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Association between *Schistosoma mansoni* Infection Rates in Humans and in *Biomphalaria pfeifferi* snails in Akwanga, Nasarawa State, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author JIC carried out the field work and wrote the first draft of the manuscript. Author AO wrote the protocol and managed the statistical analysis. Author IOO managed the literature searches. Author EUA designed the study. All authors read and approved the final manuscript.

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ABSTRACT

Schistosomiasis is a neglected tropical disease of medical importance. Intestinal schistosomiasis caused by *Schistosoma mansoni* is less wide spread than urinary schistosomiasis in Nigeria. A study was carried out in Akwanga, Nasarawa State to determine the association between *S. mansoni* infection rates (prevalence) in humans and infection rates in *Biomphalaria pfeifferi* snails in Akwanga, Nasarawa State, Nigeria. The study was carried out in two communities: Gwanje community and MadaHills community in Akwanga. For infection rates in humans, four hundred (400) urine samples were tested for *S. mansoni* antigen using point of care circulating cathode antigen (POC-CCA) test kit. Infection rates in snails were determined by *S. mansoni* cercarial shedding by snails. *Biomphalaria pfeifferi* snails were more abundant and had significantly higher ($p<0.05$) infection rates in dry season than rainy season in both Gwanje and MadaHills. There was a positive correlation between infection rates in humans in Gwanje and MadaHills (21.5%) and (14%) and infection rates in snails in Gwanje and MadaHills (13.9%) and (9.6%) respectively. Snails collected close to portions of the river that community residents earmarked for open

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defecation within freshwater bodies had significantly higher ($p<0.05$) infection rates (15.8%) than snails collected from across river banks, (7.1%) and snail infection rates in areas designated for fetching water for drinking and domestic use was (12.7%) . Health education, improved sanitation practices and annual chemotherapy with praziquantel could help interrupt disease transmission and bring about schistosomiasis control in both Gwanje and MadaHills communities.

Keywords: Schistosoma mansoni; urinary schistosomiasis; intestinal schistosomiasis; Biomphalaria pfeifferi.

1. INTRODUCTION

Schistosomiasis is one of the most prevalent neglected tropical diseases and among parasitic diseases, it ranks second only to malaria in terms of morbidity [1]. An estimated 206.4 million people in 78 countries require preventive treatment for schistosomiasis and 91% of people requiring treatment reside in Africa (WHO, 2018). In Africa, there are two (2) major forms of schistosomiasis in humans: intestinal schistosomiasis caused by *Schistosoma mansoni,* and urogenital schistosomiasis caused by *Schistosoma haematobium* [2]. The life cycle of *Schistosoma mansoni* involves a snail intermediate host and a human definitive host; infective humans eliminate parasite eggs via stool. It is estimated that one stool sample on reaching water may yield up to 2, 500 *S. mansoni* miracidia [3], therefore, the life cycle of schistosomiasis in itself reveals the importance of proper Water sanitation and hygiene (WASH) as an important tool for transmission interruption and control of the disease [4]. Detection of cercarial shedding is used to estimate snail infection rates; but may grossly underestimate snail infection rates as a result of intermittent and periodic shedding [5]. Abe et al. [6] reported zero cercariae shedding in snails in water bodies across Nasarawa State where schistosomiasis is prevalent. *Schistosoma mansoni* diagnosis in humans can be carried out with Kato katz technique, molecular detection of parasites in stool and with circulating cathode antigens test. Like other rapid diagnostic test, POC-CCA does not require sophisticated equipments, expertise or electricity and can be performed in less than 30 minutes (Colley *et al*., 2017). Point of care circulating cathode antigen test has high sensitivity and specificity and can be successfully used to determine *S. mansoni* infection rates (prevalence) in humans in field epidemiology and population studies (Weerakoon *et al*., 2017). This research was aimed at determining *Schistosoma mansoni* infection rates in humans and in *Biomphalaria pfeifferi* snails in Akwanga, Nasarawa State, Nigeria. Infection rates in humans and in snails could provide comprehensive data on epidemiology of schistosomiasis in an area and access the need for praziquantel mass drug administration (MDA) and additional intervention to achieve actual transmission interruption and control of the intestinal schistosomiasis.

