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Infectivity Status and Transmission Potential of Freshwater Snails at Lake Njoboliyo, Adamawa State, Nigeria

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Abstract

A study was conducted to assess the infectivity and transmission potential of freshwater snail intermediate hosts at Lake Njoboliyo, Adamawa State, Nigeria. Snail samples were collected monthly from November 2023 to March 2024 using a scoop net with a 2 cm mesh size, supplemented by handpicking. In total, 1,602 freshwater snails were collected and identified to species level based on their morphological characteristics using standard identification keys. The snail species observed were: Melanoides tuberculata (490, 30.6%), Bellamya unicolor (387, 24.2%), Pila ovata (328, 20.5%), Lanistes ovum (288, 17.9%), Lymnaea natalensis (74, 4.6%), Bulinus globosus (19, 1.2%), Cleopatra bulimoides (10, 0.6%), and Bulinus truncatus (6, 0.4%). The snails were screened for natural infections by exposing them individually to sunlight for two hours in pre-labeled shedding vials containing 10 mL of filtered water from their collection site. The results showed that Lanistes ovum and Pila ovata were the only snail species naturally infected, though, of non-human schistosomes. No cercariae were shed by Bulinus globosus, B. truncatus, Lymnaea natalensis, or other species. There was no significant difference in infection rates between the infected snails (p > 0.05). The overall infection rate at Lake Njoboliyo was 2.75%, with Lanistes ovum and Pila ovata showing infection rates of 10.70% and 3.96%, respectively. The highest infection rate was observed in December, at 3.87%, coinciding with the highest transmission potential of 32.91%. No significant difference in infection rates was found across the sampling months (p > 0.05). However, Bulinus species showed 0.00% infection and transmission potential, as did other snail species. These findings highlight the importance of implementing targeted interventions during specific months to control snail-borne diseases at Lake Njoboliyo. An effective snail control program and public awareness efforts about the role of snails in disease transmission are strongly recommended.

Keywords: Adamawa State, Freshwater, Snail intermediate host, infection rate, Lake Njoboliyo.

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INTRODUCTION

Schistosomiasis, also known as bilharzia, snail fever, or katayama fever, is a neglected tropical disease primarily transmitted by freshwater snails (CDC, 2013; Usman *et al*., 2017). It is particularly prevalent and severe in Africa, especially in sub-Saharan Africa, due to favorable climatic conditions and socio-economic factors in the region (Tamirat *et al*., 2022). The disease affects nearly 210 million people globally, with annual deaths estimated between 12,000 and 200,000 (Lozano *et al*., 2012; Thetiot-Laurent *et al*., 2013; Fenwick, 2012). Schistosomiasis is caused by blood fluke parasites of the *Schistosoma* genus, including *S. haematobium*, *S. mansoni*, and *S. intercalatum*, which are the primary species infecting humans in Nigeria (Dida *et al*., 2014; Singh *et al*., 2016). Prevalence rates for the disease range from 14.2% to 91.4% in different regions (Nagi *et al*., 2014; Singh *et al*., 2016; Abdulkadir *et al*., 2017).

The disease manifests with symptoms such as bloody urine, bladder lesions, kidney failure, bladder cancer, splenomegaly, persistent diarrhea, pain, stunted growth, delayed sexual maturity, and chronic dermatitis (Norberg, 2004). Schistosomiasis has severe consequences for school-aged children, as it often prevents them from attending school, hindering their academic progress and future opportunities. There are two main types of schistosomiasis: urogenital schistosomiasis, caused by *S. haematobium*, and intestinal schistosomiasis, caused by *S. mansoni* and *S. japonicum* (Colley *et al*., 2014).

