

Distribution of Snails species and its infectivity with Schistosomes at Mwanga District, North Eastern Tanzania

Seif Abdul^{1,2*}, Ribson E. Mlaki¹, Emmanuel J. Awe¹, Petty J. Mzubwe¹, Victor V. Mosha^{1,3}, Johnson Matowo⁵, Sia E. Msuya^{1,3,4}

¹ Institute of Public Health, Department of Community Health, Kilimanjaro Christian Medical University College (KCMUCo), Moshi, Tanzania

² National Public Health Laboratory, Ministry of Health of Tanzania (MoH), P.O. Box 9983 Dar Es Salaam Tanzania

³ Kilimanjaro Centre Research Institute (KCRI), Moshi, Tanzania

⁴ Institute of Public Health, Department of Epidemiology & Biostatistics, Kilimanjaro Christian Medical University College (KCMUCo), Moshi, Tanzania

⁵ Department of Parasitology & Entomology, Kilimanjaro Christian Medical University College (KCMUCo), Moshi, Tanzania

***Corresponding Author:** Seif Abdul, Institute of Public Health, Department of Community Health, Kilimanjaro Christian Medical University College (KCMUCo), Moshi, Tanzania.

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Abstract

Background: Schistosomiasis, a parasitic disease caused by blood flukes, is still a public health problem in low-income countries like Tanzania. Of the 201 million people infected with schistosomiasis globally, 91% are in sub-Saharan Africa countries. In Tanzania, Mass Drug Administration (MDA) is one of the key interventions to control schistosomiasis, but rapid re-infection after treatment lead to persistent high prevalence of schistosomiasis in key groups like school-aged children. Snail control is an alternative, however there is limited information on epidemiology and interventions on snails that transmit schistosomiasis in Tanzania.

Methodology: A cross sectional study was conducted at Kileo ward in Mwanga District, from April-May 2019. The snails were collected manually using scooping technique and location where the snails were obtained was mapped by using Global Positioning System (GPS). Physico-chemical properties of water from each collection site were assessed using a multiparameter pH meter. The snails sampled at individual site were transferred to a laboratory for analysis

within 4 hours of collection. The species and genus of snails were identified by shell morphology. Cercarial shedding was assessed over the first 48 hours after collection.

Results: A total of 300 snails were collected from four different sites where people come into contact with water. The species of snails identified were *Bulinus africanus* (208) and *Bulinus forskali* (92). Snails of genus *Biomphalaria* were not identified among the collected snails. No snail was found to shed cercaria of schistosomiasis after being exposed to light.

Conclusion: Finding of *Bulinus* spp support high occurrence of *Schistosoma haematobium* and in the area and the need for planning of snail control activities in this setting. There is a need to sample snails over a long period, in different seasons of the year, to map if there is season variability of snail species especially for those transmitting *Schistosoma mansoni*.

Keywords: Schistosomiasis, Snail vector, Cercarial shedding, Kilimanjaro, Tanzania

Background

Schistosomiasis is a parasitic disease caused by blood flukes (trematodes worms) of the genus *Schistosoma*. There are five genus of *Schistosoma* that infects humans, but *Schistosoma haematobium* (urogenital) and *Schistosoma mansoni* (intestinal) are common types in Tanzania and Africa. The transmission occurs when infected people contaminate water with schistosome eggs from urine and/or stool, the eggs hatch into miracidium stage, which infects the snails. Various factors exert an influence upon infection of snail by miracidia, including: the age of the snail and miracidia, the number of miracidia per snail, the temperature of exposure and the temperature at which the snail is maintained during the pre-patient period. People become infected when the larval form (cercaria) of the parasites released by fresh water snails penetrate the skin during contact with infested water [1]. The infected snail in presence of sunlight release cercaria that swims and penetrate the skin of human host when come in contact with water containing cercaria. After penetration cercaria develop into adult worm in blood vessel (veins) of the intestinal or urinary tract system. Snails are considered to be an important intermediate host because human harbor the sexual stages of the parasites and snails harbor the asexual stages.

It is estimated that 779 million people globally are at risk of schistosomiasis where by 106 million live in the irrigation scheme or close to fresh water bodies such as dams used in irrigation [2]. An estimated 250 million people in 78 countries are infected with schistosomiasis of which 85% live in Sub-Saharan Africa [3]. Sub-Saharan Africa has highest burden schistosomiasis with 120 million individuals who are infected, 20 million having chronic presentation of the disease [4]. In Sub-Saharan Africa schistosomiasis is attributed by two species namely *S. mansoni* and *S. haematobium*. In Tanzania about 23,189,294 out of 43.5 million people were estimated to be infected of schistosomiasis equal to prevalence of 51.5% in 2012 [5]. The World Health organization has set goals of controlling morbidity to be reached by 2020, along with elimination as a public health problem in certain regions by 2025.

