PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 28 (10) 3027-3034 October, 2024

Composition and Distribution of Snail Fauna in Water Bodies around Irrigation Schemes of Benue River Valley, Yola Area, Adamawa State, Nigeria

[1*]DANIEL, JL; [2]CHESSED, G; [2]VANDI, P; [2]AUGUSTINE, LM

[1]Department of Science Laboratory Technology, Gombe State Polytechnic, P.M.B. 0190, Bajoga, Gombe State, Nigeria
[2]Department of Zoology, School of Life Sciences, Modibbo Adama University of Technology, P.M.B. 2076, Yola, Nigeria.

**Corresponding Author Email: joicedaniellawiye@gspb.edu.ng*
**ORCID: https://orcid.org/0009-0002-1644-1248*
**Tel: +2348132200198*

Co-Authors Email: godlychessed@mau.edu.ng; vandiphilips@mau.edu.ng; lindaaugustine43@gmail.com

ABSTRACT: Freshwater snails that act as intermediate host and some abiotic environmental factors plays a prominent roles in these infections. The objective of this paper as to assess the composition and distribution of the snail fauna in water bodies around irrigation schemes in the Benue River Valley, Yola area of Adamawa state, Nigeria using appropriate techniques. Data obtained reveals that the distribution of freshwater snails species, showed that a total of 1,620 snails were sampled, Njoboliyo had the highest number of snails with 373, followed by Lake Geriyo with 287, Dasin Hausa with 266, Rugange with 255, Dasin Bwattiye with 235, while Boronji had the least with 204 freshwater snails. The species include *B. globosus, P. ovata, B. truncatus* and *B. reticulatus.* The diversity index showed that *H* fell below the 1.5-3.5 range while the Evenness *E* showed a potential evenness between freshwater snail species in all sites of the communities with no exception

DOI: https://dx.doi.org/10.4314/jasem.v28i10.10

Cite this Article as: DANIEL, J. L; CHESSED, G; VANDI, P; AUGUSTINE, L. M. (2024). Composition And Distribution of Snail Fauna in Water Bodies around Irrigation Schemes of Benue River Valley, Yola Area, Adamawa State, Nigeria. *J. Appl. Sci. Environ. Manage.* 28 (10) 3027-3034

Dates: Received: 30 July 2024; Revised: 29 August 2024; Accepted: 21 September 2024 Published: 05 October 2024

Keyword: Freshwater snails; Intermediate host; Irrigation; *Bulinus globosus*; *Bulinus truncates*

Molluscs are known to be extremely important organisms of diverse ecological communities (Sharma *et al*., 2014) and they play beneficial roles both economically and medically (Wosu, 2003). Different genera of these planorbid snails have been associated with some specific parasites. For example *Bulinus* species is responsible for hosting the *Schistosoma haematobium* parasite. While, *Biomphalaria,* and *Oncomelania* species are responsible for hosting *S. mansoni* and *S. japonicum*, respectively (Ayanda, 2009). Members of these families of snails are necessary intermediate hosts of blood-dwelling trematode parasites that causes serious public health challenges to man and animals in the tropical and subtropical regions of the world (Ayanda, 2009). Freshwater snails are considered important as intermediate host for trematode parasites of man and domestic animals (Taofiq *et al.*, 2017). There are species of snail that act as an intermediate host for fluke, and are thus of veterinary importance. These snails can serve as first or sole intermediate hosts in the transmission of helminth parasites infecting human and domestic animals. Helminths typically parasitize vertebrates, although invertebrates, especially arthropods and mollusca, act as intermediate hosts. Freshwater snails of the genus *Biomphalaria, Bulinus* and *Lymnaea* are common species of the subfamily Planorbidae and Lymnaeidae, respectively, and are widely distributed throughout the sub-saharan Africa (World Health Organization [WHO], 2010). The species

**Corresponding Author Email: joicedaniellawiye@gspb.edu.ng*
**ORCID: https://orcid.org/0009-0002-1644-1248*
**Tel: +2348132200198*

Biomphalaria pfeifferi and *Bulinus globosus* are known to serve as an intermediate host of *Schistosoma* parasites causing human schistosomiasis (Dida *et al.*, 2014). Other species, like the genus *Lymnaea* (*Lymnae anatalensis*) transmits *fasciola* parasites to animals and man causing fascioliasis (Dida *et al.*, 2014), all these species inhabit various natural and artificial freshwater environments like, shallow lakes, streams, rivers, wetlands, seasonal pools, rice paddies, irrigation canals, and ponds (Utzinger and Tanner, 2000). Several epidemiological studies have been carried on the types and prevalence of schistosomes and fasciola among freshwater snail intermediate hosts in Africa (Siama *et al.*, 2023). Hence, the objective of this paper is the distribution of the snail fauna in water bodies around irrigation schemes in the Benue River Valley, Yola area of Adamawa state, Nigeria.