Various species of freshwater snails act as intermediate hosts for the *Schistosoma* larvae (cercariae), which are responsible for transmitting disease (Devkota *et al*., 2011). In most cases, the cercaria is the infective form, though in some species, it is the metacercaria (Otubanjo, 2013). Freshwater snails belong to the class *Gastropoda*, including the subclasses Prosobranchia, Opisthobranchia, and Pulmonata (Strong *et al*., 2007). These snails play an important ecological role in many ecosystems and are part of the food chain (Dogara *et al*., 2022). Approximately 5,000 species of snails exist worldwide (Soldánová *et al*., 2013), many of which are associated with water bodies and play a significant role in public health (Ntonifor and Ajayi, 2007; Dida *et al*., 2014; Dogara *et al*., 2022). The presence of certain snail species in an area can indicate the risk of specific trematode infections (Choubissa, 2010). Some countries monitor freshwater snail species to predict the spread of trematodiasis and implement preventive measures accordingly (Choubissa, 2008). The prevalence and severity of trematode infections depend on the number of snails in the environment and how many are infected (Fatima *et al*., 2018).

In Chitwan district, central Nepal, a total of 1,448 individuals of nine freshwater snail species where screened for shedding cercariae. A total of 4.3% where found infected with trematode cercariae (Ramesh *et al*., 2011). A total of 23,823 freshwater snails were collected from six freshwater bodies including Bagoma dam, Gimbawa dam, Kangimi dam, Kubacha dam, Manchok water intake and Saminaka water intake in Kaduna State. Out of the total freshwater snails collected, 10.55% released one or more types of cercariae (Fatima *et al*., 2018). In another study to determine the diversity of fresh water snail fauna in Kiri dam, Adamawa State, North Eastern Nigeria, a total of 6,720 freshwater snails were collected of which 12.0% out of the 11 snail species encountered were found to harbours trematode cercariae (Sanu *et al*., 2020).
Currently, there is limited information on the infectivity status and cercarial transmission potential of freshwater snails at Lake Njoboliyo, Adamawa State, Nigeria. This study aims to gather such data to guide any future interventions that may be needed.

MATERIALS AND METHODS

Description of Study Area

Njoboliyo Lake lies within the Latitude 9.12 to 16.51^{o}N and Longitude 12.28 to 12.43^{o}E on the Eastern part of Yola South L. G. A. The major ethnic groups of this area are Bwatiye, Fulbe, Mbula and few migrant fishers that comprises of Hausa and Jukun/Agatu. Some of those migrant fishers have over the years become indigene to those areas (Ladu and Neiland, 1997). Lake Njoboliyo is a wet flooded plain found adjacent River Benue having its course from River Nafari and Chigari as inlets and empties into the River Benue. The lake is perennial. The characteristic formation of the lake is due to the fact that as river Benue, Chigari and Nafari take their courses from the Mandara highlands on entering Nigeria they meet a flat plain basin, which at peak rainfall from July to September they meanders along their ways with continues deposition of alluvial's and sands, leading to formation of many oxbow lakes within the geographical location of the Benue (Amos and Linus, 2017).

