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Source: Environmental Health Insights, 16(1)

Published By: SAGE Publishing

URL: https://doi.org/10.1177/11786302221123576

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Environmental Health Insights
Volume 16: 1–9
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DOI: 10.1177/11786302221123576

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ABSTRACT

INTRODUCTION: Urogenital schistosomiasis is one of public health problems in lowland areas of Ethiopia. The disease is caused by *Schistosoma haematobium*. Freshwater *Bulinus* snails are intermediate hosts for the parasite transmission. The aim of the study was to assess intermediate host snails of urogenital schistosomiasis, human water contact behavior and physico-chemical characteristics of Alwero Dam reservoir.

METHODS: *Bulinus* snails were sampled from 12 sites of Alwero Dam. *Bulinus* snails were collected, identified and examined for natural schistosome infections. A total of 206 people were interviewed to determine human water contact behavior. The water temperature, pH, dissolved oxygen, total dissolved solid, salinity and conductivity of the water were determined.

RESULTS: Of 1125 *Bulinus* snails collected, 72 (6.4%) were infected with echinostome cercariae but none of them were infected with schistosome cercariae. The abundance of *Bulinus* species did not show significant variation across seasons ($P = .61$). Occurrence of *Bulinus* species was significantly higher in stony substratum than sandy substratum ($P = .01$). Of the total 206 participants, 119 (57.8%) had water contact activities like washing clothes, bathing or swimming. Majority of respondents (70.0%) reported that they visited the dam reservoir once or twice a week, while 16.5% and 13.6% reported that they visited the dam 3 to 5 times a week and daily, respectively. Moreover, 72.3% of the respondents had reported they had history of urogenital schistosomiasis infection. The mean water temperature, pH, dissolved oxygen, total dissolved solid, electric conductivity, and salinity of the dam water was 28.6°C, 7.07, 5.75 mg/l, 90.0 ppm, 124.8 µS/cm, and 50.0 ppm, respectively.

CONCLUSION: At Alwero Dam, *Bulinus* snails were highly abundant and the human water contact activities were frequent. Therefore, the community awareness creation should be made to reduce water contact with snail infested water to prevent risk of urogenital schistosomiasis infection.

KEYWORDS: *S. haematobium*, intermediate host snail, urogenital schistosomiasis, Alwero Dam, Abobo, Ethiopia

RECEIVED: May 23, 2022. **ACCEPTED:** August 9, 2022.

TYPE: Original Research

FUNDING: The author(s) received no financial support for the research, authorship, and/or publication of this article.

DECLARATION OF CONFLICTING INTERESTS: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Introduction

Schistosomiasis is one of the most neglected tropical diseases.[1] It is caused by trematode worms of the genus *Schistosoma*. Human schistosomiasis is caused by *Schistosoma mansoni*, *Schistosoma haematobium*, *Schistosoma japonicum*, *Schistosoma intercalatum*, *Schistosoma guineensis, and Schistosoma mekongi*.[2,3] Among these species, *Schistosoma mansoni, Schistosoma haematobium*, and *Schistosoma japonicum* are the main causes of human schistosomiasis. The transmission of human schistosomiasis is carried out by freshwater snails of several genera. There are 3 genera of intermediate host snails for human schistosomiasis transmission: *Biomphalaria, Bulinus*, and *Oncomelania*. *Schistosoma mansoni* uses *Biomphalaria* snails as an intermediate host. *Oncomelania* is the intermediate host snails of *Schistosoma japonicum*. The genus *Bulinus* sp. serve as intermediate host for *Schistosoma haematobium*.[2] *Bulinus* snails can be found throughout Africa, as well as nations bordering the Mediterranean Region, and the Middle East. About 37 *Bulinus* species have been identified[4] and categorized into 4 major groups of species such as the *Bulinus forskalii* group, *Bulinus africanus* group, *Bulinus truncatus/tropicus* complex, and *Bulinus reticulatus* group. In each groups, there are species used as an intermediate hosts for schistosomes.

