forceps and gloves and put in open plastic bucket that contained a small quantity of water and weeds. Thereafter, snails were transported to Medical Parasitology laboratory, College of Medicine and Health Sciences, University of Gondar for determination of infection and identification. Then, snails were examined for natural trematode infections by shedding method(18).Each snail was placed individually in the shedding vials with water (deionized water) and then exposed to electric light for about one hour. The cercariae shed by the snails was identified to the genus level by their tail morphology following WHO recommendation(5, 6).

Socio demography and risk factor assessment

Well-structured questionnaire based on the known risk factors for Schistosoma was prepared in Amharic and was translated later in English version. It was translated later into the Amharic, local language of the study area. The questionnaire addresses inhabitant's socio-demographic information and risk factors. A pretest was conducted and additional response categories was added based on the pretest findings.

Parasitological Techniques

A single stool specimen of about 2 g was collected from each study participant using clean, dry and leak proof plastic container labeled with unique identification number. A portion of the sample was processed

by Kato-Katz method using a template holding 41.7 mg of stool(19). Kato-Katz smears were processed in study sites and slides were transported and examined under a microscope at University of Gondar (UoG), Medical Parasitology Laboratory. A small portion of the stool samples was preserved in 10% formalin for repeating for formol-ether concentration techniques(19, 20). Examination for hookworm was performed within one hour of stool collection and Kato-Katz slide preparation. The slides were left for 24 h to clear for easy visualization of *S. mansoni* and other helminthes eggs. After 24 h, two experienced laboratory technologists examined each slides independently. Whenever the result of the two laboratory technologists discorded, the third experienced laboratory technologist examined the slides. Results of the laboratory investigation was recorded on a format prepared for this purpose. Infection intensity of the *S. mansoni* and STHs was estimated by multiplying the total number of eggs counted by 24, which gives as the eggs per gram (epg) of stool. Besides, the species specific classes of infection intensity with *S. mansoni* and STH were classified as light, moderate and heavy per the threshold set by WHO (21). Inhabitants who were found positive for intestinal parasites infection were treated with standard dose of anti helmintic treatment(22).

Evaluation of physicochemical parameters

The evaluation of the physico-chemical parameters of water bodies was carried out to a depth not exceeding 0.5 meters. Using conductivity ($\mu\text{S}/\text{cm}$) multi-parameter digital probe recorder (HANNA instruments). Then the tube was placed in the device for 3 minutes to obtain the value. Hydric potential (pH) was obtained using pH-meter (HANNA instruments) by immersion of a probe. The water temperature ($^{\circ}\text{C}$) was measured by a flowatch (HANNA instruments) equipped with a submerged propeller at a depth of 0.5 meters(7).

Data Analysis and Interpretation

Data were double entered, coded, cleaned, and verified using *EpiData* Version 4.4.2.1 software (EpiData Association, Odense, Denmark). Data analysis was carried out using SPSS version 20.0 (IBM Corp. IBM SPSS Statistics for Windows, Armonk, NY, USA) and STATA version 15.0 (StataCorp. Statistical Software: College Station, TX 77845, USA). Different variables were described and characterized by frequency distribution (n (%)). Binary and Multivariable logistic regression analysis was done for associated risk factors for acquiring *S. mansoni* infection. Distribution analysis was done using ArcGIS system for Geographical Information System (GIS) for proximity analysis. The prevalence of schistosomiasis was computed as percentage (8).

Results

Socio-demographic characteristics

A total of 385 study participants of which 189 (49.1%) males and 196 (50.9%) females were participated in the study (Table 1). All the study participants were urban residents in Gorgora town. The mean age of

participants was (23.84) years. Age of the participants ranged from 1 to 80 years (SD $\pm$ 17.547)

Table 1
Socio-demographic characteristics of study participants at Gorgora town, Western
Dembia, Northwest Ethiopia 2020.

Socio-demographic variables		Frequency	Percentage
Sex	Male	189	49.1%
	Female	196	50.9%
Age	< 4	35	9.1%
	5–9	52	13.5%
	10–14	76	19.7%
	15–19	21	5.5%
	20–24	30	7.8%
	25–29	56	14.5%
	30–34	26	6.6%
	35–39	18	4.8%
	> 40	71	18.4%
Educational level	Illiterate	106	27.5%
	Primary	167	43.4%
	Secondary	85	22.1%
	Tertiary	27	7.0%
Occupational status	Not employed	266	69.1%
	Self employed	88	22.9%
	Government employed	26	6.8%
	Private employed	5	1.3%
Average monthly income (Birr)	< 1000	309	80.
	1001–2000	53	13.8%
	2001–3000	12	3.1%
	> 3000	11	2.9%
Marital status	Married	140	36.4%
	Single	226	58.7%
	Divorced	11	2.9%