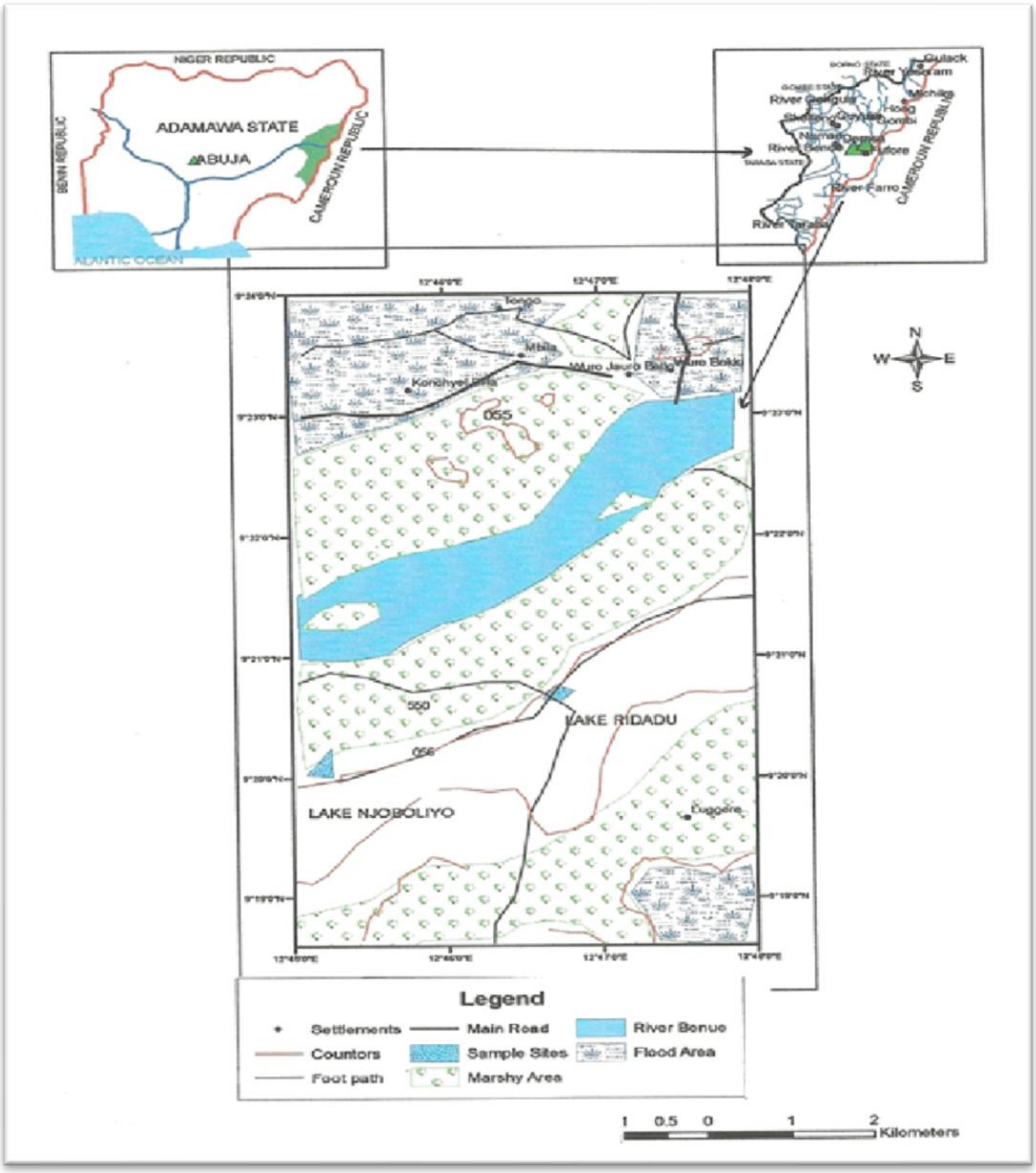

Figure1: Map of Adamawa State, showing Lake Njoboliyo
(Adopted from Amos and Linus, 2017).

Snail sampling and identification

Snail sampling was conducted using the scoop net and hand picking technique while wearing hand gloves as described by Ikpeze and Obikwelu (2016), in the morning hours between 8am-10am. This was done monthly from November, 2023 to March, 2024, where snails collected were kept in a labelled wide mouth plastic container with perforated lid and half-filled with water and aquatic vegetation from the same sampling area. They were transported to the laboratory of the Department of Zoology, Modibbo Adama University, Yola for sorting, counting, identification and possible natural infection.

Snail identification

The snails captured were identified based on their morphological characteristics such as shell shape, shell size, position of aperture, number of whorls, color and banding pattern of the shell with reference to standard identification keys of Brown (1994). Afterwards, the identified snails were captured using an Android phone's camera and were kept at dark for 48 hours after which, they were used for cercariae shedding experiment.

Infectivity Status

The infectivity status was determined as described by Fatima *et al*. (2018). This was done by placing individual snail collected into a pre-labelled shedding vial that contained 10 ml of filtered water from the site of collection. The shedding vials containing the snails were exposed to sunlight for 2 hours between 10.00am and 12.00 noon, after which, snails were removed using forcep and the water in each shedding vial was carefully examined for the presence of cercariae using a dissecting microscope. When at least one type of cercaria is seen, the snail was considered to be infected. The numbers of cercariae emerged from each snail species were recorded.