MATERIALS AND METHODS

Study Area: Adamawa State is found in the Northern-Eastern part of Nigeria. The state lies between latitude 7º and 11º N of the equator and between longitude 11 and 14 E of the Greenwich meridian. It has an altitude of 185.9 meters and covers a land area of about 38.741 km^2. It shares boundary with Taraba State in the South and West, Gombe State in its northwest and Borno state to the north. Adamawa state has an international boundary with Cameroon Republic along its Eastern border. The Benue which is the major river in the state rises from the highlands of Cameroon and flows south ward to join the River Niger at Lokoja (figure 1). The state experiences two seasonal periods: the wet and the dry seasons. The months of May to October constitute the wet season. During this period no place receives less than 60 mm of rain. The months of November to April constitute the dry season. It experiences harmattan between the months of November to February. March and April are the hottest months (42.78º), while November and December are the coldest months (11.11º). (Adebayo and Tukur, 1999). The study covered the community of Lake Geriyo and along the banks of the River Benue, Yola area starting from Boronji Community (behind the Adamawa State Water Board Treatment Plant) close to the bridge at the boundary of Yola North L.G. Area and Girei L.G.A., it will follow the communities of Rugange Bwatiye through Njoboliyo in Yola South L.G.A and Dason Bwatiye upto Dasin Hausa in Fufore L.G.A. These areas are characterized by farming and fishing activities all year round.

Ethical consent: An introductory letter was collected from the Department of Zoology, Modibbo Adama University, Yola, addressed to the Permanent Secretaries, Ministry of Livestock Production and Ministry of Health, Yola.

Snail Habitat Data: Samplings was done for twelve (12) months, in sites where there are major human water contact within settlements along the scheme of the Benue River, Yola area. This period of sampling, snails were captured once every month covering both the dry and wet season. The two seasonal periods shows changes in the ecosystems around the River based on the quantity and quality of water (Alhassan *et al.*, 2017).

Malacological surveys: Snails were sampled from identified Sites on the basis of availability of water and observation of human or animal water contact activities. Collection was done once every month for a period of 12 months (September, 2022 to August, 2023). The survey covered a different range of site types including irrigation canals which draw water directly from the River Benue, and the smaller dirt-lined canals that deliver water to rice paddies; the rice paddies themselves, the river (shallows of the main body of the River Benue), and spillways (floodplain of tributaries feeding into the river). All the water contact sites where people used for irrigation, watering of Cattle and other activities were surveyed. Sampling was carried out by 2 trained field collectors using standard snail scoops or occasionally, by hand collection where necessary. The same collectors scooped for snails throughout so as to achieve some level of standardized sampling effort. Sampling time was fixed at 30 minutes per location and was performed between 08:30 am and 10:30 am. Sampling area per location was approximately 5m^2, whereas lengths of 10 metres along streams shoreline was used also. At each collection time, snails from each site was appropriately labelled and transported in separate perforated plastic containers. The collected snail specimens was transferred to the Department of Zoology laboratory as described by Opisa *et al.* (2011). Snails was identified according to shell morphology and structure using standard identification keys (Brown, 1994; WHO, 1998; Panda *et al.*, 2014).

Data analysis: Diversity of the snails was determined using Shannon Weiner's diversity index (H) as in Eyo and Paul, (2015), it was calculated by using the formula shown below;

Shannon-weiner diversity index (H) = $-\sum$ (Pi x ln Pi)
S

Where; H is the Shannon diversity index; Pi is the fraction of the entire population made up of species; i is the estimation of the proportion as Pi=ni/N; S is numbers of species encountered; ∑ is sum from species 1 to species S; Ln is the natural log, which makes the terms of the summation negative.