Socio-demographic variables	Frequency	Percentage
Other	8	2.1%

Prevalence of *S. mansoni* infections by demographic characteristics

Schistosoma mansoni infection was observed in 141(36.6%) study participants. Of the 141 *S. mansoni* infected 76(40.2%) were males and 65(33.3%) were females. Out of 385 total participants examined, 208(54.0%) were positive for at least single helminth infection; and among the seven helminths identified, the prevalence of other helminthic parasites were 17.4% of which *Ascaris lumbricoides* (14.1%) was the highest followed by hookworm (2%). One hundred ninthly four (50.4%) study participants had single infection and 14(3.6%) had multiple infections (Table 2).

Table 2
Sex distribution of *S. mansoni* and intestinal helminths infections among study subjects of Gorgora western Dembia, Northwest Ethiopia 2020.

Types Helminths Parasites	Kato-Katz technique result (n = 385)		
	Male N% (n = 189)	Female N% (n = 196)	Total N% (n = 385)
<i>Schistosoma mansoni</i>	76(40.2)	65(33.2)	141(36.6)
<i>Ascaris lumbricoides</i>	27(14.3)	27(13.8)	54(14.1)
Hookworm	4 (2.1)	4(2.0)	8 (2.1)
At least one parasite infection	111(58.7)	97(49.5)	208(54.0)
Single infection	104(55.0)	90(45.9)	194(50.4)
Multiple infection	7 (3.7)	7 (3.6)	14(3.6)

Assessing risk factors for *S. mansoni* infection

Among 385 participants 58(15.1%), 207(53.8%), and 120(31.2%) had reported none, sometimes and frequent contact with Lake Tana, respectively. Of this 16(11.3%), 67(45.5%) and 58(41.1%) were infected with *S. mansoni*. In bivariate analysis, risk factors associated with (p-value > 0.05) and those variables with (p-value < 0.25) were carried to multiple logistic regression to see independent effect of variables. The odds of getting *S. mansoni* infection among individuals swimming sometimes was 7.7 times higher than those they didn't have an exposure of swimming at Lake Tana (AOR: 7.7; 95% CI: 2.42–24.5; p =

0.001). The odds of getting *S. mansoni* infection among individuals swimming frequently was 10 times higher than those they didn't have an exposure of swimming at Lake Tana (AOR: 10.0; 95% CI: 3.19–36.6; $p = 0.000$). The odds of getting *S. mansoni* infection among individuals living 1 km away from the shoreline was 1.7 times higher than those who are living 1 km away from the shoreline at Lake Tana (AOR: 1.70, 95% CI: 1.03–2.84; $p = 0.039$). The odds of getting *S. mansoni* infection among individuals Fishing and Farming was 7.9 times higher than those they didn't have an exposure of fishing and farming at Lake Tana (AOR: 7.9, 95%CI: 2.15–29.1; $p = 0.002$) (Table 3).

Table 3

Binary and Multivariable logistic regression analysis of factors associated to *S. mansoni* infection in Gorgora town, Western, Dembia District, Northwest Ethiopia 2020.

Variables	<i>Schistosome</i> infection		Frequency No. (%) (n = 385)	OR (95% CI)		P-value
	Positive N (%)	Negative N (%)		COR	AOR	
Sex						
Female	65(33.3)	131(66.8)	196(50.9)	1*		
Male	76(40.2)	113(59.8)	189(49.1)	1.35(0.89-2.05)	1.19(0.7–2.04)	0.532
Age						
1–4	26(10.7)	9(6.4)	35(9.1)	1*		
5–9	41(16.8)	11(7.8)	52(13.5)	0.77(0.28–2.12)	0.51(0.15–1.76)	0.289
10–14	39(16.0)	37(26.2)	76(19.7)	2.74(1.14–6.62)	1.4(0.4–4.61)	0.629
15–19	12(4.9)	9(6.4)	21(5.5)	2.26(0.68–6.83)	1.05(0.39–4.69)	0.940
20–24	18(7.4)	12(8.5)	30(7.8)	1.93(0.67–5.52)	0.70(0.17–2.83)	0.624
25–29	36(14.8)	20(14.2)	56(14.5)	1.60(0.63–4.08)	0.49(0.13–1.83)	0.294
30–34	11(4.5)	15(10.6)	26(6.8)	3.94(1.33–11.67)	1.09(0.3–4.46)	0.894
35–39	9(3.7)	9(6.4)	18(4.7)	2.88(0.87–9.54)	0.94(0.20–4.35)	0.940
> 40	52(21.3)	19(13.5)	71(18.4)	1.05(0.41–2.65)	0.56(0.10–1.75)	0.323
Educational level						
Illiterate	29(27.4)	77(72.6)	106(27.5)	1*		
Primary	64(38.3)	103(61.7)	167(43.4)	1.64(0.97–2.79)	0.95(0.44–2.01)	0.896
Secondary	36(42.4)	49(57.6)	85(22.1)	1.95(1.06–3.57)	1.18(0.50–2.79)	0.694

