Original Research Article

Environmental parameters and *Biomphalaria*snail distribution along River Kochi, West Nile region, Uganda

.

ABSTRACT

Aims: To explore the abundance and distribution of the common fresh water mollusks in River Kochi, with a special focus on *Biomphalaria* species, a vector responsible for transmitting *Schistosomamansoni* to humans.

Study design:

Place and Duration of Study: This study was conducted between October 2007 and March 2008 as a master's project along Kochi River in Koboko, Yumbe and Moyo in the West Nile region of Uganda.

Methodology: Five sites along the river approximately 20 km apart, were selected and data on snail abundance and various environmental variables thought to be influencing the distribution of snails along this river were collected. These variables included: altitude, season of the year, water flow velocity, water pH, water temperature and concentrations of total dissolved solids in the water.

Results: Findings indicate that numbers of *Biomphalaria* species of snails increased with decreasing altitude (mean numbers 0, 15.33, 19, 50 & 73.33 from highest to lowest altitude points) and no snails of this species were recorded during the wet season. Water flow velocity and pH were the main predictors of the presence of *Biomphalaria* snails (Pearson correlations -0.749 and0.614 for flow velocity and pH respectively). *Biomphalaria* snail numbers increased when water velocity decreased and the reverse was true for pH.

Conclusion: Altitude influences the distribution *Biomphalaria*snails and hence potential prevalence of schistosomiasis. Water users of Kochi River should therefore try to minimize contact with water in this river especially during the dry season. Local leaders should lobby to government for alternative sources of water during the dry season.

Keywords: Biomphalaria, Schistosomamansoni, *River Kochi, West Nile*

1. INTRODUCTION

Approximately 30 species of *Biomphalaria* are recognized and the genus is widely distributed in South America and on the African continent [1].*Biomphalaria* is an aquatic snail that acts as a host for a human blood fluke *Schistosomamansoni*that cause the disease intestinal schistosomiasis (bilharzia) in humans [2].With its many lakes, rivers, streams, swamps and ponds, Uganda has a diverse fresh water environment that offers numerous and suitable habitats for the *Biomphalaria*species. Currently two species of *Biomphalaria*namely: *B. stanleyi*and *B. sudanica*(hereby known as *Biomphalaria*)are the most common in the west Nile region of Uganda [3].

Whereas Nelson [4] in 1950s pioneered research works on schistosomiasis in West Nile region approaching the infections from ecological and geographical points of view and from both human populations and snail vectors in water bodies, research that followed his works mainly concentrated either in human communities that live close to the shores of lake Albert/ Albert Nile [5, 6, 7, 8, 9&10]or from hospital records [5, 11], with the exception of findings ofKazibwe et al [3].Contrary to the aforementioned studies, Kazibwe [3] looked at the effect of environmental factors on the distribution of *Biomphalaria* in Lake Albert, Western Uganda. Findings from this study revealed that climatic conditions primarily air temperature, rainfall, lake depth level, water temperature; water conductivity and water pH influence the distribution and abundance of snails in Lake Albert. Similarly Appleton [11]and Thieltges et al. [13] showed that climatic conditions primarily rainfall and temperature influence the distribution and abundance of snails because they have an effect on their breeding and the rate of schistosomal development.

It is clearly evident from the aforementioned studies that the studies on *Biomphalaria* snail species ecology was restricted to large water bodies, with little or no attention given to small ones, which are also a source of water and fish for the local communities. However, it is important to mention that Odongo-Aginya and others [14] conducted a research on urban *Schistosomamansoni*near Enyau River in Arua town, a small river in the highland areas of the region further away from the Nile River but his focus was on infections in humans. In addition, human populations in the township comprise of people from different origins and locations, and may therefore not have given dependable results since all the *S. mansoni*cases registered may not have been contracted from Enyau River. We therefore strongly believe that conducting research on vector dynamics in smaller water bodies will result into better understanding of the disease prevalence and its distribution in the region considering that a lower number of snails mean a lower number of cercariae and therefore a diminished risk of infection. Studies on diseases vectors are very important for evidence based mitigation and control measure. The main objective of the study was therefore to investigate effects of altitude, season and water environmental variables on the distribution of *Biomphalaria*snail species along the Kochi River, West Nile region. Findings from this study will generate some current information on the distribution of the disease vectorin the different infection zones and altitudes in the study area.