Kerkhoff, (2010), states that typical values of Shannon Weiner index are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. Evenness is an index that makes the *H* values comparable between communities by controlling the number of species found within the communities.

$$E = \frac{H}{LnHmax} \quad (1)$$

Where; *H*= Shannon Weiner value; *Hmax*= Total number of species

E can range from close to 0 or close to 1. When it is close to zero, it means all species are rare and just a few are abundant, close to 1 means the potential evenness between species (*Hmax*) is equal to that which was observed (*H*).

RESULTS AND DISCUSSION

The results from the communities along the scheme of River Benue, Yola area showed that the snail distribution species in wet season period, *Bulinus reticulatus* was the highest in Lake Geriyo, Boronji and Dasin Hausa, with 49, 37 and 50 respectively. *Bulinus globosus* was the highest in Njoboliyo, Rugange and Dasin Bwatiye with 63, 47 and 50 respectively. On the other hand, *Lymnaea natalensis* was the least in Lake Geriyo (42), Boronji (27) and Dasin Hausa (36). The diversity index showed that *H* fell below the 1.5-3.5 range while the Evenness *E* showed a potential evenness between freshwater snail species in all sites of the communities except for site A in Dasin Bwatiye which recorded less evenness (Table 1). The snail distribution species during the dry season period showed that *L. natalensis* was the highest in Lake Geriyo (31), *B.truncatus* was the highest in Boronji with 23. While, in Njoboliyo, and Rugange *B. globosus* was the highest snail species found with 52 and 29 respectively. Dasin Bwatiye and Dasin Hausa had *B. globosus* and *B. reticulatus* with 26 and 30 respectively. On the other hand, *B. reticulatus* was the least in Lake Geriyo (14) and Boronji (16). *L. natalensis* was the least in Njoboliyo with 26. *B. truncatus* was the least in Rugange, Dasin Bwatiye and Dasin Hausa with 22, 23 and 14 respectively. The diversity index showed that *H* fell below the 1.5-3.5 range while the Evenness *E* showed a potential evenness between freshwater snail species in all sites of the communities with no exception (Table 2).

Table 1: Snail Distribution in the wet season at the study sites

Location	*L. natalensis*	*B. globosus*	*B. reticulatus*	*B. truncatus*	Total	*H*	*LnH*max	Evenness
Lake Geriyo								
Site A	23	19	24	16	82	1.37	4.41	0.99
Site B	19	28	25	29	101	1.37	4.62	0.99
Total	42	47	49	45	183	1.38	5.21	0.99
Boronji								
Site A	13	19	17	16	65	1.38	4.17	0.99
Site B	14	16	20	17	67	1.38	4.20	0.99
Total	27	35	37	33	132	1.38	4.88	0.99
Njoboliyo								
Site A	21	24	23	20	88	1.38	4.48	0.99
Site B	22	20	15	18	75	1.38	4.32	0.99
Site C	19	19	20	8	66	1.33	4.19	0.96
Total	62	63	58	46	229	1.38	5.43	0.99
Rugange								
Site A	21	28	14	17	80	1.35	4.38	0.97
Site B	14	19	21	19	73	1.38	4.29	0.99
Total	35	47	35	36	153	1.38	5.03	0.99
Dasin Bwatiye								
Site A	19	25	14	3	61	1.21	4.11	0.87
Site B	16	25	13	21	75	1.36	4.32	0.97
Total	35	50	27	24	136	1.34	4.91	0.97
Dasin Hausa								
Site A	21	24	22	27	94	1.38	4.54	0.99
Site B	15	21	28	17	81	1.36	4.39	0.97
Total	36	45	50	44	175	1.38	5.16	0.99