Schistosomiasis is transmitted when infected individuals contaminate water bodies with urine or feces containing schistosome eggs. Miracidia, free living stage of the parasite, are released from the eggs in favorable environmental conditions, and they swim and penetrate appropriate freshwater snails. Miracidia develop into cercariae inside the appropriate snail body and hundreds of cercariae then shed into water. Human

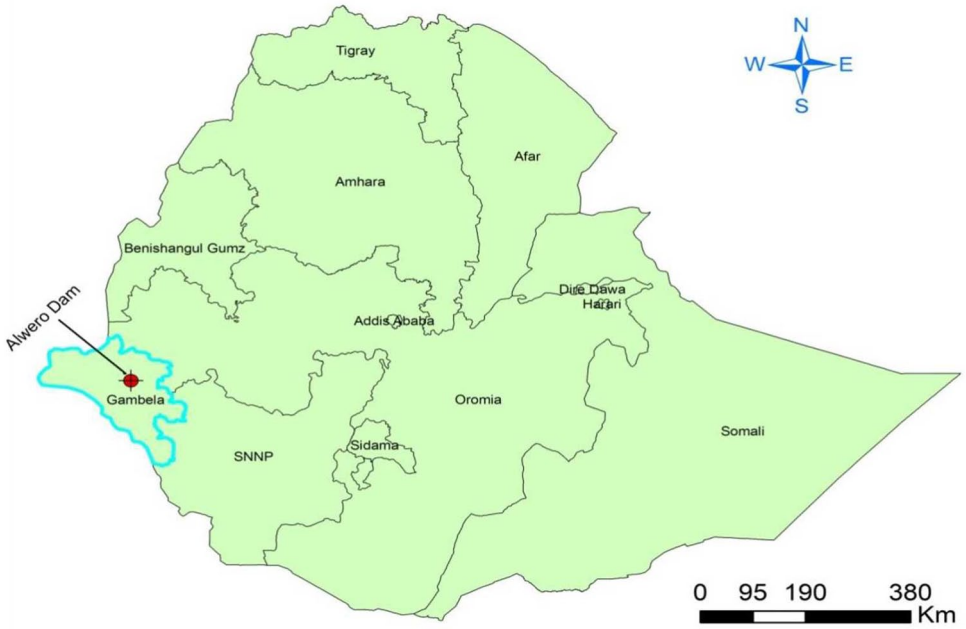

Figure 1. Map of the study area.
Source: Authors of this manuscript, created using ArcGIS version 10.5.

get schistosome infection when there is contact with cercariae-infested freshwater.[5,6] Higher human activities related to water favors schistosomiasis transmission,[7] like swimming or agricultural activities (eg, rice farming),[8] washing clothes,[9] fishing and proximity to places where cercariae shedding snails live.[10]

Praziquantel (PZQ) is a drug of choice for treatment of schistosomiasis due to its safety and low cost. Control of schistosomiasis is mainly based on mass drug administration to the schistosomiasis risk groups supported by safe water supply, sanitation & hygiene, snail control and education.[11] Due to financial constraints and a lack of comprehensive identification of water bodies, environmental management for snail control has not been widely implemented in the Sub-Saharan African region. In larger water bodies controlling snails is basically difficult as a result it is important to target specific sites with frequent human water contact. Environmental changes such as the removal of vegetation, the lining of canals with cement, and emptying of water bodies can result in decrease of snail abundance.[12,13]

In Ethiopia, both *Schistosoma haematobium* and *Schistosma mansoni* are endemic. Previous studies reported that *Schistosoma mansoni* is widely distributed in many parts of the country while *Schistosoma haematobium* is distributed only in 3 lowland regions, including the Awash valley; Wabe Shebele valleys, and Kurmuk at the Ethio-Sudan border.[14] Recently, *Schistosoma haematobium* infection was reported in Abobo town (Gambella region), Western Ethiopia.[15] In Ethiopia, *Biomphalaria pfeifferi* and *Biomphalaria sudanica* transmit intestinal schistosomiasis whereas *Bulinus abyssinicus* and *Bulinus africanus* transmit urogenital schistosomiasis,[16] though 10 *Bulinus* species are reported and are considered potential intermediate hosts.[16] From the previous study, it was established that in Awash valley *Bulinus abyssinicus* transmits *Schistosoma haematobium*, whereas *Bulinus africanus* transmit the disease in Kurmuk (a town at Ethiopia-Sudan border).[17] The intermediate host in Gambella region and Somali region has not yet been identified but *Bulinus abyssinicus* in Somali region (Wabe Shebele) is assumed to be the intermediate host, since this is the host in the same river basin in neighboring Somalia. *Schistosoma haematobium* distribution is confined to lowlands areas of Ethiopia below 800 m above sea level. Its distribution is also limited by the distribution of its appropriate molluscan intermediate hosts.