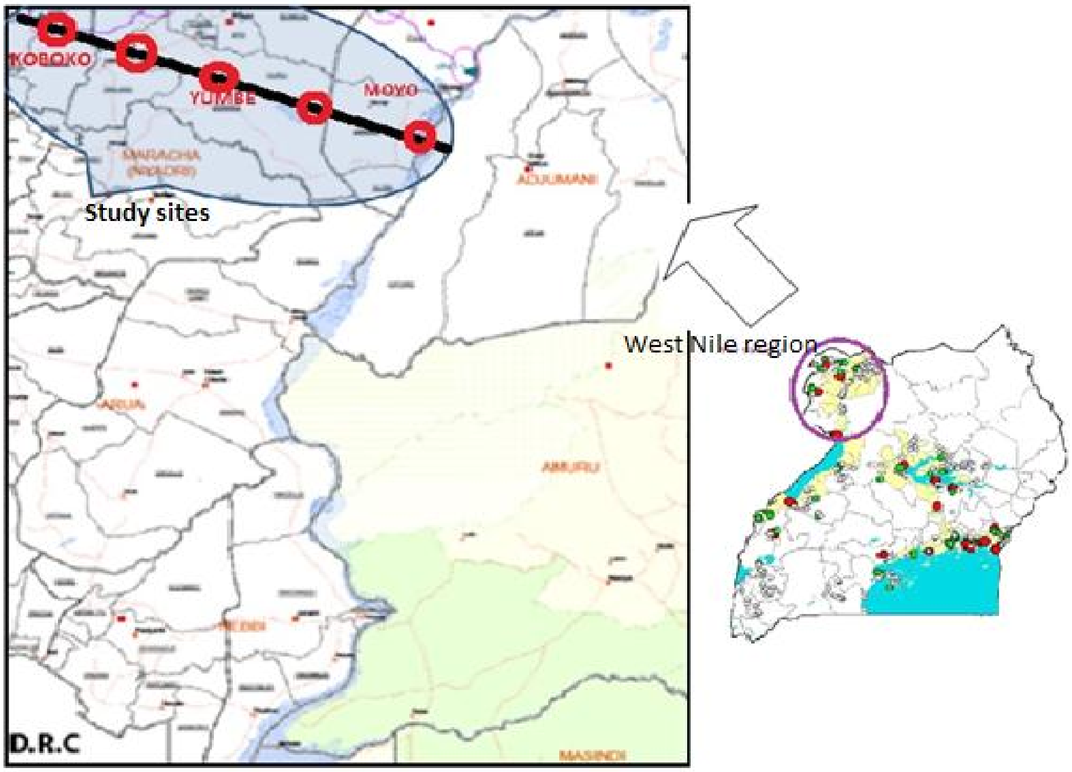
2. MATERIAL AND METHODS

2.1 Study sites

The study took place in Kochi River located in Koboko, Yumbe and Moyo districts of West Nile region. Generally, the study area was divided into three altitude zones i.e. Koboko with altitude of above 1000 m; Yumbe (two sites: Yumbe 1 and Yumbe 2) with altitude range of 700 m to

1000 m and Moyo (two sites: Moyo 1 and Moyo 2) with altitude range of 600 m to 700 m above sea level. Kochi River has its origin in Koboko district near Uganda-DR Congo boarder at an altitude of above 1000 m where it starts as a small stream and gradually widens downstream as it passes through Yumbe district and finally joins the Albert Nile in Moyo at an altitude of about 600 m above sea level (Fig 1). This river stretches all the schistosomiasis infection belts of the region that Nelson [4] hadestablished in 1958. The rainfall pattern in this region is bimodal peaking in late March to May (about 900 mm), and August to December (above 900 mm) each year. The rest of the months experience dry spells with sporadic rainfall which fluctuate the water levels of the rivers and its stream tributaries where some seasonal ones dry up completely.

Fig.1. Map showing the study sites



2.2 Estimating snail abundance and water parameters

Biomphalaria snail abundance was estimated from well-defined areas along the river. These areas measured 30 m along the bank and 3 m into the main body of the water. The corners of these rectangular sampling areas were marked by pegs so that successive samplings could be performed across the same area. These areas were searched for a period of 30mins and all snails found floating or attached to vegetation were collected using a scooping net with a long handle and placed on white plastic trays in order to be able to rapidly identify the different species based on the standard field identification key guide of the Danish bilharziasis laboratory [15]. Each site was visited weekly and snail samples collected over a period of six months between October 2007 and March 2008. Three of the months (October, November and

December) experienced heavy rains of above 900 mm and have been recorded as wet, whilst the other three months (January, February and March) experienced little or no rains and have been recorded as dry. Although our main focus was *Biomphalaria,* snail types like *Lymnae, Bulinus* and *Pila* species were collected because they coexist with the *Biomphalaria* snails and are intermediate hosts to other human and animal diseases. Snails were collected from 5 altitude belts spread across the study area at intervals of about 20 km apart.