Determination of Infectivity rate and Cercarial Transmission Potential

Habitat infectivity (HI), monthly infectivity (MIR) and monthly cercarial transmission potential (MCTP) of each snail species as developed by Chu and Dawood (1970), Okafor (1990) and Rudge *et al*. (2013), were adopted with little modification as shown below:

(a) Habitat Infectivity = $\frac{\text{Number of snails infected in the habitat}}{\text{Number of snails collected from that habitat}} \times \frac{100}{1}$

(b) Snail Infectivity = $\frac{\text{Number of snail species infected in the habitat}}{\text{Number of snail species collected from that habitat}} \times \frac{100}{1}$

(c) Monthly Infectivity = $\frac{\text{Number of snails infected for each month}}{\text{Number of snails collected in that month}} \times \frac{100}{1}$

(d) MCTP = $\frac{\text{Monthly Number of infected snails in each group}}{\text{Sum of infected snails in that group}} \times \frac{100}{1}$

Statistical Analysis

The data collected were analyzed using Statistical Package for Social Sciences (SPSS) software, Version 26.0. Also, a test of significance was carried out using chi-square (χ^2). A value of $P < 0.05$ was regarded as significant. Tables were equally used to elucidate data.

RESULTS AND DISCUSSION

Results

The results regarding the infectivity status and infection rate of snail species at Lake Njoboliyo are summarized in Table 1. The study identified a total of 1,602 snails, with the following species and their respective proportions: *Melanoides tuberculata* (490 snails, 30.6%), *Bellamya* *unicolor* (387 snails, 24.2%), *Pila ovata* (328 snails, 20.5%), *Lanistes ovum* (288 snails, 17.9%), *Lymnaea natalensis* (74 snails, 4.6%), *Bulinus globosus* (19 snails, 1.2%), *Cleopatra bulimoides* (10 snails, 0.6%), and *B. truncatus* (6 snails, 0.4%). Of these snails, only 44 (2.7%) were found to be infected with cercariae, including *Lanistes ovum* (31 snails, 10.7%) and *Pila ovata* (13 snails, 3.98%), though the infections were of non-human schistosome species. Snail species such as *Bulinus* sp., *Lymnaea natalensis*, and others were not infected. There was no statistically significant difference in infection rates between the different snail species (p>0.05).

Table 2 presents the monthly infectivity status of the snails at Lake Njoboliyo, showing variation in infection rates throughout the months. December had the highest infection rate at 3.87%, while March had the lowest at 2.20%. In November 2023, 7 out of 304 snails (2.30%) were infected, while in December 2023, 13 out of 336 snails (3.87%) were found to shed cercariae. In January, February, and March 2024, infection rates were 3.27% (13 out of 398 snails), 1.72% (5 out of 291 snails), and 2.20% (6 out of 273 snails), respectively. Among the infected snails, *Lanistes ovum* and *Pila ovata* had peak infection rates of 62.50% and 18.18%, respectively, in March and February. The infection rates across different months were not statistically significant (p>0.05). Table 3 illustrates the monthly transmission potential (M.T.P) of cercariae from various snail species at Lake Njoboliyo. The results revealed fluctuations in transmission potential over the months, with December showing the highest M.T.P at 29.55%. This was followed by a slight decrease in January (27.27%), while February and March remained stable at 13.64%. November, however, saw a small increase to 15.91%. *Lanistes ovum* had the highest transmission potential in December and January, both at 32.26%, while *Pila ovata* peaked in November with an M.T.P of 30.77% (Table 3). Statistical analysis showed no significant differences in transmission potential across the months (p>0.05).

Table 1: Infectivity status and infection rate of Snail species at Lake Njoboliyo Adamawa State, Nigeria (November 2023 to March 2024)

Snails	Number of Snails Examined (%)	Number of Snails Infected	Infection Rate (%)
Bulinus globosus	19 (1.2)	0	0
B. truncatus	6 (0.4)	0	0
Bellamya unicolour	387 (24.2)	0	0
Cleopatra bulimoides	10 (0.6)	0	0
Lymnaea natalenses	74 (4.6)	0	0
Lanistes ovum	288 (17.9)	31	10.7
Melanoides tuberculata	490 (30.6)	0	0
Pila ovata	328 (20.5)	13	3.96
Total	**1,602 (100)**	**44**	**2.75**

X^2 =14.97; df= 11, p>0.05

Table 2: Monthly Infectivity status of Snail species at Lake Njoboliyo Adamawa State, Nigeria (November 2023 to March 2024).