Ethiopian *Bulinus* snails are not well studied and identified in several urogenital schistosomiasis endemic areas such as the Gambella region. In Abobo district, one of the districts in Gambella administrative region, urogenital schistosomiasis is prevalent in several localities around Alwero dam such as Abobo town and Perbongo (villages 5&6).[15] Information is not available about the potential intermediate snail hosts of *Schistosoma haematobium* in the area. Furthermore, the human water contact behavior and physico-chemical characteristics of water in Alwero reservoir have not been determined. Therefore, the aim of the study was to assess the potential intermediate host snails for the transmission of urogenital schistosomiasis (*Schistosoma haematobium*), human water contact behavior of the community and physico-chemical characteristics of water at Alwero Dam reservoir, Gambella region, Ethiopia.

Materials and Methods

Study area

The study was conducted at Alwero reservoir in Abobo, Gambella region (Figure 1). Abobo is a town in Abobo district and located at 822 km Southwest of Addis Ababa at

geographical coordinates of 7°51′N, 34°33′E. It is about 45 km from Gambella Town. Based on 2007 census of central statistical agency of Ethiopia, the projected total population of the town is 15 220 in 2021. Abobo town and villages 5&6 are situated near the Alwero Dam reservoir. The Alwero Dam is a reservoir used for irrigation in the Abobo district. The dam was built in 1985 on Alwero river and located at 7°52′N, 34°30′E. It was constructed for irrigation with water capacity of 74.6 million cubic meters. The Dam water is ecologically and malacologically receptive to intermediate host snails. Hence, the dam reservoir was selected purposively for this study based on the prevalence of urogenital schistosomiasis determined in previous study.[14]

Water contact behavior

Cross-sectional study on water contact behavior of the community was conducted in the study area. Villages 5&6 were selected for the study due to its proximity to Alwero Dam. Study sites of dam were selected based on observations on water contact where people usually go to fetch water, wash clothes, bathe and swim or play. People coming to the dam were counted for 1 week and used as population of the study. A total of 450 people who visited the dam in 1 week for several activities were recorded. Using published table for survey studies,[18] the sample size was determined. A total of 206 study participants were randomly selected for interview. The participants were interviewed using semi-structured questionnaire on socio-demographic information, water contact activities, water contact frequencies, previous history of having urogenital schistosomiasis (since they started living in the study villages), signs and symptoms of urogenital schistosomiasis, and actions taken after infection. The questionnaire for interview was translated into local language (Amharic and Agnua language) from English for ease of communication and understanding by respondents.