The occurrence and abundance of freshwater snail in the present study differ from the report of Mereta *et al.* (2019), who recorded a total of 3107 freshwater snails belonging to five species, the sites where the snails in the present study were collected was far less than what Mereta *et al.* (2019), who recorded 130 sites. Muriel *et al.* (2019), reported that a total of 59,674 snails were found throughout the period of the study. Adejumoke *et al.* (2016) recorded a total of 2559 snails belonging to six species, five genera, three families and two subclasses were collected in River Ogbesse and River Ureje during their study, Yirenya-Tawiah *et al.* (2011), reported a total of 1034 snails collected, comprises of five different species; these were *Bulinus truncatus, Bulinus globosus, Biomphalaria pfeifferi, Melanoides* sp., P*hysa waterlotti and Pila* sp. The dominant was found to be *B. truncates* 735/1034 (71.0%), followed by *Biomphalaria* 125/1034 (12.0%) and *B. globosus* (6.1%). Ayanda (2009), recorded a total of 648 snails, comprising 392 (60.5%) *B. globosus* and 256 (39.5%) *B. pfeifferi* were examined The species recorded in the present were less when compared with the study of Mereta *et al.* (2019), who reported; *B. pfeifferi, B. sudanica, B. globosus, B. forskalii*, *Lymnaea natalensis* and *Lymnaea truncatula*. Ejehu *et al.* (2017) reported that out of the 385 freshwater snails collected; On the basis of shell morphology, 216 (56.1%) of the snails were identified as *L. anatalensis*, 150 (39%) as *B. globosus* whereas 19 (4.9%) were identified as *Pila* spp from the shores of Oguta Lake. Taofiq *et al.* (2017) reported that the species of snails identified comprised of 371 (45.57%) *Achatina fulica*, 229 (28.13%) *B. globosus* and 214 (26.28%) *L. natalensis*. Abdullahi *et al.* (2020), reported that a total of 108 snails were collected from Kubanni reservoir, of which 52 (48.15%) were *B. pfeifferi*, 43 (39.81%) were *L. natalensis,* and 13 (12.04%) were *B. globosus*.

Table 2: Snail Distribution in the dry season at the study sites

Location	*L. natalensis*	*B. globosus*	*B. reticulatus*	*B. truncatus*	Total	*H*	*LnH*max	Evenness
Lake Geriyo								
Site A	16	17	9	8	50	1.33	3.91	0.96
Site B	15	12	5	22	54	1.28	3.99	0.92
Total	31	29	14	30	104	1.33	4.64	0.95
Boronji								
Site A	9	10	11	14	44	1.37	3.78	0.99
Site B	8	6	5	9	28	1.36	3.33	0.98
Total	17	16	16	23	72	1.37	4.28	0.99
Njoboliyo								
Site A	8	17	16	4	45	1.26	3.81	0.90
Site B	9	18	8	16	51	1.33	3.93	0.95
Site C	9	17	8	14	48	1.34	3.87	0.96
Total	26	52	32	34	144	1.35	4.97	0.97
Rugange								
Site A	15	14	16	18	63	1.38	4.14	0.99
Site B	8	15	12	4	39	1.29	3.66	0.93
Total	23	29	28	22	102	1.38	4.62	0.99
Dasin Bwatiye								
Site A	17	11	12	13	53	1.37	3.97	0.99
Site B	9	15	12	10	46	1.37	3.83	0.98
Total	26	26	24	23	99	1.38	4.60	0.99
Dasin Hausa								
Site A	12	10	15	8	45	1.36	3.81	0.98
Site B	14	11	15	6	46	1.34	3.83	0.96
Total	26	21	30	14	91	1.35	4.51	0.97

The most dominant species reported in the present study differ from the findings of Mereta *et al.* (2019), who reported that *B. pfeifferi* accounted for 66% of the total collection and collected from 40% of the surveyed sites while *B. globosus* accounted for less than 10% of the total collection. While Masceline *et al.* (2020) collected 1558 freshwater snails that were putatively identified as *Bulinus* spp. based on their sinistral, ovate, globose shells. Among these, 1542 were morphologically identified as *B. globosus* and 16 as *B. truncatus*, based on the shape of the columella.