We took measurements on water flow velocity, water pH, water temperature and concentration of total dissolved solids (TDS) in the water shortly before collecting the snail samples. Water flow velocity was obtained by sprinkling methyl orange dye from the upstream mark of the sampling area and recording the time taken for the dye colour to cover the 30 m distance to the downstream mark and velocities computed. Values for pH and temperature were obtained by using a pH meter integrated with a temperature probe (Model 3150/REV A/04-95). TDS concentration was determined using a conductivity meter (Model 4200/REV A/05-95).

2.3 Data analysis

Data were analysed using Genstat version 3. Firstly, we made a descriptive summary of the abundance of all snails in total, and then secondly we singled out *Biomphalaria*species and explored how its distribution is affected by the environmental factors considered in this study. Pearson-r Correlation Coefficient tests were done to establish associations between the different variables. Environmental variables that had strong associations with the abundance of *Biomphalaria*species were then used in Simple Regression models.

3. RESULTS AND DISCUSSION

Higher numbers of *Biomphalaria* and *Pila* were recorded in Yumbe and Moyo while that of *Lymnae* and *Bulinus* snail species were registered in Koboko (Fig 2). Considering that these locations are positioned at different altitudinal zones, these results already indicate an effect of altitude on the distribution of these snail species. The results further show that no *Biomphalaria* species of snails were recorded during the wet season, and the number of snails increased with decreasing altitude during the dry season from none recorded at an altitude of 1189 m to a mean of 62 snails recorded per month at an altitude of 638 m or 639 m (Table 1).

Fig. 2. Abundance and distribution of common snail species at sites along River Kochi

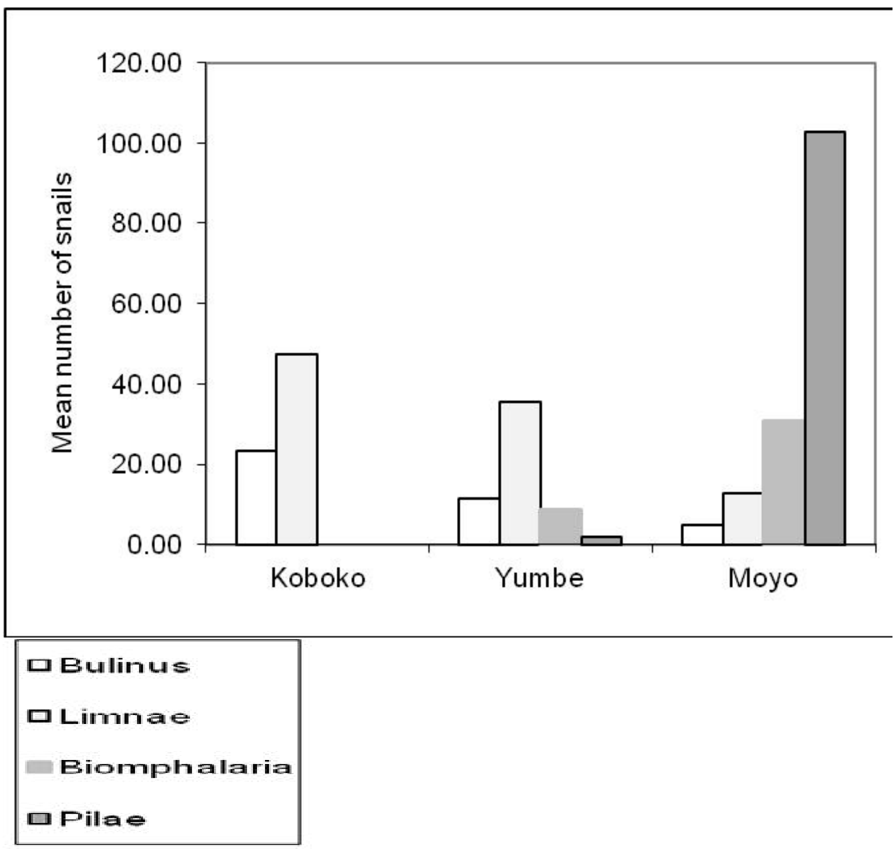


Table 1: Altitudinal and seasonal variation in the number of *Biomphalaria* species