Snail sampling

Snail sampling was conducted from August 2020 to April 2021 in 12 sites where there was major human water contact activities, at Alwero Dam reservoir. The geographical coordinates for each site was recorded using handy GPS. The 12 major human water contact sites of the Dam were selected purposively. In each site of the Dam, *Bulinus* snails were collected. At each water contact site, sampling was performed at 3 different times representing the rainy season, post-rainy season, and dry season. The number of surveys were conducted once each season that is in August, November–December, and January. Trained snail collectors were involved in all 3 surveys. *Bulinus* species abundance was determined by considering the total number of snails collected per hour and per person. Snail sampling at all sites was performed using a metal scoop net and occasionally by handpicking. Sampling time was fixed at 40 minutes per location. Sampling area per location of the lakeshore was approximately 6 m^2. *Bulinus* snails were identified in the field using shell morphology as described by Brown[4] and Kristensen.[19] Snails with globose, ovate shells of small to medium size, and sinistral shell with blunt apex were identified as *Bulinus*. *Bulinus* species were further grouped as *Bulinus africanus* group and *Bulinus truncatus/tropicus* species complex group in the laboratory. *Bulinus* snails with truncate columella were identified as *Bulinus africanus* group whereas snails with no truncate columella were identified as *Bulinus truncatus/tropicus* species complex group. The snails were transferred in to plastic buckets containing water and vegetation and transported to Malacology Laboratory of Akililu Lemma Institute of Pathobiology at Addis Ababa University. The snails were then examined for natural schistosome infections by the shedding method. Each snail was placed individually in the shedding vials containing aged water and then exposed to light (sunlight and electric light depending on seasons) for about 2 hours to stimulate cercarial shedding. Each snail was checked for cercariae shedding 2 times in a week for 3 weeks. The presence of cercariae in each vial was checked using a dissecting microscope. Snails which did not shed cercariae on the first exposure were re-exposed and checked again. The cercariae shed by the snails were identified to the genus level using methods described by Frandsen and Christensen.[20]

Physico-chemical characteristics of the water of the sampling sites

Physico-chemical characteristics of water in each sampling sites in 3 main seasons were measured and recorded. Substratum type and vegetation cover were observed and recorded. Temperature (°C) of water, pH, total dissolve solid (TDS, ppm), electric conductivity (EC, µS/cm), and salinity (ppm) were recorded using Tracer pocket tester (LaMotte 1749, Taiwan). Dissolved oxygen (DO, mg/l) was also determined using HQ40d multimeter (HACH LANGE, NV).

Data analysis

Data were analyzed using Microsoft Excel 2007 and IBM SPSS (version 20). Descriptive statistics was used to describe frequencies and percents. Chi-square test was employed to assess associations between variables. A one-way analysis of variance (ANOVA) was used to compare mean difference in snail density among the 3 seasons. *P*-value less than .05 with 95% confidence interval was considered significant.

Ethical consideration

This study was carried out after getting ethical approval from Institutional Review Board (IRB) of Institute of Health, Jimma University (Reference no. IHRPGD/3006/18). The

Table 1. Abundance and distribution of *Bulinus* species by site, substratum type and season, Alwero reservoir, Ethiopia, 2021.

SAMPLING SITE	GPS COORDINATES	SEASONS				TOTAL
		SUBSTRATUM TYPE	RAINY SEASON	POST-RAINY SEASON	DRY SEASON	N (%)
			N (%)	N (%)	N (%)	
Site 1	7°52′24″N & 34°30′5′E	Sandy	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Site 2	7°52′29″N & 34°30′3′E	Sandy	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Site 3	7°52′29″N & 34°29′57′E	Stony	35 (3%)	37 (3%)	34 (3%)	106 (9.4%)
Site 4	7°52′28″N & 34°29′56′E	Stony	30 (2.6%)	35 (3.1%)	44 (4%)	109 (9.6%)
Site 5	7°52′28″N & 34°29′55′E	Stony	27 (2.4%)	28 (2.5%)	45 (4%)	100 (9%)
Site 6	7°52′27″N & 34°29′55′E	Stony	34 (3%)	45 (4%)	32 (2.8%)	109 (9.6%
Site 7	7°52′26″N & 34°29′54′E	Stony	38 (3.4%)	51 (4.5%)	36 (3.2%)	127 (11.3%)
Site 8	7°52′26″N & 34°29′55′E	Stony	36 (3.2%)	35 (3.1%)	37 (3.3%)	108 (9.6%)
Site 9	7°52′3″N & 34°29″54″E	Stony	29 (2.5)	44 (4%)	38 (3.4%)	111 (9.8%)
Site 10	7°52′25″N & 34°29′53′E	Stony	40 (3.5%)	43 (3.8%)	31 (2.7%)	114 (10%)
Site 11	7°52′24″N & 34°29′53′E	Stony	34 (3%)	38 (3.3%)	44 (4%)	116 (10.3%)
Site 12	7°52′23″N & 34°29″52″E	Stony	37 (3.3%)	45 (4%)	43 (3.8%)	125 (11.1%)
Total, n (%)			340 (30)	401 (36)	384 (34)	1125 (100)

district health officer in Abobo administration and leaders of the villages were contacted for permission to conduct the study. Study participants for interview were requested for consent and informed consent was obtained from all study participants. COVID-19 prevention protocol was applied during data collection.