Muriel *et al.* (2019), reported *B. truncatus* as the most abundant (*n* = 42,500), followed by *B. forskalii* (*n* = 11,989), *R. natalensis* (*n* = 2530) and *Bi. Pfeifferi* (*n* = 2290). *B. globosus* and *B. senegalensis* were also present but found in low numbers (*n* = 290 and *n* = 76 in total, respectively, Sanu *et al.* (2020), reported that eleven (11) different snail species were encountered in the kiri dam of Shelleng LGA, these include *B. globosus*, *B. truncatus*, *B. pfeifferi*, *L. natalenses*, *Lanistes ovum*, *Lanistes varicus*, *Melanoides meculata*, *Melanoides tuberculata*, *Gabiella tchadiensis*, *Bellamya unicolor*, and *P. ovata*, Ejehu *et al.* (2017) reported that in terms of seasonal abundance, a total of 304 (79%) and 81 (20.9%) snail species were collected during the wet and dry season, respectively. More *Lymnaea* spp were collected in the dry season (77.7%) than in the wet season (50.3%); while more *Bulinus* and *Pila* were in the wet season, 43.4% and 6.2% respectively. A total of 153 and 63 species of *L. natalensis* was collected in the wet and dry season, respectively. The results also show that 132 (43.4%) and 18 (22.2%) *B. globossus* snail species were collected respectively in wet and dry season while 19 (6.2%) *Pila* snail species were collected in the wet season and none in the dry period. The distribution of freshwater snail in relation to the types of sites in the present study showed a slight similarities with the findings of Muriel *et al.* (2019), who reported that *B. truncatus* was significantly more abundant in secondary than tertiary canals, and had lowest abundance in spillways and rice paddies. Site type was a significant predictor of abundance in *B. truncatus*. In contrast, *B. forskalii* was more abundant in tertiary than secondary canals, and also had high abundance in pond, rice paddy and spillway sites (although the latter show very large standard errors due to large variation). River and rivulet sites had very low abundances. *Radix natalensis* were mostly found in tertiary canals, then ponds, with very low numbers in secondary canals, contrasting with both *Bulinus* species and *Bi. pfeifferi.* There was a strong similarity of species of fresh water snail found across the communities in the present study. This however differs with the findings of Muriel *et al.* (2019), who reported differences in abundances across localities, that *B. truncatus*, was the most abundant at majority of localities, which showed an almost bimodal distribution of either very low abundances or relatively much higher numbers at a few localities. Ejehu *et al.* (2017) reported that spatial distribution of snails was clustered, with only two sites (Okpaosha and Onu Okpaosha) accounting for the presence of snails. Of the four sites surveyed, two sites (Osemotor and Edu Ngwugwu) did not yield any snail. The presence of *B. globosus* is of public health importance. Several studies have identified this species as an important vector for schistosomiasis (Owojori *et al.,* 2006; Ekwunife *et al.,* 2008). In the present study, all the sites are characterized with shallow depth, Ejehu *et al.* (2017) reported that *B. globosus* was noticed to prefer shallow waters and occurred on bare substrata, but commonly among aquatic plants such as the *Nymphea lotus* in and around the lake; this was also as observed and reported by Thomas and Tait, (1984). Van-Schayck, (1985) reported that the snail hosts are not directly dependent on aquatic plants but they may prefer a habitat with aquatic vegetation as these plants help to provide food and shelter for the intermediate host snail. Besides, the aquatic macrophytes have been shown to play vital roles in the distribution of snails in different parts of Africa. However, snails may also move deeper into a water body with an increase in temperature; therefore, the relationship between snail microhabitat, temperature and infection may be complex. Other factors could significantly affect the abundance and distribution of the snail species surveyed that were not measured, such as submerged vegetation as supported by Coulibaly *et al.* (2004); Wood *et al.* (2019). It was found that there is evidence of seasonality affecting the abundance of freshwater snails in this study, with higher numbers found in the wet season, and reductions in the dry season. This suggests the observation is due to abiotic factors, likely working in concert; for example, snail displacement in wet months as water levels rise and flow increases, and rain creating turbidity. Ejehu *et al.* (2017) reported that the highest population density of snail was recorded in May which could be attributed to the beginning of the rains. This was in line with some researchers who have been able to demonstrate the usefulness of these parameters namely rainfall and water velocities in the increase or decrease of snail population (Kristensen *et al.*, 2001).