(Note: COR: crude odd ratio; CI: confidence interval; AOR: adjusted odd ratio; * Reference category, **Significant association.)

Variables	<i>Schistosome</i> infection		Frequency No. (%) (n = 385)	OR (95% CI)		P-value
	Positive N (%)	Negative N (%)		COR	AOR	
Tertiary	12(44.4)	15(55.6)	27(7.0)	2.12(0.88-5.07)	2.7(0.68-10.7)	0.156
Occupational status						
Not employed	88(33.1)	178(66.9)	266(69.1)	1*		
Self employed	41(46.6)	47(53.4)	88(22.9)	1.76(1.08-2.88)	1.7(0.79-3.09)	0.164
Govt' employed	10(38.5)	16(61.5)	26(6.8)	1.26(0.55-2.90)	1.4(0.29-7.33)	0.645
Private employed	2(40.0)	3(60.0)	5(1.3)	1.34(0.22-8.22)	1.9(0.23-16.18)	0.543
Average monthly income						
< 1000	106(34.3)	203(65.7)	309(80.3)	1*		
1001-2000	29(54.7)	24(45.3)	53(13.8)	2.31(1.28-4.17)	1.25(0.48-3.26)	0.641
2001-3000	4(33.3)	8(66.7)	12(3.1)	0.95(0.28-3.25)	0.58(0.09-3.89)	0.578
> 3000	2(18.2)	9(81.8)	11(2.9)	0.43(0.09-2.01)	0.22(0.19-2.47)	0.221
Household drinking water source						
Lake	1(16.7)	5(83.3)	6(1.6)	1*		
Spring	3(50.0)	3(50.0)	6(1.6)	4.99(0.34-72.7)	2.9(0.14-59.7)	0.486
Pipe Water	137(36.7)	236(63.3)	373(96.9)	2.90(0.33-25.1)	2.71(0.24-29.6)	0.415
Lake						
Washing	117(36.3)	205(63.7)	322(83.6)	1*		
Collecting water	6(37.5)	10(62.5)	16(4.2)	1.01(0.36-2.81)	1.2(0.40-3.98)	0.605
Swimming/Playing	6(37.5)	10(62.5)	16(4.2)	0.76(0.40-1.43)	0.68(0.33-1.38)	0.290

(**Note:** COR: crude odd ratio; CI: confidence interval; AOR: adjusted odd ratio; * Reference category, **Significant association.)

Variables	<i>Schistosome</i> infection		Frequency No. (%) (n = 385)	OR (95% CI)		P-value
	Positive N (%)	Negative N (%)		COR	AOR	
Fishing/Farming	12(38.7)	19(61.3)	31(8.1)	9.9(2.81–37.7)**	7.9(2.15–29.1)**	0.002**
Latrine practices						
No	140(36.6)	240(63.4)	382(99.2)	1*		
Yes	1(33.3)	2(66.7)	3(0.8)	0.86(0.08–9.61)	1.6(0.07–52.6)	0.801
Swimming frequency						
None	4(2.8)	54(22.1)	58(15.1)	1*		
Sometimes	79(56.0)	128(52.5)	207(53.8)	8.3(2.91–23.9)**	7.7(2.42–24.5)**	0.001**
Frequent	58(41.1)	62(25.4)	120(31.2)	12.6(4.30–37.1)**	10.0(3.19–36.6)**	0.000**
Proximity to Lake Tana						
< 1 km	115(81.6)	176(72.1)	291(75.6)	1.70(1.03–2.84)**	1.89(1.05–3.36)**	0.033**
≥ 1-1.5 km	26(18.4)	68(27.9)	94(24.4)	1*		
(Note: COR: crude odd ratio; CI: confidence interval; AOR: adjusted odd ratio; * Reference category, **Significant association.)						