	Mean	
Season	Dry	Wet
Altitude		
638.0	73.33	0.00
639.0	50.00	0.00
898.0	19.00	0.00
933.0	15.33	0.00
1189.0	0.00	0.00

A correlation analysis indicated that there was an association between the number of *Biomphalaria* snails and water flow velocity (-0.749) and between *Biomphalaria* snails and pH (0.614) (Table 2). Water flow velocity and pH were in turn highly correlated (-0.899) indicating a strong association between them (Table 2 and Fig 3). Weak associations existed between number of *Biomphalaria* snails and Temperature and Total dissolved solids (Table 2). In view of the result shown in table 1 that show that snail incidence varied with altitude and season we found it important to summarize mean values for water flow velocity and pH levels in the same way. Results for water flow velocity show that snails were found only in the dry season at the five sites where the velocity was in a range of 0.19 to 0.31 m/s. No snails were recorded at Koboko, which is the site at the highest altitude. The water velocity in the dry season was 0.48 m/s, which is at the lower end of the range of values shown for the wet season and above the value of 0.4 m/s (the upper limit for presence of snails shown in Table 1). A similar trend can be seen for pH. Snails were found only when pH values were 7.1 or above (Table 3).

Table 2: A correlation matrix between numbers of *Biomphalaria*and environmental variables

*** Correlation matrix ***

	NBiom	TDS	Temp	Velocity	pH
NBiom	1.000				
TDS	-0.264	1.000			
Temp	0.012	0.746	1.000		
Velocity	-0.749	0.182	0.027	1.000	
pH	0.614	0.099	0.084	-0.899	1.000

**NBiom = number of Biomphalaria snails; TDS = Total Dissolved solids*

Fig. 3: Relationship between water flow velocity and water pH

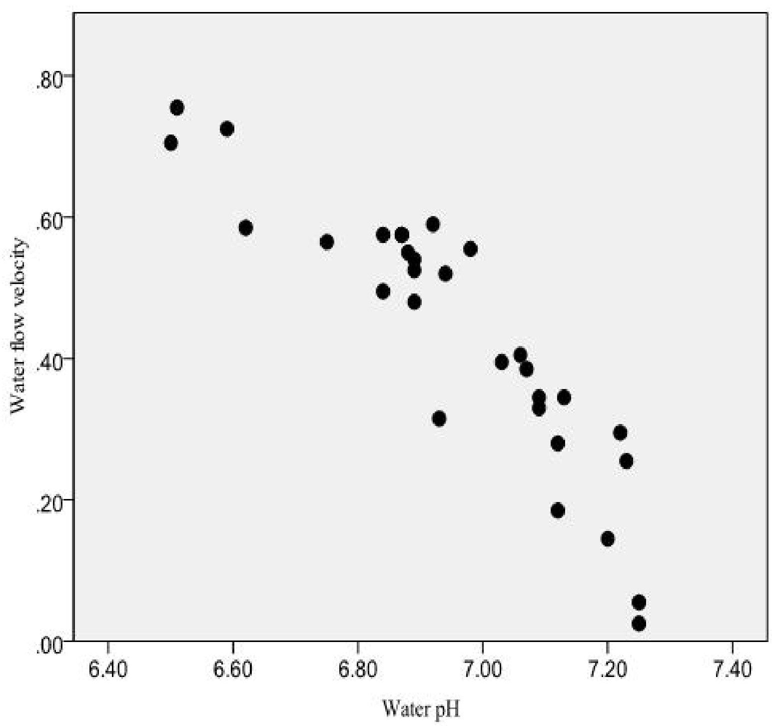


Table 3:Altitudinal and seasonal variation in Water flow velocity and water pH

	Mean (Water flow velocity)			Mean (water pH)	
Season Altitude	Dry	Wet	Season Altitude	Wet	Wet
638.0	0.1867	0.4733	638.0	7.200	6.947
639.0	0.2267	0.5400	639.0	7.187	6.837
898.0	0.2917	0.5683	898.0	7.183	6.893
933.0	0.3083	0.5600	933.0	7.080	6.900
1189.0	0.4450	0.7283	1189.0	6.813	6.533