Months	Snail species								
	Bulinus globosus	*Bulinus truncatus*	*Bellamya unicolor*	*Cleopatra bulimoides*	*Lymnaea natalenses*	*Lanistes ovum*	*Melanoides tuberculata*	*Pila Ovata*	Total
	NE NI(%)	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**	**NE NI(%)**
November, 2023	0 0(0)	0 0(0)	7 0(0)	0 0(0)	0 0(0)	36 3(8.33)	55 0(0)	206 4(1.94)	304 7(2.30)
December	0 0(0)	0 0(0)	16 0(0)	1 0(0)	0 0(0)	128 10(7.81)	120 0(0)	71 3(4.23)	336 13(3.87)
January, 2024	2 0(0)	1 0(0)	82 0(0)	1 0(0)	0 0(0)	110 10(9.09)	170 0(0)	32 3(9.38)	398 13(3.27)
February	7 0(0)	1 0(0)	155 0(0)	2 0(0)	22 0(0)	6 3(50.00)	87 0(0)	11 2(18.18)	291 5(1.72)
March	10 0(0)	4 0(0)	127 0(0)	6 0(0)	52 0(0)	8 5(62.50)	58 0(0)	8 1(12.50)	273 6(2.20)
Total	**19 0(0)**	**6 0(0)**	**387 0(0)**	**10 0(0)**	**74 0(0)**	**288 31(10.76)**	**490 0(0)**	**328 13(3.96)**	**1602 44(2.75)**

$X^2 = 6.838$, df = 4, p = 0.145
NB: NE = Number Examined; NI = Number infected

Figure 2: Cercaria of the infected snails (*Pila ovata* and *Lanistes ovum)* as observed under a dissecting microscope (Source: Field work, 2024)

Table 3: Monthly Cercarial Transmission Potentials of Snail species at Lake Njoboliyo Adamawa State, Nigeria (November 2023 to March 2024).

Months	Snail species								
	Bulinus globosus	*Bulinus truncatus*	*Bellamya unicolor*	*Cleopatra bulimoides*	*Lymnaea natalenses*	*Lanistes ovum*	*Melanoides tuberculata*	*Pila ovata*	Total
	NI MTP(%)	NI MTP(%)	NI MTP(%)	NI MTP(%)	NI MTP(%)	NI MTP(%)	NI MTP(%)	NI MTP (%)	NI MTP (%)
November, 2023	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	3 9.68	0 0.00	4 30.77	7 15.91
December	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	10 32.26	0 0.00	3 23.08	13 29.55
January, 2024	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	10 32.26	0 0.00	1 23.08	12 27.27
February	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	3 9.68	0 0.00	2 15.38	6 13.64
March	0 0.00	0 0.00	0 0.00	0 0.00	0 0.00	5 16.13	0 0.00	1 7.69	6 13.64
Total	**0**	**0**	**0**	**0**	**0**	**31**	**0**	**13**	**44**

$\chi 2 = 15.973$; df = 4; p = 0.065
NB: NI = Number Infected, MTP (%) = Monthly Transmission Potential in Percentage

DISCUSSION

The overall infection rate of 2.75% observed at Lake Njoboliyo is lower than the 7.33% reported by Tigga *et al*. (2014) at Ranchi Lake. This difference may be attributed to variations in environmental conditions (Ayanda, 2009), such as favorable climatic factors and the timing of snail collection. Notably, of the eight snail species found in the study area, only two: *Lanistes ovum* and *Pila ovata* shed cercariae, although these species do not transmit human schistosome. Despite this, there was no significant difference in infection rates between the infected snails ($p>0.05$). Additionally, snails known to serve as intermediate hosts for schistosome and *Fasciola* species, such as *Bulinus* spp. and *Lymnaea natalensis*, did not shed cercariae, likely because only juvenile snails of these species were observed during the study period. The absence of cercaria shedding in these snails may be due to the fact that cercariae may have preferred and thrived more in larger snails, where the miracidium can more effectively penetrate, and where the processes of encystation, sporocyst formation, and cercarial release are more efficient. This finding supports Ubaka's (2019) report that snail size influences parasite infection. However, the presence of non-infected *Bulinus* and *Lymnaea* species suggests that both schistosomiasis and fascioliasis transmission may still occur in the area, as human and livestock activities around the lake such as defecation, swimming, fishing, and grazing were observed, and these activities contribute to the risk of infection.