Intensity of *S. mansoni* infection

Among *S. mansoni* infected study participant (141/385) 30.5%, 27.0% and 42.6% had light, moderate, and heavy intensity of infection, respectively. Of the total 60 (42.6%) heavy infections of *S. mansoni*, the highest 7(11.7%), 7(11.7%), was observed in participants of the aged group of 10–14 and, > 40 years, respectively followed by 6(10.0%) and 6(10.0%) in adolescent 25–29 and 30-34years, respectively. The heavy infections to *S. mansoni* in males and females were 19(50.0%) and 19 (50.0%), respectively. The highest egg count was 3600 egg per gram of stool (Table 4).

Table 4
Intensity of infections for *S. mansoni* among participants in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Variables		Parasites identified (<i>S. mansoni</i> *)			Total N (%)
		Classes of intensity(n = 141)			
		Light N (%)	Moderate N (%)	Heavy N (%)	
Age	1–4	3(7.0)	4(10.5)	2(3.3)	9(6.4)
	5–9	4(9.3)	3(7.9)	4(6.7)	11(7.8)
	10–14	10(23.3)	20(52.6)	7(11.7)	37(26.2)
	15–19	2(4.7)	5(13.2)	2(3.3)	9(6.4)
	20–24	6(14.0)	5(13.2)	1(1.7)	12(8.5)
	25–29	5(11.6)	9(20.9)	6(10.0)	20(14.2)
	30–34	5(11.6)	4(10.5)	6(10.0)	15(10.6)
	35–39	2(4.7)	4(10.5)	3(5.0)	9(6.4)
	> 40	6(14.0)	6(15.8)	7(11.7)	19(13.5)
Sex	Male	23(53.5)	34(56.7)	19(50.0)	76(53.9)
	Female	20(46.5)	26(43.3)	19(50.0)	65(46.1)
Total		43(30.5)	38(27.0)	60(42.6)	141(100)
* Light (1–99 epg), Moderate (100–399 epg), Heavy (≥ 400 epg).					

Spatial distribution of *S. mansoni* and Malacological surveys

A total of 385 study participant (141 positives for *S. mansoni*) participated in the study, and their household and snail collection area geo-location was mapped (Fig. 3). Spatial distribution of intermediate snail hosts of human schistosomes in the Lake Tana provided insights on the diversity of snail and their density. *S. mansoni* infections were clustered near the eastern edge of the surveillance area.

Prevalence of *S. mansoni* and swimming frequency

Among 385 study participant who had 120(31.2%), 207(53.3%) and 58(15.1%) had frequently sometimes and none swimming frequency respectively. Of 141 positives for *S. mansoni* participants of this 58(41.1%),79(56.0%) and 4(2.8%) had frequently, sometimes and none swimming frequency respectively, (Table 5).

Table 5

Prevalence of *S. mansoni* among study participants self-reported swimming frequency per week with the shoreline of Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Parasite finding	Swimming frequency			Total
	None (0 per week)	Sometimes (1 per week)	Frequent (2–3 per week)	N%
	N%	N%	N%	
Positive	4(2.8%)	79(56.0%)	58(41.1%)	141(36.6%)
Negative	54(21.1%)	128(52.5%)	62(25.4)	244(63.4%)
Total	58(15.1%)	207(53.3%)	120(31.2%)	385(100)

Human infection rate in proximity to water point

Out of 94(24.4%) who are living beyond 1-1.5 km from the shoreline of Lake Tana 15(10.6%) positive for *S. mansoni* of this 6(40.0%), 8(53.3%) and 1(6.7%) had frequently, sometimes and none swimming frequency respectively.

Table 6

Prevalence of *S. mansoni* among study participants swimming frequency and proximity to the shoreline of Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Lake Tana Contact	< 1 km		≥ 1-1.5 km			Total
	No. Tested	No..Positive (%)	No. Tested	No..Positive (%)	No..Positive (%)	No. Tested
None	50(17.2)	3(2.4)	8(8.5)	1(6.7)	4(3.0)	58(15.1)
Some	157(54.0)	71(56.3)	50(53.2)	8(53.3)	79(56.0)	207(53.8)
Frequent	84(28.9)	52(41.3)	36(38.3)	6(40.0)	58(41.1)	120(31.2)
Total	291(75.6)	126(89.4)	94(24.4)	15(10.6)	141(36.6)	385(100)

S. mansoni intensity of infections in proximity to water point

Out of 385/Two hundred ninety-one 75.6% participants lived in less than 1 km from the shoreline Lake Tana. From 291 participants lived in less than 1 km 81.6% of *S. mansoni* positive cases are found in this area while 18.4% of the infections occurred beyond 1 km distance (Table 7).