** Altitude decreases from Koboko to Moyo*

Considering that pH and flow velocity were strongly correlated with each other, we decided to use Simple linear regression models for each variable to predict *Biomphalaria* snail abundance. The results showed highly significant relationships between water pH and flow velocity (P<.001) and that pH accounted for 38% of the variation while water flow velocity accounted for 56% of the variation in *Biomphalaria* numbers. There was a positive association between *Biomphalaria* snails and pH when pH is 7.1 or above and no snails were found when pH was below 7.1 (Fig 4). In addition, the number of *Biomphalaria* snails increased when water flow velocity decreased below about 0.4 m/s and no snails were found when velocity was 0.4 m/s or above (Fig 5).

Fig. 4: Relationship between numbers of *Biomphalaria* snails and water pH

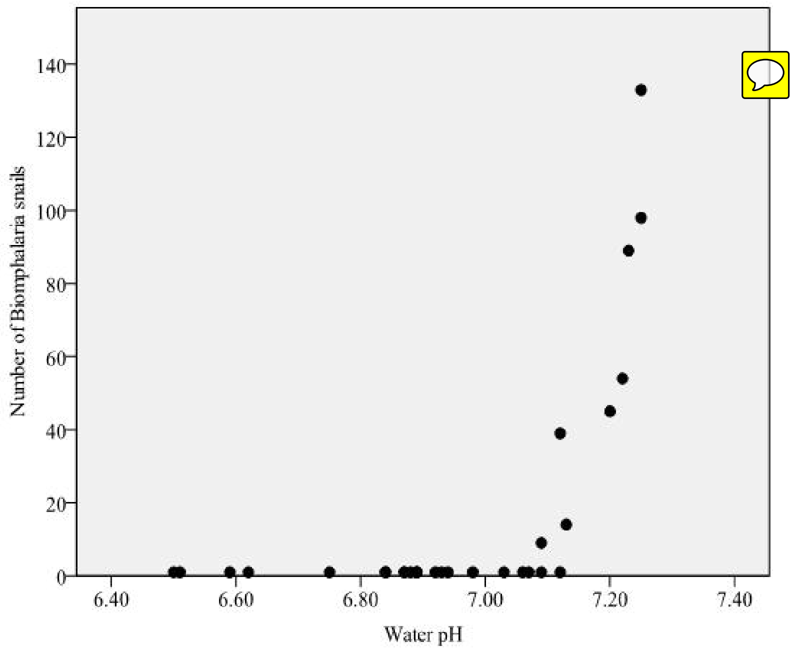
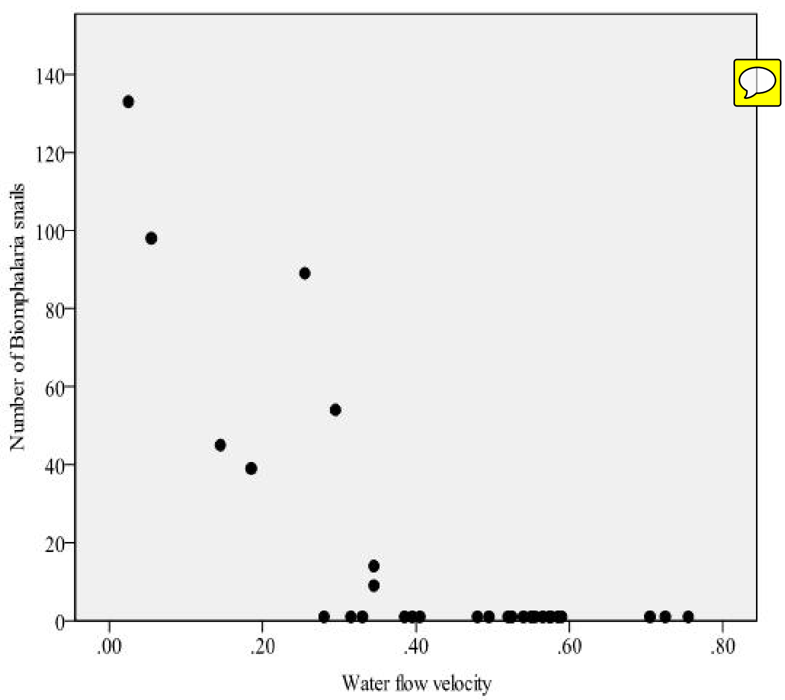