Results

Bulinus *snail abundance and distribution*

A total of 1125 *Bulinus* snails belonging to *Bulinus africanus* group and *Bulinus truncatus/tropicus* species complex were collected from 12 different sampling sites in 3 different seasons. Of the total collected snails in 3 different seasons, 340 (30.0%), 401(35.6%), and 384 (34.1%) were collected during the rainy season, post rainy season, and dry season, respectively (Table 1). The abundance and distribution of *Bulinus* species in the 3 seasons showed no significance difference ($F = 0.48$, $P = .61$), although higher number of snails were recorded in post rainy season.

Of the total 1125 *Bulinus* snails collected in 12 sampling sites at Alwero reservoir, the highest frequency was recorded from sampling site-7 (11.3%) while no snails detected at sites 1 and 2 at the time of the survey. As shown in Table 1, the occurrence of *Bulinus species* was significantly higher in stony substratum than sandy substratum ($F = 336$, df = 1, $P = .01$). Sandy type of habitat was observed only in 2 sampling sites (1 and 2) of 12 surveyed sites while 10 sampling sites (3-12) were stony substrata habitat type among the total sampled sites.

Bulinus *snail infection*

Of the 1125 *Bulinus* species collected, 114 (10.1%) died during transportation. However, no *Bulinus* snail was found to shed schistosome cercariae. Regardless of species, 72 (6.4%) of the collected *Bulinus* snails were found infected with echinostome cercariae (Figures 2 and 3).

Demographic characteristics of study participants

Of the total 206 study participants, 119 (57.8%) were males and 87 (42.2%) were females. The mean age of respondents was 36 ± 14.4 (range from 12 to 67 years). Among the total participants, 141 (68.4%) were above 25 years (Table 2). Most of the respondents, 149 (72.3%) claimed that they had history of urogenital schistosomiasis infection (either confirmed by parasitological diagnosis or by clinical manifestations such hematuria and painful urination). Urogenital schistosomiasis infection history was higher in males 87 (58.4%) compared to females 62 (41.6%). Of the 206 respondents, 165 (80.1%) knew that blood in urine and painful urination are symptoms of urogenital schistosomiasis. When clinical symptoms were noticed,

Figure 2. Shell of *Bulinus* snails (collected at Alwero Dam reservoir, Ethiopia).

Figure 3. Image of Echinostome cercariae shed by *Bulinus* snails, Alwero Dam reservoir, Ethiopia.

Table 2. Study participants by gender and age group around Alwero Dam, Ethiopia, 2021.

AGE GROUP (YEARS)	GENDER OF PARTICIPANTS		TOTAL
	MALE	FEMALE	
5-15	4	6	10
	3.4%	6.9%	4.9%
16-25	31	24	55
	26.1%	27.6%	26.7%
Above 25	84	57	141
	70.6%	65.5%	68.4%
Total	119	87	206
	100.0%	100.0%	100.0%

most of the respondents (72.8%) visited the nearby healthcare facilities, 12.1% used herbal medicine and 15.0% did not take any action.

Human-water contact activities and contact frequency

In this study, 119 (57.8%) of the respondents reported that washing, bathing or swimming in the dam water was their major activities (Table 3). At Alwero Dam reservoir, both males and females involved in the water contact activities; however, some activities exhibited a distinct gender related pattern such

Table 3. Water contact activities around Alwero Dam, Ethiopia, 2021.