Table 7
Intensity of *S. mansoni* infection and proximity of study participant from the shoreline of Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020

Distance (km)	Tested No. (%)	Intensity of infections No. (%)			Total infected No. (%)
		Light	Moderate	Heavy	
		N %	N %	N %	
< 1 km	291(75.6)	33(28.7)	49(42.6)	33(28.7)	115(81.6)
≥ 1-1.5 km	94(24.4)	10(38.5)	11(42.3)	5(19.2)	26(18.4)
Total	385 (100)	43(30.5)	60(42.6)	38(27.0)	141(36.7)
* Light 1–99 eggs per gram (epg); Moderate 100–399 epg; Heavy ≥ 400 epg.					

Snail species, distribution, abundance and Infection Rates

A total of 1,105 freshwater snail specimens were collected from 14 different sampling sites along the shores of Lake Tana. Out of this 546 were *Biomphalaria pfeifferi*. Among the living 500 *Biomphalaria* snails 492 were not observed to shed human schistosome cercaria, while 8 (1.6%) shed bird's schistosome cercariae. Although, the highest snail abundance was observed in Fish Farm and Military Camp (FF & MC), where 220 snails were collected representing 40.2% of the total *Biomphalaria* spp. collected in the village, this habitat had neither the highest number nor the highest prevalence of snails with patent infection, with only 8 (1.6%) shedding bird schistosome cercariae (Table 8).

Table 8

Total number of snail population collected and infestation rate in Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Habitat no.	Habitat name	Total No. of Snail collected	No. of snails <i>Biomphalaria</i> (%)	Tested Spp. <i>Biomphalaria</i>	No. of snails infested rate (%)
1	Deber Sina (DS1 & DS2)*	65(5.9)	61(11.2)	60(12.0)	1(1.7)
2	Tim & Kim (TK1& TK2)*	222(20.1)	67(12.3)	60(12.0)	2 (3.3)
3	Military Camp 5th (MC1& MC2)*	298(26.9)	116(21.2)	100(20.0)	3(3)
4	Fish Farm Center (FF1& FF2)*	297(26.9)	104(19.0)	100(20.0)	2(2)
5	Port Hotel (PH1& PH2)*	87(7.8)	71(13.0)	60(12.0)	0(0)
6	Port Transport (TP1&TP2)*	68(6.1)	62(11.3)	60(12.0)	0(0)
7	Market Area (MA1&MA2) *	86(7.7)	65(11.9)	60(12.0)	0 (0)
Total		1,105(100)	546(49.4)	500(91.6)	8(1.6)
* Area code					

Snail species and Morphometrics

On the basis of shell morphology, 546 (49.4%) of the snails collected were putatively identified as *Biomphalaria pfeifferi*, whereas 310(28.1%), 101(9.1%), and 147(13.3%) were identified as *Bulinus* spp., *Lymnaea* and *Bivalve*. (Table 9). Other than *Biomphalaria* and *Bulinus* species (the intermediate host snails of *S. mansoni* and *S. haematobium*, respectively), the other commonly identified freshwater snail was *Lymnaea natalensis*.

Table 9

Snail population and distribution numbers dead and live by habitat in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Habitat no.	Habitat name	<i>Biomphalaria pfeifferi</i>	<i>Bulinus</i> spp.	<i>Lymnea</i>	<i>Bivalve</i>	Total
1	Deber Sina (DS)	61	4	0	0	65
2	Tim & Kim (TK)	67	64	41	50	222
3	Military Camp 5th (MC)	116	89	40	53	298
4	Fish Farm Center (FF)	104	110	24	41	279
5	Port Hotel (PH)	71	16	0	0	87
6	Port Transport (TP)	62	6	0	0	68
7	Market Area (MA)	65	21	0	0	86
Total		546(49.4%)	310(28.1%)	105(9.5%)	144(13.3%)	1,105

Physico-chemical parameters of the water points

During snail collection the average water temperature, pH and conductivity was recorded as indicated in Table 10 below

Table 10

Physico-chemical characteristics of snail collection site water at Lake Tana in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Habitat no.	Habitat name	Temperature (°C)	pH	Conductivity (µS/cm)
1	Deber Sina (DS)	21.2	9	204.26
2	Tim & Kim (TK)	25.4	8.3	126.01
3	Military Camp 5th (MC)	24.5	9	200.06
4	Fish Farm Center (FF)	24.2	9	195.16
5	Port Hotel (PH)	25.7	7.84	129.08
6	Port Transport (TP)	24.3	8.97	151.06
7	Market Area (MA)	24.3	9	124.09

Discussion

Schistosomiasis is the most prevalent helminthic infection in Ethiopia. Depending on various reasons, the prevalence of *S. mansoni* is ranging from less than 1% up to more than 90% in Ethiopia(9). In Western Dembia District, numerous studies conducted in different localities showed that the prevalence of *S. mansoni* were high among school-age children and preschool aged children. The present study was aimed to assess the distribution of snail and risk factors of *S. mansoni* in proximity to water contact points in Gorgora town.