Snails are slow moving gastropods living on land or in water and having spiral protective shell. Snails are considered to be intermediate host because they harbor the asexual stage of the parasite while human being is a definitive host because harbors the sexual stage of the parasite [6]. Without snails, the transmission of schistosomiasis cannot be sustained, thus snail control will contribute in decreasing the burden of disease.

There are four main species of snails that are considered to be of medical importance for transmission of schistosomiasis. The genera that are main in sub-Sahara Africa are *Biomphalaria*, *Bulinus*, *Oncomelania* and *Tricula*, by which they are divided into two groups as aquatic snails (*Biomphalaria* and *Bulinus*) and amphibious snails which are adapted for living in and out of water (*Oncomelania*).

Distribution of snails causing schistosomiasis differs in Tanzania. The main species of *Biomphalaria* snails important in transmission of *Schistosoma mansoni* and found in Tanzania are *B. choanomphala*, *B. pfeifferi*, *B. sudanica* and *Biomphalaria angulosa*. *Biomphalaria choanomphala* restricted only to large water bodies (Lake Victoria), *Biomphalaria pfeifferi* is found in all regions of mainland part of the country except eastern coastal region, Unguja and Pemba. *Biomphalaria sudanica* is found in all regions of mainland part of the country except central region of Dodoma, Singida, the eastern and southern coastal region, Unguja and Pemba. And *Biomphalaria angulosa* common in lower lands and highlands southern [5].

Bulinus species are important in transmission of *S. haematobium*. Species distributions differ in different parts of Tanzania. *Bulinus globosus* is found in Unguja, Pemba and in mainland Tanzania while *Bulinus nasutus* (for *S. haematobium* & *S. bovis*) is found in Pemba, Mafia Island and all region of mainland parts of the country. *Bulinus africanus* (for *S. haematobium* and *S. bovis*) is distributed in all the region of Tanzania. *Bulinus forskalii* is probably distributed in all regions of mainland part of the country and Mafia Island [5].

WHO recommend and put forward recently ambitious goals for the year 2020 to control schistosomiasis globally and all countries should have schistosomiasis prevalence of less than 5% among school-aged children. The interruption of transmission and elimination of schistosomiasis should be encouraged whenever resources allow [7]. Mass Drug Administration (MDA) and education have been two interventions used by most Sub-Sahara Africa countries including Tanzania to reduce schistosomiasis morbidity [1,8]. However these efforts without snail control efforts have led to still high burden of disease in Africa and Tanzania.

Despite the application of molluscicides and biological control to reduced snail population that has been done in some places in Tanzania over time, vector (snail) control has been forgotten, and has not received the same emphasis like MDA in schistosomiasis control. The establishment of chemotherapy campaigns (mass drug administration to at risk populations) did not go hand-to-hand with snails' control in the country. There is therefore limited information on snail's distribution and infectivity patterns hence there is a need to have an information which guide the presence of intermediate hosts, their distribution and infectivity potential. The information may contribute in vector control activities to achieve control of schistosomiasis properly.

METHODS

Study area

Field work was conducted at Kileo in Mwanga district. Mwanga is the one of the seven districts of the Kilimanjaro region in northeast Tanzania. It is bordered to the northeast by Kenya, to the northwest by the Moshi rural, to the southwest by the Manyara region, and to the south by the Same district. The Mwanga district is administratively divided into 16 wards, Kileo being among them. Kileo ward is situated at 726.00m from sea level.

Kileo ward has the total population of 13,645 according to 2012. The ward has two villages; Kileo and Kivulini. The most economical activity in the area is rice cultivation through traditional irrigation scheme. In addition, people cultivate vegetables and fishing. All these are facilitated by presence of Kileo forest where two streams (Gona and Ruvu) originates, providing water throughout the year. Such environmental factors facilitate the presence of snails that transmit schistosomiasis.

Malacology Procedure

The snails were selected in four different sites (A, B, C and D) during April 2019 in Kileo village. The sites were selected based on human-water contact. Scooping technique-using scoops, hand sieves and forceps were used to collect the snails manually. The snails sampled at individual sites was stored in container filled with water depend on size and number of snails from the originating and transferred to laboratory. The snail samples were kept at room temperature (24-27 °C) at pH of 6.7.

The containers were labeled according to site of collection, date of collection and numbered. In the laboratory snails were kept alive in covered water tanks at room temperature using water from the original source without chlorination.

The types of vegetation cover and presence or absence of algal mass in each sampling site was recorded. Physico-chemical characteristics of the water at each sampling site was determined including a multiparameter pH meter (Eutech PCSTEST35-01X441506/Oakton 35,425–10, Vernon Hills, Illinois, 60,061, USA) based on guidelines provided by the manufacturer.

The location where the snail obtained was mapped by using Global Positioning System. All habitats where the snails sampled were mapped by Global Positioning System (GPS) using hand-held GPS unit.