The higher infection rate of 3.87% in December suggests that the community is heavily reliant on lake water for domestic use, particularly when stored rainwater run out during the dry season. Many people who cannot afford to buy water resort to using lake water for drinking and other activities. This increases human contact with the water, leading to poor environmental sanitation and facilitating snail infection. The infection rate of 3.87% in December is similar to the 3.9% observed by Usman *et al*. (2017) in Bauchi State, Nigeria, during the same month. Despite fluctuations in infection rates, there were no significant differences across the sampling months ($p>0.05$).

The highest Monthly Transmission Potential (M.T.P) of 29.55% in December aligns with the findings of Ito *et al*. (2024), who observed higher transmission potential during the dry season, when increased temperatures enhance snail metabolic activity, fecundity, and feeding, thereby boosting the number of snail generations per year (Kristensen *et al*., 2001; De La Rocque *et al*., 2008). However, Ubaka (2019) suggested that cercarial transmission dynamics may be influenced by the infection rates of snails in specific habitats, which in turn affects the epidemiology of schistosomiasis in a given region. Thus, the highest infection rates and M.T.P observed in this study, particularly in December, highlight the importance of targeted interventions during specific months to control the disease.

CONCLUSION

This study found that freshwater snails in Lake Njoboliyo were naturally infected with cercariae. To the best of our knowledge, this is the first attempt to document the infectivity status of freshwater snail fauna at the Lake. *Pila ovata* and *Lanistes ovum* were the only species of snails shedding cercariae, but these were of non-human schistosomes. In contrast, *Bulinus* species and *Lymnaea natalenses* were not naturally infected, as only juvenile snails were collected from the lake. The highest infectivity rate and transmission potential occurred in December. The presence of *Bulinus* spp. and *Lymnaea natalenses* suggests a possible future occurrence of trematodiasis in the community. Therefore, it is crucial to ensure safe water supplies for drinking and domestic use in the community and surrounding areas. Additionally, raising health awareness about the risks of frequent water contact should be prioritized at the community level. Lastly, biological and integrated control methods should be adopted to complement ongoing schistosomiasis prevention and control efforts.

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REFERENCES

Abdulkadir, F. M., Maikaje, D. B. and Umar, Y. A. (2017). Ecology and Distribution of Freshwater Snails in Gimbawa Dam, Kaduna State, Nigeria. *Nigerian Journal of Chemical Research*, 22(2): 98-106.

Amos, S.O. and Linus, B.G. (2017). Fish Biodiversity and Fishing Activities at Njoboliyo Lake, Adamawa State, Nigeria. *Journal of Fisheries and Livestock Production*, 5(2):1-6. DOI:10.4172/2332-2608.1000226.

Ayanda, O.I. (2009). Prevalence of snail vector of schistosomiasis and their infection rates in two localities within A.B.U Campus Zaria, Kaduna State, Nigeria. *Journal of Cell and Animal Bio,* 3(4): 58–61.

Brown, D.S. (1994). Freshwater Snails of Africa and their Medical Importance, eBook, CRC Press, London, Pp. 43-257.

Centers for Disease Control and Prevention (2013). Laboratory Identification of Parasitic Disease of Public Health Concern. *CDC INF* (800). Pp. 232-4636.

Choubissa, S. L. (2008). Focus on Pathogenic Trematode cercariae infecting freshwater snails (Mollusca: Gastropoda) on tribal region of Southern Rajasthan (India). *Journal of Parasites diseases*, 32(1):47-55.

Choubissa, S. L. (2010). Snails as Bioindicators for dreaded Trematodiasis disease. *Journal of communicable Disease*, 42(3): 223-226.