The prevalence of intestinal schistosomiasis in the current study was 36.6% (CI: 32-41.9). This result is higher when compared to studies carried out in Western Kenya 16.3% (10), Kwale, 0.0% (11), Western Uganda 27.8%(12), Sesse Islands, Uganda 31.4%(13), Nyanza, western Kenya 13%(14), Chuahit, Northwest Ethiopia 11.2%(15), Gorgora, Northwest Ethiopia 20.6% (16), Hawassa, Southern Ethiopia 31% (17), Zegie Peninsula, Northwestern Ethiopia 29.9%(18), Jimma Zone, South West Ethiopia 27.6% (19), Sanja, northwest Ethiopia 16.67%(20), in Addiremets town, Western Tigray, Ethiopia, 26.3%(21). This difference may be because of ecological, climatic condition of study area, sample size used, contact with open water sources which is infested with infective stage of the parasites and presence of intermediate hosts in water bodies in the area or control activities. However, it was in line with another report from Sanja, Northwest Ethiopia 35%(22). This similarity may be because of contact with open water sources.

The result of the present study was lower than previous studies conducted, in Mbita causeway, Western Kenya 45.1%(23), Uganda 47.5%(24), Mbita District, Western Kenya 76.8%(25), Sanja, Northwest Ethiopia 83.3%(26), Wolaita, Southern Ethiopia 81.3%(27), Yachi, southwestern Ethiopia 42.9%(28) Sanja, Northwest Ethiopia 5–9 and 10–14 years were 84.6% and 75.2%, respectively (29), Similarly, the prevalence of *S. mansoni* infection in the present study was lower than the findings in Wondo Genet, Southern Ethiopia 74.9%(30), Tigray, Ethiopia 42.4%(31). Sanja, Northwest Ethiopia 89.9%(32), Alamata, Northern Ethiopia 73.9%(33), Hayk town, northeastern Ethiopia, 45%(34). This variation might be due to the study area sociodemographic factors, ecological distribution of intermediate host (snail), local endemicity of the parasite, sample size, awareness regarding the transmission and prevention and difference in study period.

In the current study *S. mansoni* intensity of study participants was 30.5%, 27.0% and 42.6% for light, moderate, and heavy infection, respectively. The present study has high proportion of heavy intensity of infection, compared with a report from Western Kenya, (9.8%)(10), Sanja, Northwest Ethiopia, (18.7%) (32), Sanja, Northwest Ethiopia, (36.3%)(26), and Addiremets town, Western Tigray, Ethiopia, (16.7%) (21). Similarly, In Mbita District, Western Kenya, the intensity of infection was 16.1% heavy infections (25). In south Nyanza, western Kenya 12.6% had heavy intensity of infection (14). In Wondo Genet, Southern Ethiopia 42.4% (30) had high intensity of infection. This variation might be due to low level of education, poor hygienic practice and absence of control and preventive measures in the area. However, this finding was in contrast to a study carried out in Wolaita Zone, Southern Ethiopia, with an overall heavy intensity

of infection of 56.4% (27). This variation might be due to infection rate and frequency of contact with cercaria contaminated water bodies.

In the current study *S. mansoni* was 7.7 times more likely to happen in study participants with the sometimes habit of contact to Lake Tana than those who had no habit of contact to Lake Tana. This finding was positively associated when compared to studies carried out, in Western Kenya(10), higher than Wolaita Zone, Southern Ethiopia, (3.9 times) (27), while in Jimma Zone, South West Ethiopia children who have bathing habits in open water sources 8.8 times (19), southern Ethiopia, had shown that those who swum in the lake Hawassa are infected about 2.7 times more than those who do not(17), Sanja, northwest Ethiopia, had shown that those who swum in river about two times more than who do not(20), Jiga town, Northwest-Ethiopia, showed that habit of contact with river who were swum in river were 4.8 times(35). This variation might be due to immune status of participants, distance from the water source and frequency of contact with infected water which is a common scenario seen in almost all schistosomiasis studies in the country and in the current study area.