Sample was carried out by two trained field collectors using standard snail scoops. The same collectors scooped for snails throughout so as to achieve same level of standardized sampling effort. In rice paddies where the water was very shallow, the snails were picked directly using foreceps. The sampling was fixed at 30 minutes per location and was performed between 8:30 am and 10:30 am. At each collection time, snails from sites were labeled and transported in perforated falcon tube separately to the laboratory for investigation. (**fig 1.**)



A



B

Laboratory methods

Laboratory procedures were carried at KCMUCo parasitology laboratory. Daily, snails were separated soon after arrival in laboratory. Brown Standard keys of Brown (1994) and DBL-WHO (1998) were used to identify the snails, based on the characteristics of shell morphology. The cercarial shedding was assessed over the first 48 hours after collection. Snails were rinsed using tap water, then inspected for infection by placing them in beakers with 10mls of tap water followed by exposure to light for 3 hours. After exposure, the water was examined under a dissection microscope for presence of schistosoma cercaria. The snails that did not shed cercaria were exposed in the following day for cercarial shedding.

RESULTS

Species of snails

300 snails were collected from four different sites where people come to contact with water. The species of snails collected were *Bulinus africanus* (180) and *Bulinus forskali* (120). **(fig 2)**



(A)



(B)

Photo 2 (A) *Bulinus forskali* image (B) *Bulinus africanus* image
Infectivity of snails

No snail was found to shed cercaria of schistosomiasis after being exposed to light.

Distribution of snail species

The snails were collected from four sites named A, B, C and D. All four areas were covered with algae and vegetation. Site A was in Kivulini canal containing water at 25°C where both *Bulinus africanus* and *Bulinus forskali* were found. The site B containing water of 27°C, in this site we found only *Bulinus africanus* in rice paddies with water from Bogoyo canal. The site C was with water of 24°C near the water spring (Mtindi forest). In this site we found *Bulinus forskali* and few *Bulinus africanus*. The site D was located with water of 28°C. This was a flooded area forming a breeding site. In this area we found only *Bulinus africanus*. It seems that *Bulinus africanus* prefer high temperature than *Bulinus forskali*. (**Table 1**)

Table 1: Distribution of snail species (N=75)

SITE	n	%
Site A		
<i>Bulinus africanus</i>	27	36
<i>Bulinus forskali</i>	48	64
Site B		
<i>Bulinus africanus</i>	75	100
<i>Bulinus forskali</i>	0	0
Site C		
<i>Bulinus africanus</i>	3	4
<i>Bulinus forskali</i>	72	96
Site D		
<i>Bulinus africanus</i>	75	100
<i>Bulinus forskali</i>	0	0

DISCUSSION

The study investigated distribution of snails that transmit schistosomiasis and its infectivity at Kileo, Mwanga district northeastern Tanzania. Two species of snail found were *Bulinus africanus* and *Bulinus forskali*. Snails were tested for cercaria shedding but none of the species was found to shed cercaria.

Snails were found distributed in all areas of slow-moving water covered with vegetation and algae. In rice paddies with water from Bogoyo canal (site B) and in flooded area (site D) only *Bulinus africanus* species were found. Near the water spring (site C) and Kivulini canal both *Bulinus forskali* and *Bulinus africanus* were found but *B. forskali* dominating the areas. The average characteristics of water pH was 7.35 and the temperature was 26°C.

In Gombe National Park, nearby village and Kigoma in western Tanzania total of 235 snails were collected from stream close to human settlement. Snails were individually exposed to light to induce shedding of cercaria, which was examined using compound light microscope. None of the snails from Gombe or Bugamba were shedding cercaria, the prevalence of cercaria shedding from the snail of another region (Kiziba Mtanga Mwamgongo and Bugamba) was

12%. Some snail which were not shedding cercaria were PCR positive for the 500 base pair Internal Transcribed Spacer (ITS) which was predicted to indicate infection with schistosomiasis [9].

Further study is needed to test the infectivity of the snails in different season of the year because snails were sampled within short period (1month) hence the seasonal variation of snail's distribution and infectivity with *Schistosoma* was not captured.

Manuscript trial number: Not Applicable

Declarations

Manuscript trial number

Not applicable

Ethical approval and consent to participate

Ethical approval to carry out the current study was obtained from Kilimanjaro Christian Medical College Research Ethics and Review Committee (KCMU-CREC) with clearance number **UG. 23/2019**.

Consent for publication

Written informed consent for publication of identifying images (**Photo 1**) was obtained from all of the participants (data collectors).

Availability of Data and Materials

All data and materials concerning this research article are available for sharing if needed.

Competing interests

All authors have no competing interests on the findings of this study

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Authors' contributions

SA – develop the concept design the methodology, conducted data analysis and wrote the manuscript.

REM, EJA, and PJM – develop the concept, conducted data collection and participate in data analysis

VVM– conducted data analysis and manuscript writing

JM – Review the manuscript

SEM – review the concept, methodology design and data analysis

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