Chu, K.Y. and Dawood, I.K. (1970). Cercarial Transmission Seasons of *Schistosoma mansoni* in the Nile Delta Area. *Bulletin of World Health Organisation*, 42(4): 575-580.

Colley, D. G., Bustinduy, A. L., Secor, W. E., and King, C. H. (2014). Human schistosomiasis. *The Lancet*, 383, 9936, 2253-2264.

De La Rocque, S., Rioux, J. A. and Slingenbergh, J. (2008). Climate change: effects on animal disease systems and implications for surveillance and control. *Revue Scientifique et Technique*, 27(2): 339–354. DOI: 10.20506/rst.27.2.1807

Devkota, R., Budha, P. B. and Gupta, R. (2011). Trematode cercariae infections in freshwater snails of Chitwan district, Central Nepal. *Himalayan Journal of Science*, 7(9):9-14 DOI:10.3126/hjs.v7i9.2183

Dida, G.O., Gelder, F.B., Anyona, D.N., Matano, A-S., Abuom, P.O., Adoka, S.O., *et al*. (2014). Distribution and abundance of schistosomiasis and fascioliasis host snails along the Mara River in Kenya and Tanzania. *Infection Ecology and Epidemiology*, 4(1): 24281 DOI: 10.3402/iee.v4.24281

Dogara, M.M., Goni, K. A., Joshua, B. B., Muhammad, M. A., Auwal, A. B., Abubakar, R. S. *et al*. (2022). Distribution and Abundance of Freshwater Snails in Warwade Dam, Dutse, Northern Nigeria. *Dutse Journal of Pure and Applied Sciences (DUJOPAS)*, 8 (1b): 69-81 DOI: 10.4314/dujopas.v8i1b.9

Ito, E.E., Eze, C.N. and Nduka, F.O. (2024). Spatiotemporal and seasonal transmission dynamics of Schistosoma haematobium and snail infectivity in Ase River catchment, Delta State, Nigeria. *J Parasit Dis*., 48(2):235-246. DOI: 10.1007/s12639-024-01656-4

Fatima, M. A., Maikaje, D.B. and Umar, Y.A. (2018). Cercarial Diversity in Freshwater Snails from Selected Freshwater Bodies and Its Implication for Veterinary and Public Health in Kaduna State, Nigeria. *International Journal of Animal and Veterinary Sciences*, 12 (2): 52-58. DOI: 10.5281/zenodo.1315823

Fenwick, A. (2012). The Global Burden of Neglected Tropical Diseases. *Public health*, 126 (3): 233–6. DOI: 10.1016/j.puhe.2011.11.015

Ikpeze, O.O. and Obikwelu, M.E. (2016). Factors affecting seasonal abundance of gastropod of public health importance found at Agulu Lake shorelines in Nigeria. *Int J. Pure Appl Biosci*., 4(2):91-102. DOI: 10.18782/2320-7051.2264

Kristensen, T.K., Malone, J.B. and McCarroll, J.C. (2001). Use of satellite remote sensing and geographic information systems to model the distribution and abundance of snail intermediate hosts in Africa: A preliminary model for Biomphalaria pfeifferi in Ethiopia. *Acta. Tropica*, 79(1): 73–78. DOI:10.1016/S0001-706X(01)00104-8

Ladu, B.M.B. and Neiland, A. (1997). A review of fisheries policy in Nigeria since 1950 (With Special reference to inland fisheries of North Eastern Nigeria). Center for Economics and Management of Aquatic Resources. *Discussion Papers*, 126: 34.

Lozano, R., Naghavi. M., Foreman, K., Lim, S., Shibuya, K., Aboyans, V., Abraham, J. and Adair, T. (2012)."Global and Regional Mortality from 235 Causes of Death for 20 Age Groups in 1990 and 2010: A Systematic Analysis for the Global Burden of Disease Study 2010". *Lancet*, 380. (9859): 2095–128. DOI: 10.1016/S0140-6736(12)61728-0.