S. mansoni was Ten times more likely to happen in participants with frequent habit of swimming in Lake Tana than those who had no habit of swimming. Frequent swimming had accounted for infection in a study carried out in Tigray, Ethiopia, (31), and Western Kenya (10). This finding was in contrast to a report from Blantyre, Malawi where frequency of water contact was not significantly associated with *Schistosoma* infection (36). This variation might be due to time of water contact which is associated with shedding of infective *S. mansoni* cercaria.

The odds of getting *S. mansoni* infection among individuals Fishing and Farming was 7.9 times higher than those who do not. This finding correlates with a report from western Kenya, where fishing in Lake Victoria was associated with a higher risk of infection(10).

With regard to proximity of water, the present study has demonstrated higher likely infection odds of *S. mansoni* infection among individuals living 1 km away from the shoreline; 1.7 times higher than those who living 1 km away from the shoreline at Lake Tana. This finding is supported by a study carried out in western Kenya where the school nearest the lake less than 1 km had a prevalence of 80% and the mean prevalence decreased to approximately 20% at a distance of 4 km. In addition beyond the 4 km line, the prevalence decreased further to 2.8% for children living beyond 9 km from the shoreline (10). Similar finding in Kwale, Kenya, showed a significant low infection risk among participants who were residing far away from a river(11).

In Blantyre, Malawi, the odds of getting *S. mansoni* infection among individuals living less than 1 km was 5.3 times higher than 1 km living (36). This finding is not surprising as children who live closer to the lake are more likely to have contact with water on a regular basis (10).

The current study had revealed malacological diversity in the study area. As assessed using morphological methods, 546(49.4%) of the snails collected were putatively identified as *B. pfeifferi*, whereas 310(28.1%), 101(9.1%), and 147(13.3%) were identified as *Bulinus* spp., *Lymnaea* and *Bivalve*,

respectively. This result is consistent with the malacological survey conducted in freshwater bodies, in Sanja, Northwest Ethiopia, during January and April, where *B. pfeifferi* were 150(97.4%) and 180(81.4%), respectively and also *B. forskalii* and *L. natalensis* (29). In North-Western Nigeria, 788 (47.94%) *L. natalensis*, 492 (29.93%) *B. trophicus* and 364 (26.14%) *B. forskalii* (37), were reported. This similarity might be due to the abundancy and occurrence of snail species were largely influenced by water quality.

Similarly, in Kpong Head Pond, Ghana a total of 1,034 snails were collected throughout the study period. Five different snail species were identified. The dominant schistosome vector species found were the *B. truncates* 735/1034 (71.0%), followed by *Biomphalaria* 125/1034 (12.0%) and *B. globosus* (6,1%)(38). In Niger River Valley West Africa, *B. truncatus* was the most abundant species found, followed by *B. forskalii*, *R. natalensis* and *B. pfeifferi* that showed a significant positive association with dry season and a significant negative association with the wet season (39). In Mecha North West Ethiopia, 46.1% *Helix*, 23.7% *Lymnaea*, 13.2% *Bulinus*, 9.2% *Planorbin*, and 7.9% *Oncomelania* (40) was reported. In Middle Paranapanema River region of São Paulo, Brazil, of the 10,722 snails collected, 86.7% were in the Planorbidae family (75.5% *Biomphalaria* and 11.2% *Drepanotrema*) and 13.3% were other non-Planorbidae species (*Lymnaea*, *Melanoides*, *Physa* and *Pomacea*) (41). This variation might be due to seasonality of snail abundance and freshwater snails are generally encountered in freshwater body that is polluted with human and animal excreta.

On the other hand, this finding was in contrast when compared to studies carried out in Kisumu City, western Kenya, which reported out of 1,059 snails collected, 407 (38.4%) were putatively identified as *B. sudanica*, 425(40.1%) as *B. pfeifferi* and 227(21.5%) as *Bulinus globosus*(42). In Mara River in Kenya and Tanzania, all the four different snail species were found to be attached to different aquatic weeds, with *B. pfeifferi* accounting for over half (61.1%) of the snails attached to the sedge, followed by *B. africanus* and *Lymnaea* spp., accounting for 22.2% and 16.7%, respectively(43). A study from Omo Gibe River Basin, southwest Ethiopia, reported distribution of snails as *Bi. pfeifferi* 2072(66.8%), *Bi. Sudanica* 7(0.2%), *B. globosus* 148(4.8%), *B. forskalii* 133(4.3%) and *L. natalensis* 747(24%)(44). The main reason for the variation here may be an increase in organic matter will increase the concentration of detritus and possibly the proliferation of algae that forms the diet of *planorbid* and *prosobranch* snails and prevalence of *Schistosoma* spp. infection, abundance, freshwater snails in the current study are showed that the ecology is suitable due to good vegetation cover, low alkaline pH and moderate temperature.