WATER CONTACT ACTIVITIES	GENDER OF PARTICIPANTS		TOTAL
	MALE	FEMALE	
Washing cloth	10	15	25
	40.0%	60.0%	100.0%
Washing, bathing or swimming	62	57	119
	52.1%	47.9%	100.0%
Fishing	32	0	32
	100.0%	0.0%	100.0%
Fetching water	5	15	20
	25.0%	75.0%	100.0%
washing bikes	10	0	10
	100.0%	0.0%	100.0%
Total	119	87	206
	57.8%	42.2%	100.0%
	100.0%	100.0%	100.0%

as fishing and washing bikes. The water contact activities were significantly associated to males compared to females ($\chi^2 = 24.5$, df = 3, $P < .01$).

Majority of respondents 144 (70.0%) claimed that they visited the dam reservoir once or twice a week, while 16.5% visited the reservoir 3 to 5 times a week and 13.6% visited the dam daily (Table 4).

Table 4. Water contact frequency by respondents around Alwero Dam, Ethiopia, 2021.

WATER CONTACT FREQUENCY	GENDER OF PARTICIPANTS		TOTAL
	MALE	FEMALE	
Once in a week	19	15	34
	55.9%	44.1%	100.0%
Two times in a week	38	34	72
	52.8%	47.2%	100.0%
3-5 times in a week	34	38	72
	47.2%	52.8%	100.0%
Every day	28	0	28
	100.0%	0.0%	100.0%
Total	119	87	206
	57.8%	42.2%	100.0%

Environmental and physico-chemical characteristics of Alwero Dam water

The most dominant vegetation covers identified in Alwero reservoir were floating macrophytes. However, there was no association between vegetation cover with snail abundance. The mean water temperature was 28.60 ± 0.42°C and the mean pH was 7.07 ± 0.31. The mean TDS was 90.0 ± 3.6 ppm. There was no variation in TDS among all sampling sites. The mean salinity was 50 ± 2.4 ppm. Except site 7, in all sites salinity of the water was similar. The mean conductivity and DO level was 124.80 ± 1.6 µS/cm and 5.75 ± 0.26 mg/l, respectively. Conductivity of the water and DO level of the water in all sampling sites was similar (Table 5). All the physicochemical characters recorded showed no association with *Bulinus* snail abundance.

Discussion

This study was the first malacological study conducted at Alwero Dam reservoir, Abobo, Ethiopia. The study attempted to show the abundance and distribution of *Bulinus* species at Alwero dam. The study showed that *Bulinus* snails were abundant in 10 sampling sites where human water contact was frequent but absent in 2 sampling sites. The physico-chemical characteristics of the water was similar across all 12 sampling sites but showed significant differences by substratum type. The 10 sampling sites were stony substratum habitat type and the 2 sites where *Bulinus* snails absent were sandy substratum habitat type. Such stony substratum habitat preference might

Table 5. Determination of physico-chemical characteristics of snail sampling sites at Alwero Dam, Ethiopia, 2021.

SAMPLING SITE	TEMP (°C)	pH	TDS (PPM)	SALINITY (PPM)	EC (µS/CM)	DO (MG/L)	TOTAL *BULINUS* SNAILS COLLECTED
	MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE	MEAN ± SE	
Site 1	28.8 ± 0.4	7.08 ± 0.4	90 ± 3.9	50 ± 2.5	129.6 ± 1.5	6.50 ± 0.2	0
Site 2	28.9 ± 0.3	7.08 ± 0.6	80 ± 3.8	50 ± 2.8	129.1 ± 1.7	6.00 ± 0.1	0
Site 3	28.7 ± 0.2	7.09 ± 0.1	80 ± 3.7	50 ± 2.7	128.2 ± 1.6	6.20 ± 0.3	106
Site 4	28.7 ± 0.8	7.1 ± 0.1	80 ± 3.2	50 ± 2.2	127.6 ± 1.5	6.10 ± 0.1	109
Site 5	28.6 ± 0.5	7.08 ± 0.5	80 ± 3.6	50 ± 2.3	131.2 ± 1.3	5.90 ± 0.2	100
Site 6	28.6 ± 0.2	7.07 ± 0.4	90 ± 3.5	50 ± 2.2	131.5 ± 1.8	5.85 ± 0.4	109
Site 7	28.7 ± 0.1	7.08 ± 0.2	80 ± 3.9	60 ± 2.4	127.8 ± 1.8	5.90 ± 0.2	127
Site 8	29.0 ± 0.3	7.08 ± 0.5	80 ± 3.6	50 ± 2.3	124.8 ± 1.9	5.75 ± 0.5	108
Site 9	29.1 ± 0.7	7.08 ± 0.4	80 ± 3.0	50 ± 2.2	127.3 ± 1.8	5.90 ± 0.2	111
Site 10	29.4 ± 0.3	7.08 ± 0.3	80 ± 2.8	50 ± 2.8	128.3 ± 1.7	5.79 ± 0.6	114
Site 11	29.5 ± 0.9	7.09 ± 0.1	80 ± 3.2	50 ± 2.3	128.1 ± 1.4	6.10 ± 0.1	116
Site 12	29.3 ± 0.4	7.1 ± 0.2	80 ± 3.4	50 ± 2.2	127.3 ± 1.5	6.01 ± 0.3	125