Nagi, S., Chadeka, E.A., Sunahara, T., Mutungi, F., Justin, Y.K.D., Kaneko, S. *et al*. (2014). Risk factors and spatial distribution of *Schistosoma mansoni* infection among primary school children in Mbita District, Western Kenya. *PLoS Neglected Tropical Diseases*, 8(7):1-10. DOI: 10.1371/journal.pntd.0002991

Norberg, E. (2004). Communicable Diseases, Third Edition, A Manual for Health Workers in Sub-Saharan Africa. Africa Medical and Research Foundation, Nairobi, Kenya, Pp. 130–136.

Ntonifor, H. and Ajayi, J. (2007). Studies on the ecology and distribution of some medically important freshwater snail species in Bauchi State, Nigeria. *International Journal of Biological and Chemical Sciences*, 1(2):121-127. DOI:10.4314/ijbcs.v1i2.39681

Okafor, F.C. (1990). *Schistosoma haematobium* Cercariae Transmission Patterns in Freshwater Systems of Anambra State, Nigeria. *Angewandte Parasitologie*, 31: 159 – 166.

Otubanjo, O. (2013). Parasites of Man and Animals. Concepts publications Lagos, Nigeria. Pp. 252 – 344.

Ramesh, D., Prem, B.B. and Ranjana, G. (2011). Trematode cercariae infections in freshwater snails of Chitwan district, central Nepal. *Himalayan Journal of Sciences*, 7(9): 1-14. DOI: https://doi.org/10.3126/hjs.v7i9.2183

Rudge, J.W., Webster, J.P. and Lu, D.B. (2013). Identifying Host Species Driving Transmission of Schistosomiasis Japonica; a Multi Host Parasite System, in China. Proceedings of the National Academy of Science of the United States of America, 110: 114-117.

Sanu, K. M., Istifanus, W. A., Musa, M. S. and Mao, P. S. (2020). The diversity of fresh water snail fauna in Kiri dam, Adamawa State, North Eastern Nigeria. *GSC Biological and Pharmaceutical Sciences,* 11(02): 099–104. DOI: 10.30574/gscbps.2020.11.2.0118

Singh, K., Muddasiru, D. and Singh, J. (2016). Current status of schistosomiasis in Sokoto, Nigeria. *Parasite Epidemiology and Control*, 1(3): 239-44. DOI: 10.1016/j.parepi.2016.08.003

Soldánová, M., Selbach, C., Kalbe, M., Kostadinova, A. and Sures, B. (2013). Swimmer's itch: etiology, impact, and risk factors in Europe. *Trends in parasitology*, 29(2):65-74. DOI: 10.1016/j.pt.2012.12.002

Strong, E.E., Gargominy, O. Ponder, W.F. and Bouchet, P. (2008). Global diversity of gastropods (Gastropoda; Mollusca) in freshwater. *Hydrobiologia*, 595(1): 149-166. DOI: 10.1007/s10750-007-9012-6

Tamirat, H., Endalkachew, N. and Abaineh, M. (2022). Distribution and seasonal abundance of *Biomphalaria* snails and their infection status with *Schistosoma mansoni* in and around

Lake Tana, northwest Ethiopia. *Scientific Reports*, 12: 1-12. DOI: 10.1038/s41598-022-21306-0

Thétiot-Laurent, S.A., Boissier, J., Robert, A. and Meunier, B. (2013). "Schistosomiasis Chemotherapy". Angewandte Chemie (International ed. in English) 52 (31): 7936–56.

Tigga, M.N., Bauri, R.K., Deb, A.R. and Kull, S.S. (2014). Prevalence of Snails Intermediate Hosts Infected with Different Trematodes Cercariae in and Around Ranchi. *Veterinary World Journal*, 7(8): 630 – 634. DOI: 10.14202/vetworld.2014.630-634

Ubaka, U.A. (2019). Snail fauna and Schistosoma haematobium transmission patterns in freshwater systems of Ishielu local government area, Ebonyi State. M.Sc Thesis, Nnamdi Azikiwe University, Awka, Pp. 1-127.

Usman, A.M., Babeker, E.A. and Malann, Y.D. (2017). Effects of some Physico-chemical parameters on prevalence of intermediate host of animal trematodes in Bauchi State, Nigeria. *Science World Journal*, 12(4): 94-97.