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Gwanje community and MadaHills community in Akwanga, Nasarawa State, Nigeria. Nasarawa State is located in North Central Nigeria Fig. 1.

2.2 Sample Size

Two hundred (200) urine samples were collected from MadaHills Primary School, 100 urine samples from Gwanje primary school and 100 urine samples from Junior Secondary School (JSS). Ages of school children enrolled in the research ranged from 7 years to 23 years.

Research subjects who tested positive for intestinal schistosomiasis were treated with praziquantel by a clinician; drug dosage was administered based on body weight 40 mg/kg.

2.3 Questionnaire Forms

Questionnaires were administered in English and where necessary in local dialect to obtain information on knowledge, attitudes and practices of the residents of the area, and data on age, sex and location.

2.4 Time of Sample Collection

Terminal urine was collected from research subjects using a 20 ml plastic universal bottle bearing a unique identification number which tallied with the subject's questionnaire and consent/assent form number. Time of sample collection was between 10 am and 2 pm which is

the peak egg shedding period for *Schistosoma* species. Urine samples upon collection, were transported to the laboratory for diagnosis.

2.5 Diagnosis of *S. mansoni* in Urine

Diagnosis for intestinal schistosomiasis was done using Point of Care Circulating Cathode Antigen (POC CCA) Test Kit. A straw pipette from within the kit was used to suction and place two drops of the urine into a pit on the POC-CCA cassette and the results were read after 20 minutes. The appearance of two lines (the control line and another red line) was interpreted as positive and the appearance of a single line (only the control line) was interpreted as negative.

2.6 Health Education

A brief health education was done for school children and teachers in schools where the study was carried out, informing them on the disease, its symptoms, how it is transmitted, and the importance of annual chemotherapy with praziquantel and proper water sanitation and hygiene for the control of the disease.

2.7 Snail Collection

Snails were collected in the early hours of the mornings from River Gwanje and River MadaHills between 6 am-7 am when the water was undisturbed [7] and transported to the laboratory; snails were sampled across water bodies using scoop nets and hand picking wearing rain boots and thick hand gloves to protect from accidental infection of the collectors by cercariae shed by the snails. In the laboratory the snails were washed twice in tap water to rid them of the layers of algae and debris around them which could obstruct cercariae shedding. After washing, the snails were placed in Petri dishes one snail per dish, submerged in tap water and placed under direct sunlight for two (2) hours to stimulate cercariae shedding in infected snails [8]. After two (2) hours, each dish was examined for shed cercariae under a dissecting microscope. Where present, cercariae were identified by their characteristic head, neck and bifurcate tail and active swimming. Snails that did