Fig. 5: Relationship between numbers of *Biomphalaria* snails and water flow velocity



DISCUSSION

Bulinus and *Lymnae* snail species were distributed throughout the river length. On the other hand,*Biomphalaria* and *Pila* species were not however found at all in some of the sites especially those towards the source of the river in Koboko above 1000 m. They were only found in sites towards the Nile in Yumbe and Moyo at fairly lower altitudes. The presence of *Lymnae*species in the river poses a threat of *Fasciola hepatica* (liver fluke) transmissions in domestic animals that graze along the river in case some of the animals happen to be infected with the disease. In the same token *Schistosomahaematobium* (urinary schistosomiasis) could easily spread in this area as their intermediate snail vectors (*Bulinus* species) are readily available in the river and the fact that major roads that cross into South Sudan where *S. haematobium* exists also cross this river. With high human mobility across these two countries, existence of *S. haematobium* in the area if not the region is highly likely and therefore needs investigation.

Biomphalaria numbers in the dry season were associated with water flow velocity and pH levels. A possible explanation for the association is that the river becomes wider and so the flow speed of the water reduces further downstream. Stable water conditions downstream would be particularly prevalent during the dry season. Such conditions would enable the snails to anchor more easily on the water vegetation. Also, as the debris carried down the river settles and rots down, so the pH of the water gradually increases. This would explain why higher numbers of *Biomphalaria* species of snails are associated with lower water flow rates and higher pH levels (See also [3]). It is however important to note that not all the variation in *Biomphalaria* species numbers was explained by water velocity and pH. It is possible that this unexplained variation could be due to other factors such as amount of vegetation and snail prey present at the study sites, which were out of the scope of this study.

Numbers of *Biomphalaria* species of snails increased with decreasing altitude and no snails of this species were found during the wet season. The complete absence of snails in the wet season is very difficult to explain. However, we think that this is attributed to the fact that during this time of the year, the water flow velocity in river Kochi was very high thereby drifting the snails away. In addition the water table was also very high therefore submerging the vegetation onto which the snails attach. This seems to suggest that there is need for lowering the sweep net further deeper into the water to search the snails.

Furthermore Kabetereine, [16] recorded bigger numbers of *Biomphalariastanleyi* in shallow waters along Lake Albert during dry season and this was mainly attributed to the effects of light penetration on the growth of *Vallisneria* weeds which serve as food for the snails in the river. Fewer numbers of snails were recorded when lake levels increased and light penetration to support growth of the weeds reduced. In addition, warmer and wetter conditions encouraged snails to lay more eggs thereby increasing the densities of young snails several weeks later. In this current study we attribute the big numbers of *Biomphalaria* snails collected during dry season to the preceding wetter and warmer months of wet season that resulted in mass egg laying and subsequent development of these eggs into the large number of adult snails registered later in the drier months of dry season.

There was no significant effect of temperature on the distribution and abundance of *Biomphalaria* snail species along Kochi river. This finding is rather contrary to studies conducted elsewhere in the world [16, 11, 18, 19 & 20]. These findings could be attributed to the fact that there was/is severe fluctuations in temperature as compared to the extreme cold and hot temperatures experienced in the study sites considered in the above mentioned studies.

4. CONCLUSION

In conclusion, we want to acknowledge that although this study was limited in time scope compared to earlier studies, our findings are consistent as they seem to indicate that despite national schistosomiasis control efforts,*Biomphalaria* snail species are still present within the West Nile region. The continued presence of these snail species and other associated snail species in smaller water bodies could thwart the efforts to contain schistosomiasis in this region and pose an unforeseen threat to a number of snail transmitted diseases to humans, and domestic animals in communities along the rivers most especially in the lower altitudes. We recommend regular community sensitisation by the Ministry of health about the risks of getting into contact with the river water during the dry season and that the concerned local governments lobby to government to provide alternative sources of water e.g. boreholes that can be used in the dry season to minimise peoples' contact with the river water. Mass control interventions by the government to the schistosomiasis pandemic in this region following quick diseases surveys in human communities will yield little results if no focus is paid to the water sources where the disease is contracted. Further research may be directed towards scaling up the study along other rivers in the west Nile region and also incorporating other variables like the amount of vegetation and snail prey present at the sites.