DO, dissolved oxygen; EC, electric conductivity; TDS, total dissolved solid; Temp, temperature.

be due to the fact that *Bulinus* snails can adhere on the rock substratum to resist the water wave to avoid dislodging than sandy substratum habitat. Dabo et al[21] reported *Bulinus truncatus* snails are abundant in slow flowing water with rocky substratum than fast flowing water, sandy and muddy substratum.

Urogenital schistosomiasis was prevalent in Abobo Town and Villages 5&6. Alwero Dam reservoir could be the main source of infection for urogenital schistosomiasis in the area. Geleta et al[15] reported high prevalence of the urogenital schistosomiasis in Abobo and villages 5&6 suggesting that the water reservoir of Alwero Dam is likely the local risk of urogenital schistosomiasis infection. The high abundance of *Bulinus* species in the Alwero dam reservoir can serve as a potential host for *Schistosoma haematobium*. Similar study in Kenya reported high *Bulinus* snail abundance and presence of infected *Bulinus* snails along River Nyamasaria and around Kanyamedha dam.[22]

In this study, physico-chemical variables measured in 12 sampling sites showed no significant variation except substratum type. A study in Uganda reported positive correlation between snail abundance and water temperature showing snail distributions limited to high temperature.[23] However, Kariuki et al[24] reported no association between snail abundance and water temperature but presence of different snail species was associated with availability of vegetation types. This study revealed that there was no significant association between abundance of snail and pH since pH doesn't seem to have changed substantially across the survey period. Similar study showed that pH is not the main determinant for snail abundance.[25] However, on the contrary, Levitz et al[26] reported that a lower pH (more acidic) associated with higher snail abundance.

This study showed that small proportion of *Bulinus* snails shed echinostome cercariae. However, none of the *Bulinus* snails found shedding schistosome cercariae. The snails in this study were properly stimulated by light. *Schistosoma haematobium* cercariae released when there is enough sunlight and larger number can be collected in midday.[27] Given that the area was a high schistosomiasis transmission area, it seemed counterintuitive that no snails shed schistosome cercariae. Generally our findings were similar with others studies reported that in endemic areas with high transmission few or none of collected snails shed cercariae. Several difficulties reported in getting infected snails in areas where higher proportion of children infected with *Schistosoma haematobium*. In Msambweni (Kenya), prevalence of urogenital schistosomiasis was high though *Bulinus* snails shedding cercariae were few (1.2%).[24] A Study in Kenyan coast, also reported that cercariae shedding as either low or absent.[28] In Lake Victoria (basin western Kenya), of the total collected snails only 1.04% shed cercariae.[27] Recent study in Sesse Islands of Lake Victoria (Uganda) observed that none of collected snails shed schistosome cercariae.[27] Several assumptions can be forwarded for the absence or low numbers of snails shedding cercariae. First, it has been suggested that the percentage of infected snails may be very low or cercariae may shed for only a limited period of time. Second, cercarial release might be prevented by different invertebrates and contaminants maintained by the snails. For example, rotifers block the whorl of shells and also release chemicals that can cause paralysis of schistosome cercariae and limit cercarial release from patent snails.[29] Third, snails in highly endemic areas infected by schistosome may not release cercariae.[30] Given that prepatent infection might persist several weeks and that only a small percentage of snails reach the stage of cercarial shedding,[31] and that prepatent infection rates can be substantial, and exceed patent infection rates,[32] it is also possible to safely say that the majority of the snails in this study had prepatent infections. Snail crushing methods to search cercariae can be used to clarify such prepatent infections but this method is inappropriate for accurate and large scale surveillance. Cercarial emergence method can result in underestimation of schistosome prevalence in snails.[33] Generally, finding schistosome infected snails is confirmatory of schistosomiasis transmission. A brief onetime exposure to water infested by cercariae is enough for schistosome cercariae infection,[34] even if there were not many cercariae shedding snails.[35]