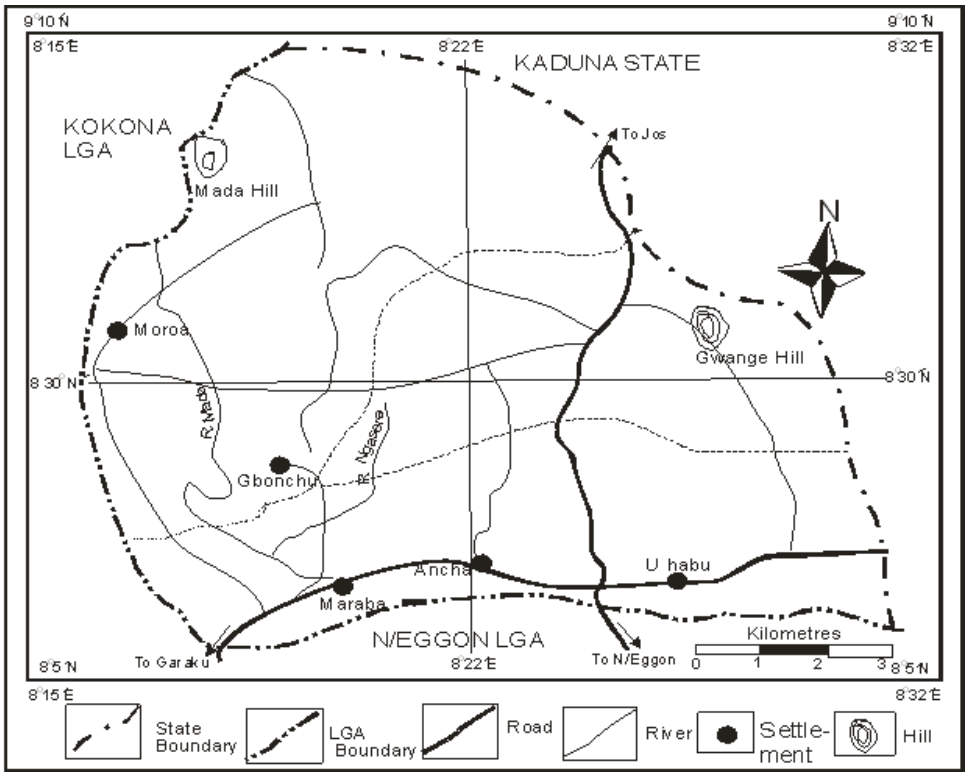


Fig. 1. Map of Akwanga Local Goverent Area showing Hills
Source: Ministry of lands and survey, Lafia, Nasarawa State

not shed on the first day (day 1), were again placed in direct sunlight the next day for two hours and the process repeated daily until the snails aestivated. The shedding experiment lasted for 15 days, within which period all snails collected aestivated.

2.8 Statistical Analysis

Chi-square test was used to verify the homogeneity of the disease in the different schools. Associations between *S. mansoni* infection rates in *B. pfeifferi* snails, and *S. mansoni* infection rates in humans was tested using Spearman's correlation (rho) at P< 0.05 significance level.

Infection rates in snails was calculated as:

$$\frac{No.\ of\ snails\ infected}{Total\ No.\ of\ snails\ collected} \times 100$$

Infection rates in humans were calculated as:

$$\frac{No.\ of\ people\ infected}{Total\ No.\ of\ people\ tested} \times 100$$

3. RESULTS

Table 1 showed infection rates in snails and humans in Gwanje and MadaHills. Infection rates in humans was 21.5% in Gwanje and 14% in MadaHills. Infection rates in snails was 13.9% in Gwanje and 9.6% in MadaHills. Table 2 showed seasonal abundance of *B. pfeifferi* snails. In wet season the total infection rates in snails was 3.3%, and in dry season the total infection rate in snails was 12.3%. Table 3 showed infection rate of *B. pfeifferi* snails by collection location within freshwater body in Gwanje and MadaHills. Total infection rates in snails collected in both Gwanje and MadaHills from toilet areas was (15.8), from across river banks was (7.1), and (12.7) from across areas earmarked for fetching drinking water. Figure 2 showed a positive correlation of r^2 = 0.828% between *S. mansoni* infection rates in snails and *S. mansoni* infection rates in humans in Gwanje and MadaHills, Nasarawa State.

4. DISCUSSION

4.1 High *S. mansoni* Infection Rates (Prevalence) in Humans

Our study revealed high *S. mansoni* prevalence rate in both Gwanje and MadaHills. High prevalence rate in humans is a call for treatment with praziquantel. Praziquantel is aimed at reducing both morbidities and transmission (WHO, 2016). Pam et al. [9] reported prevalence of 3.19 % in Keffi LGA, Nasarawa; and Okwori et al. [10] reported 5.3% *S. mansoni* prevalence in Gadabuke district, Nasarawa State. Prevalences from this study was however higher than reported by the above mentioned researchers. This could be as a result of the use of Kato katz technique which relies solely on egg detection which could underestimate *S. mansoni* infection due to intermittent release of parasite eggs. For this reason, the use of up to three serial stool samples is recommended to increase sensitivity. Spencer et al. [11] and Woldegerima et al. (2019) reported higher prevalences of 93.7% in Madagascar and Ethiopia respectively using point of care circulating cathode antigen test kit for diagnosis.