REFERENCES

1. Brown, D. S. Freshwater snails of Africa and their medical importance. Taylor & Francis, London; 1994.
2. Jordan, P. & G. Webbe. Epidemiology. In: Human schistosomiasis(Eds P Jordan, G. Webbe, & R. F. Sturrock). Commonwealth Agricultural Bureau International, Wallingford;1993:87-158.
3. Kazibwe, F., B. Makanga, C. Rubaire-Akiiki, J. Ouma, C. Kariuki, N. B. Kabatereine, M. Booth, B. J. Vennervald, R. F. Sturrock, J. R. Stothard. Ecology of Biomphalaria

(Gastropoda: Planorbidae) in Lake Albert, Western Uganda: Snail distribution, infections with schistosomes and temporal associations with environmental dynamics. Hydrobiologia. 2006;568(1):433-444.

4. Nelson, G.S.Schistosomamansoni infection in West Nile District of Uganda. Part II. The distribution of S. mansoni with a note on the probable vectors. East African Medical Journal. 1958;35:335-344.
5. Ongom V.L. & Bradley D.J. 1972. The epidemiology and consequences of Schistosomamansoni infection in West Nile. Part I. Field studies of a community at Panyagoro. Transaction of Royal Society of Tropical Medicine and Hygiene. 1972;66:835-851
6. Ongom, V.L. *et al*. The epidemiology and Consequences of SchistosomamansoniInfection in West Nile, Uganda. II. Hospital investigation of a sample from the Panyagoro Community. Transaction of Royal Society of Tropical Medicine and Hygiene. 1972;66:851-863.
7. Bukenya, G. & S. Andama. Circumstantial epidemiology of Schistosomamansoniin the West Nile District of Uganda: Results of a cross-sectional study in the Rhino Camp Area. Journal of Tropical Medicine and Hygiene. 1986;89:243-248.
8. Kabatereine N.B., C. Ariho, &N.O.Christensen.Schistosomamansoniin Pakwach, Nebbi District, Uganda, 40 years after Nelson. Tropical Medicine and Parasitology. 1992;43:162-166.
9. Laroni-Lakwo T, Odongo-Aginya EI, Schweigmann U, Schickerling S, Linder D, Doehring-Schwerdtfeger E. Transmission of Schistosoma mansoni in Rhino Camp, Uganda. E. Afr. Med. J. 1994;71:165-166.
10. Kabatereine, N.B., F. Kazibwe, & J. Kemijumbi. Epidemiology of schistosomiasis in Kampala, Uganda. East African Medical Journal. 1996;73:795-800.
11. Williams, E.H., R.J. Hayes, & P.G. Smith. Admissions to rural hospital in the West Nile District of Uganda over a 27 year period. Journal of Tropical Medicine and Hygiene.

1986;89:193-211.

12. Appleton, C.C. Review of literature on abiotic factors influencing the distribution and life cycle of bilharziasis intermediate snail. Malacological Review. 1978;11:1-25.
13. Thieltges, D., K.Jensen& R. Poulin. 2008. The role of biotic factors in the transmission of free living endoheliminth stages. Parasitology. 2008;135:407-426
14. Odongo-Aginya, E.I. Lakwo TL, Schweigmann U, Schickerling S, Lindner D, Mueller A, Doehring-Schwerdtfeger E.Urban Schistosomamansoninear Enyau River in Arua Town, Uganda. East African Medical Journal. 1994;71:604-606.
15. Danish Bilharziasis Laboratory. A Field Guide to African Freshwater Snails, (2nd edn.) East African species. World Health Organization Collaborating Centre, Copenhagen.1987:29–32
16. Kabatereine, N.B., F.M. Flemming, U. Nyandindi, J.C.L. Mwanza, and B. Lynsey. The control of schistosomiasis and soil transmitted helminths in East Africa. Trends in Parasitology. 2006;7:332-339.
17. Shati, A. A. Factors affecting the prevalence of human schistosomiasis in Aseer regions, Saudi Arabia. Journal of Biological Sciences. 2009;9:815-819.
18. Martens, W.J.M.Modelling the effect of global warming on schistosomiasis on the prevalence of schistosomiasis. GLOBO Report Service. 1995;10:1-31.
19. Gryseels, B., K. Polman., J. Clerinx& L. Kestens. Human schistosomiasis. Lancet. 2006;368:1106-1118.
20. Brooker, S. Spatial epidemiology of human schistosomiasis in Africa risk models transmission dynamics and control. Transaction of Royal Society of Tropical Medicine and Hygiene. 2007;101:1-8.