This study showed that washing, bathing or swimming were major human water contact activities and the majority of respondents had history of urogenital schistosomiasis. Similar study showed that bathing or swimming is known to play a significant role for schistosome infection.[36] This study showed that males had significantly higher frequency of water contact and urogenital schistosomiasis infection history than females. Some studies have reported that there is significant difference in schistosome infection by gender and the reason has been attributed to variations in some cultural and behavioral practices in relation to water contact activity patterns.[37-42] A study in Benin showed that males had significantly higher frequency of water contact than females.[46] Hence, it is expected that schistosome infection could be higher in males compared to females in the study areas. Furthermore, prevalence of schistosomiasis had been found to be higher in males than in females.[43-45]

In this study, *Bulinus* snails (*Bulinus africanus* group and *Bulinus truncatus/tropicus* species complex) were identified as potential intermediate host snails in Alwero Dam reservoir. The 2 *Bulinus* species groups are major suspects for transmission of urogenital schistosomiasis in Ethiopia. More frequent human water contact activities were recorded at Alwero Dam that makes community at risk of urogenital schistosomiasis infection.

A clear limitation of this study was that *Bulinus* snails were not identified to species level using molecular techniques. Future studies using molecular techniques help to identify *Bulinus* species at species level. Furthermore, monthly malacological study should be made for at least 1 year to make allowance for seasonal variations. When no snails shed cercariae by light stimulation, snail crushing method is recommended to

determine infection. However, we acknowledge this method was not done in the present study and we suggest further studies should consider this method. The depth of water in each sampling site was not measured to see its effect on snail abundance and it can be taken as limitation of the study.

Conclusion

Higher abundance of *Bulinus* snails and frequent human water contact activities were confirmed at Alwero Dam reservoir. The local risks for urogenital schistosomiasis infection observed within Abobo Town and surrounding villages (village 5&6). The *Bulinus* snails were potential intermediate hosts of S*chistosoma haematobium* in the area even though none of *Bulinus* snails were found shedding schistosome cercariae. Some *Bulinus* snails shed echinostome cercariae that cause human echinostosomiasis. At Alwero Dam reservoirs fishing activity is common and people who may eat raw fish or under cooked might be infected by echinostosomiasis. Avoiding contact with *Bulinus* snail infested water, mass drug administration (MDA), improved local sanitation and hygiene, as well as public awareness creation should be encouraged to reduce infection and re-infection by urogenital schistosomiasis in the study areas.

Acknowledgements

The authors acknowledge the study participants cooperation and voluntarily participation in this study. The authors also appreciate health personnel of Abobo District Health Center and laboratory technicians of Akililu Lemma Institute of Pathobiology, Addis Ababa University.

Authors' contributions

KD: Designed the study, performed the experiments, analyzed the data and made inputs in manuscript write-up. ZM and DY involved in supervision of data collection and critically reviewed the manuscript. BE and STM reviewed the manuscript. All authors read and approved the final version of the manuscript.

Data availability statement

Authors present the data in the main paper.

Ethics approval and consent to participate

The protocol for this study was reviewed and approved by the Institutional Review Board (IRB) of Institute of Health, Jimma University. Samples for this study was collected after getting permission from districts administrator and verbal consents from study participants.

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