4.2 Presence of *Biomphalaria pfeifferi* Snails in Gwanje and MadaHills

Biomphalaria pfeifferi fresh water snails were present in Gwanje and MadaHills, Nasarawa State. The presence of *Biomphalaria* snails have been reported across freshwater bodies in Nasarawa State (Abe et al., 2016), Kaduna State [12]; Osun State [13] and Ebonyi State [14]. Schistosomiasis epidemiology and distribution in humans is associated with the presence and distribution of the freshwater snail host [15]. For this reason xeno-surveillance (snail host monitoring/surveillance) and snail control is necessary in areas where *B. pfeifferi* snails host are present as their presence presents potential risk of transmission of schistosomiasis.

4.3 Snail Infection with *S. mansoni* Parasite

Biomphalaria pfeifferi snails in both Gwanje and MadaHills were shedding *S. mansoni* cercariae. Snail infection rates were higher in Gwanje than MadaHills. When people come in contact with *S. mansoni* cercariae, it could infect them by penetrating their skin. Therefore, high infection rates in snails are a critical indicator of transmission risk and could have dire implications for annual mass drug administration with praziquantel because in communities with high snail infection rates, reinfection could occur soon after praziquantel drug treatment; thereby making MDA a futile routine. High infection rate in snails as observed in this study is also indicative of poor hygiene practices of residents of both communities. Moser et al. [16] and

Table 1. *Schistosoma mansoni* infection rates in humans and in snails

Location	Infected humans		Infected snails	
	No examined	No Infected (%)	No Examined	No Infected (%)
Gwanje	200	43 (21.5)	501	70 (13.9)
MadaHills	200	28 (14)	125	12 (9.6)
Total	400	71 (17.8)	626	82 (13.1)

X^2 = 6.592, p<0.05, DF=1

Table 2. Seasonal abundance of *B. pfeifferi*

Location	Wet season		Dry season		Total	
	No coll	No inf (%)	No coll	No inf (%)	No coll	No inf (%)
Gwanje	46	3 (6.5)	455	68 (14.9)	501	71 (14.2)
Mada Hills	7	0 (0)	118	12 (10.2)	125	12 (9.6)
Total	53	3.3	573	12.3	626	83 (13.3)

P= 0.00, DF=2

Table 3. Infection rate of *B. pfeifferi* snails by collection location within freshwater body

Location	Gwanje		Mada hills		Total	
	No exam	No Inf (%)	No exam	No Inf (%)	No exam	No Inf (%)
Toilet	188	31 (16.5)	46	6 (13)	234	37 (15.8)
Across riverbank	62	5 (8.1)	22	1(4.5)	84	6 (7.1)
Drinking area	251	35 (13.9)	57	5 (8.8)	308	39 (12.7)
Total	501	71 (14.2)	125	12 (9.6)	626	82 (13.1)