In the current study, the prevalence of schistosome infection in *B. pfeifferi* was 0.0%. this finding is in line with a study conducted in Addis Ababa town, Western Tigray, Ethiopia, 0.0%(21), North western Angola 0.0%(45), Sesse Islands, Uganda, 0.0%(13), Wolaita Zone, Southern Ethiopia 0.0%(27), Maksegnit and Enfranz Towns, northwestern Ethiopia, 0.0% (46), and Gombe or Bugamba 0.0%(47). This absence of infected snails may be associated with seasonality of infection with *Schistosoma* spp. In addition, the low prevalence of cercariae in this study might be due to the presence of other trematodes such as *Echinostome* cercariae and resistance of some snail species to trematode infection.

On the other hand there are reports of snails shedding cercaria finding from a study conducted in Sanja, Northwest Ethiopia, 16.9% and 0.027% during February and April, respectively (29), Omo Gibe River Basin, southwest Ethiopia, 4.6%(44), Hayk town, northeastern Ethiopia, from Keti Stream, 3.2%(34), Maksegnit and Enfranz Towns, northwestern Ethiopia, 14.3% (46), western Tanzania Gombe National Park all collected 12.3% of snails shed larvae (47), Niger River Valley West Africa 3.45% (39), Kisumu City, western Kenya 1.7% in *B. sudanica* and 1.6% in *B. pfeifferi* (42). The reason for finding infected snails in these study areas in contrast to the current study could be the variation in season during sample collection.

Conclusion

In conclusion, high prevalence of *S. mansoni* infection was observed in Gorgora town. Swimming, fishing and farming were associated risk factors of contracting schistosomiasis. More than Eighty-two percent of observed Schistosoma positive participant had proximity to lake water. A total of four different freshwater snail intermediate host species with a potential of transmitting diseases of human and veterinary public health importance had been identified. No *Bi. pfeifferi* was found shedding cercariae. Health education, snail control and safe water supply is recommended.

Abbreviations

ArcGIS= ArcGIS Geographical Information System, DALYs= Disability Adjusted Life Years, EPG= Eggs Per Gram, GIS= Geographical Information System, GPS= Global Positioning System, HH= House Holds, ICE= Information, Communication, and Education, LMIC = Low- and Middle-Income Countries, MDA= Mass Drug Administration, NTD= Neglected Tropical Disease, PC= Preventive Chemotherapy, PZQ= Praziquantel, SOP= Standard Operating Procedure, STH= Soil Transmitted Helminth, WASH= Water, Sanitation and Hygiene, WHO= World Health Organization

Declarations

Ethics approval and consent to participate

The proposed study was approved by the research and ethics committee University of Gondar, College of Medicine and Health Science ethical school of biomedical and laboratory science review committee who approved this work concerning the ethical issues.

Ethical Considerations

Ethical approval was obtained from the school of Biomedical and laboratory science (SBLS) ethical committee and a permission letter was obtained from Central Gondar Zonal Health Office, western Dembia District Health Bureau and selected study site *Kebeles* leaders. When the inhabitants of nearby villages in proxy to water sources are identified, the purpose, objectives and benefits of the study was explained. Consent and assent for participation was obtained from the children's parents/guardians. Study participant who was found positive for *S. mansoni* and other intestinal parasites infection was

linked with the health center and treated with standard dose of anti-schistosomal and anti-helminthic treatment.

Consent for publication

Not applicable. This study does not contain any individual or personal data.

Availability of data and materials

Data is available upon request.

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Authors' contributions

AA, MA, LW, AG, AD and DA, were involved in study conception, data collection and analysis, drafting the manuscript. AA, MA, AG and DA were critically reviewed the manuscript for intellectual content. All authors have read, edited and approved the manuscript.

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Competing interests

The authors declare that they have no competing interests.

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Figure Note

Figure 1 and Figure 2 are not available with this version.

Figures

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Figure 1

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Figure 1

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Figure 2

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Figure 2

Figure 3

Spatial distribution *S. mansoni* infection and snail survey sites the shoreline of Lake Tana in Gorgora town, Western Dembia, Northwest Ethiopia 2020. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 3

Spatial distribution *S. mansoni* infection and snail survey sites the shoreline of Lake Tana in Gorgora town, Western Dembia, Northwest Ethiopia 2020. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

Figure 4

Cercariae that emerged from *Biomphalaria pfeifferi* in Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

Figure 4

Cercariae that emerged from *Biomphalaria pfeifferi* in Lake Tana, in Gorgora town, Western Dembia, Northwest Ethiopia 2020.

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