p<0.05

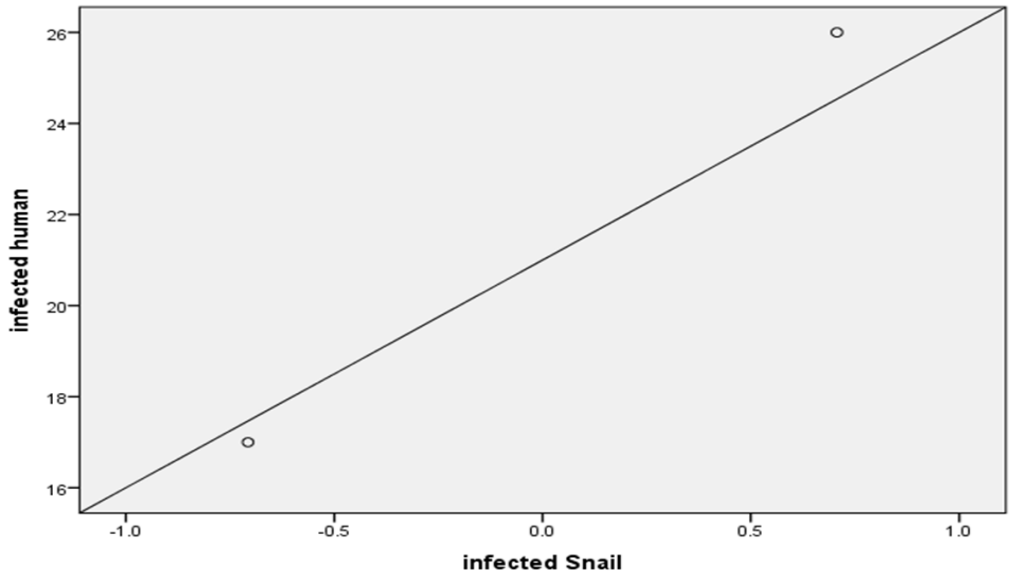
Abdulkadi et al. [12] both reported cercariae shedding in *B. pfeifferi* freshwater snails in Chad and Kaduna respectively. In contrast, Abe *et al*. (2016) reported zero cercaria shedding in *B. pfeifferi* snails in water bodies in Nasarawa. Opisa et al. [5] also reported very low cercaria shedding in areas of high schistosomiasis transmission and opined that cercarial shedding could grossly underestimate snail infection rates.

4.4 Seasonal Abundance of *B. pfeifferi* Snails

In both study areas, *B. pfeifferi* snails were more abundant in dry season and in rainy season the snail population declined significantly. This could be because in rivers, water currents are higher during rainy season than dry season. *Biomphalaria pfeifferi* snails anchor on algae mats, plant vegetation and rocks present in and around rivers and streams but may be washed off by high water velocities experienced in rainy season. Abe et al. (2016) and Okpala et al. [17] found similar findings of lower snail abundance during rainy season than dry season which the former attributed to heavy rain droplets washing off snails to bottom of streams/rivers and the later to warm temperature and nutrient availability prevalent in dry season. Abdulkadir et al. [12] on the other hand, reported no significant difference in *B. pfeifferi* abundance between rainy and dry seasons in Gimbawa Dam, Kaduna State.

4.5 Seasonality in *Biomphalaria pfeifferi* Infection Rates (Prevalence)

Biomphalaria pfeifferi snails had higher infection rates in dry season. *Schistosoma* parasite is a tropical parasite known to show periodicity. Both Gwanje and MadaHills communities rely on wells and streams/rivers for water, but wells dry up in the dry season causing people to visit streams/rivers more frequently. Increased human traffic in the river could be responsible for the increased snail infection rates. Snail control and praziquantel treatment efforts could therefore be carried out pre-dry season to make maximum impact as snail population and snail infection rates peak in dry season. Seasonality in snail infection rates was reported by Opara et al. (2010). Abulkadir et al. [12] however reported no significant difference in infection rates in rainy and dry season. Seasonality in human infection with the



$r^2 = 0.828$

Fig. 2. Correlation between *S. mansoni* infection rates in snails and *S. mansoni* infection rates in humans in Gwanje and MadaHills Nasarawa State

parasite was reported among rice farmers in Cote d'Ivoire by Gbalegba et al. [18]. In this case however, the rice farmers were more infected in rainy season than in dry season because they only spent more time in freshwater during rainy season when they cultivated their rice paddy.

4.6 Differences in Infection Rates in Snails by Collection Location

Our study revealed higher mean infection rates in snails in Gwanje than in MadaHills. We also found a positive correlation between infection rates in snails and the location from which they were collected within the water bodies. Snails collected closer to where residents of the area earmarked for defecation (toilet) had significantly higher infection rates than snails collected across river (shorelines), and snails collected in areas dammed by residents for fetching water for drinking and domestic use. However, snails from all three locations were infected even though the drinking water area was upstream from the toilet area. This goes to show that miracidia is capable of swimming upstream and that simple measures like "damming" portions of a water body for domestic use and for defecation, is grossly insufficient to protect from *S. mansoni* infections. There is therefore need for proper sanitation practices and health education of the residents of both Gwanje and MadaHills in order to control transmission in both communities. Opisa et al. [5] also reported significant difference in snail infection rates by location, with higher infection rates in snails collected from inland water bodies than in snails collected from lake shore sites in Western Kenya.

4.7 Correlation between Infection Rates in Snails and Infection Rates in Humans

We found a positive correlation between infection rate in snails and infection rate (prevalence) in humans in the two schistosomiasis endemic communities (Gwanje and MadaHills). The higher infection rates in snails in Gwanje correlated with higher infection rates in residents of Gwanje community and lower infection rates in snails in MadaHills correlated with lower infection rates in residents of MadaHills. Infected individuals visit and contaminate water bodies, high infection rates in snails maybe responsible for higher infection risk and rates in individuals in Gwanje community, and higher infection rates in people may be the reason for high infection rates in snails in Gwanje. This shows the importance of a combination of control measures like MDA to control the disease in humans, snail control and public health education on proper WASH practices in endemic communities. Bakuza et al. (2017) also reported positive correlation between infection rates in snails and infection rates in

humans in Gombe State, Nigeria, with corresponding high *S. mansoni* infection rates occurring in humans in areas where infection rates in snails were higher and low infection rates occurring in humans in places where zero infection rates were found in snails. In contrast, Opisa et al. [5] reported low infection rates in *B. pfeifferi* snails in areas where schistosomiasis was known to be endemic; which the author attributed to intermittent release of cercariae by snails which could have led to underestimation of snail infection rates.

5. CONCLUSION

Schistosoma mansoni is endemic in Gwanje and MadaHills Nasarawa State, and there is positive correlation between infection rates in snails and infection rates in humans. Reducing infection rates in snails may complement MDA with praziquantel aimed at reducing infection rates in humans. Health education on proper WASH practices may lead to reduced infection rates in snails and humans in endemic communities and could go a long way in improving the efficiency of praziquantel MDA in endemic communities thereby bridging an implementation gap.

CONSENT AND ETHICAL APPROVAL

Ethical clearance was obtained from ministry of health research ethics board. Informed consent and accent were obtained from parents, school authorities and research subjects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dawaki S, Al-Mekhlafi HM, Ithoi I, Ibrahim J, Abdulsalam AM, Ahmed A, Sady H, Atroosh WM, Al-Areeqi MA, Elyana FN, Nasr NA, Surin J. Prevalence and risk factors of schistosomiasis among Hausa communities in Kano State, Nigeria. Revista do Instituto de Medicina Tropical de Sao Paulo. 2016;58:54-62.
2. Colley DG, Bustinduy AL, Secor WE, King CH. Human Schitosomiasis. Lancet. 2014; 383(9936):2253-64.
3. Sow S, de Vlas S, Stelma F, Vereecken K, Gryseels B, Polman K. The contribution of water contact behavior to the high *schistosoma mansoni* infection rates observed in the Senegal River Basin. BMC Infectious Diseases. 2011;11:198-208.
4. Grimes JE, Croll D, Harrison WE, Utzinger J, Freeman MC, Templeton MR. The roles of water, sanitation and hygiene in reducing Schistosomiasis: A review. Parasites and Vectors. 2015;8(1):156
5. Opisa S, Odiere MR, Jura WG, Karanja DS, Mwinzi PN. Malacological survey and geographical distribution of vector snails for schistosomiasis within informal settlements of Kisumu City, Western Kenya. Parasites and Vectors. 2011;4:22-6.
6. Abe EM, Ombugadu A, Oluwole AS, Njila HL, Mogaji HO, Adeniran AA, Guo YH, Li SZ, Zhou N, Ekpo UF. Population abundance and bionomics of snail intermediate hosts of trematode parasites in Nasarawa State, Nigeria. Research Journal of Parasitology. 2017;12(1):8-18.
7. Obisike VU, Ikpa TF, Imandeh GN, Amuta EU. Distribution of freshwater snail intermediate host of trematodes parasites in some freshwater bodies in Makurdi, Nigeria. Nigerian Journal of Parasitology. 2018;39(2):1-4.
8. Sumuduni BG, Munasinghe DH, Arulkanthan A. Chronological analysis of the damages caused by the metacercariae of *Centocestus formosanus* in the gills of *Cyprinus carpio* and lesions caused by the adult flukes *in Ardeola ralloides*: An experimental study. International Journal of Veterinary Science and Medicine. 2018; 122(2):675-86.
9. Pam DD, Pam VA, Nuhu EI. Prevalence of *Schistosoma mansoni* infection among primary school pupils in Keffi Town, Keffi Local Government Area, Nasarawa State, Nigeria. Nigerian Journal of Parasitology. 2016;37(2):15-20
10. Okwori AE, Sidi M, Ngwai YB, Obiekezie SO, Makut MD, Chollom SC, Okeke IO, Adikwu TI. Prevalence of schistosomiasis among school children in Gadabuke District, Toto LGA, North Central Nigeria. British Microbiology Research Journal. 2014;4(3):255-61.
11. Spencer SA, Penney JM, Russell HJ, Howe AP, Linder C, Rakotomampianina A. L, Nandimbiniaina AM, Squire SB, Stothard JR, Bustinduy AL, Rahetilahy AM. High burden of Schistosoma mansoni infection in school-aged children in

Marolambo District, Madagascar. Parasites and Vectors. 2017;10:307-16.
12. Abdulkadir FM, Maikaje DB, Umar YA. Ecology and distribution of freshwater snails in Gimbawa Dam, Kaduna State, Nigeria. Nigerian Journal of Chemical Research. 2017;22(2):98-106.
13. Falade MO, Otarigho B. Shell morphology of three medical important tropical freshwater pulmonate snails from five sites in South-Western Nigeria. International Journal of Zoological Research. 2015; 11(4):140-50
14. Okeke, O. C. and Ubachukwu, P. O. (2017). Trematode infections of the freshwater snail *Biomphalaria pfeifferi* from a south-east Nigerian community with emphasis on cercariae of *Schistosoma*. Journal of Helminthology 91(3): 295-301
15. Gordy MA, Kish L, Tarrabain M, Hanington PC. A comprehensive survey of larval digenean trematodes and their snail hosts in central Alberta, Canada. Parasitology Research. 2016;115(10): 3867-80.
16. Moser W, Greter CS, Allan F, Ngandolo BN, Moto DD, Utzinger J, Zinsstag J. The soatial and seasonal distribution of Bulinus truncates, Bulinus forskalil, and Biomphalaria pfeifferi, the intermediate host snails of Schistosomiasis, in N'Djamena Chad. Geospatial health. 2014: 101-18.
17. Okpala HO, Agba MI, Chimezie OR, Nwobu GO, Ohihoin AA. A survey of the prevalence of schistosomiassis among Pupils in Apata and Laranto Areas in Jos, Plateau State. Journal of Health and Applied Science. 2010;1:1-4.
18. Gbalegba NG, Silue KD, Ba O, Ba H, Tian-Bi NT, Yapi GY, Kaba A, Kone B, Utzinger J, Koudou BG. Prevalence and seasonal transmission of *Schistosoma haematobium* infection among school-aged children in Kaedi town Southern Mauritania. Parasites and Vectors 2017;10:353-65.

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