Rain may also affect cumulative impacts through bringing more water, washed water plants as opposed to the suggestions of Rollinson *et al.* (2001), who reported a contrary opinion. The changing seasonal environment may also affect experimental sampling. Snails may be more difficult to find in turbid water and when dislodged from vegetation; the search-area may increase as water levels rise, and snails may also accumulate in highly localised areas such as eddies which may be missed. The reduced snail population at the end of the rains agrees with reports of Okafor (1984) who attributed this to flushing away of snails from their habitat by the rainy season flood water due to increased water flow while the same water diluted the harsh conditions in stagnant pools to tolerable levels. Knowledge of the seasonal abundance is important for snail control. The results of this study show that just like Sanu *et al.* (2020), reported that Kiri dam harbours many species of freshwater snails; lake Geriyo and River benue (Yola area) also contains freshwater snails. The species encountered in the present study are common freshwater snails which have been reported from various parts of Nigeria; Ngele *et al.* (2012) in Bende Local Government Area, Abia State, Okeke and Ubachukwu (2013) in urban and semi-urban communities in South-Eastern Nigeria, Omonijo *et al.* (2016) in Ado-Ekiti Local Government Area of Ekiti State, Awosolu (2016) in Rural Communities of South-Western Nigeria, Sunday *et al.* (2019) in Dadin-kowa man made Reservoir, Gombe State. Thus, no strange snail species were observed. Seasonal patterns could also be influenced by density-dependence in the dry season, or where numbers rise to a tipping point, where they start to decline because of factors like food limitation, or potential aestivation as supported by Perez-Saez *et al.* (2016). Findings of greater snail abundance in the wet season are actually different with the published data for *Bulinus* spp. in the NRV (Labbo *et al.*, 2008) and in similar environments such as Burkina Faso and

Mali (Dabo *et al.,* 2015; Perez-Saez *et al.,* 2016), but also in very different climates, including Kenya and Lake Victoria (Muhoho *et al.,* 1997; Gouvras *et al.,* 2015). The presence of freshwater snails in all the communities in the present study suggests the possibility of parasitic transmission in these eco-systems, it can also serve as an index of pollution of a water body Abdullahi *et al.* (2020) also opined that when they reported the presence of freshwater gastropods in the two aquatic ecosystems in their study. The presence of the same species composition of freshwater snails in all the water bodies in the present study may be due to the similarity in ecological activities such as mode of nutrition, roles at a particular trophic level, irrigation farming, washing, and bathing within these water bodies which support the existence of these snails. The Shannon–Weiner diversity index (*H*) of freshwater snails in in the present study falls within the range of the report of Abdullahi *et al.* (2020) and Nwoko *et al.* (2022), that recorded an index ranged from 0.10 to 1.63, from their study, rainfall and temperature were identified as climatic factors that affect snail diversity. Abdullahi *et al.* (2020), reported a Shannon–Weiner diversity index of 0.97, this is lower when compared with the finding of the present study. On the contrary Abdullahi *et al.* (2020), reported a higher Shannon–Weiner diversity index of 1.02. The low values of Shannon–Weiner diversity index in relation to freshwater snails in these communities can be linked to pollution level of the water. Where a value of this index above three (3) indicates clean water, thus, values lower than three indicates pollution (Maiti, 2004), and the higher the value, the greater the diversity

Conclusion: The findings in this study confirm that the distribution of freshwater snail species showed a potential evenness in the distribution across all sites of the communities except for site A in Dasin Bwatiye which recorded less evenness, there is no localized species, as all species were found in all sites. The low values of Shannon–Weiner diversity index recorded in these communities can be linked to pollution level of the water

Declaration of Conflict of Interest: The authors declare no conflict of interest

Data Availability Statement: Data are available upon request from the first author or corresponding author or any of the other authors

REFERENCE

Abdullahi, BA; Abdulsalam, A; Ibrahim, MKG; Ramatu, IS; Yunusa, AW; Rasiq, K (2020). Distribution and diversity of freshwater snails of public health importance in Kubanni reservoir and weir/sediment trap, Zaria, Nigeria. *J. Environ. Occup. Heal.*10 (1): 1–9

Adebayo, AA; Tukur, AL (1999). Adamawa State in maps publication Department of Geography, Federal University of Technology Yola, in Co-operate with paraclete publications. A division of Paraclete and sons Nigeria.

Adejumoke, OO; Samuel, OA; Ifeanyi, EO (2016). Ecology of Schistosoma Snail Vectors in Ado-Ekiti Local Government Area, Ekiti State, Nigeria. *Inter. J. Pure Appl. Zool.* 4(1): 77-84

Alhassan, AB; Balarabe, ML; Gadzama, IMK; Idris, SR; Wada, YA; Yusuf, A (2017). Influence of physico-chemical parameters on the intermediate host of *Schistosoma haematobium* and *Schistosoma mansoni* in Makwaye and Kubanni Reservoirs, Zaria, Nigeria. *J. Adv. Vet. Anim. Res.* 4(4): 363–70.

Awosolu, OB (2016). Epidemiology of Urinary Schistosomiasis and Knowledge of Health Personnel in Rural Communities of South-Western Nigeria. *J. Parasit. Vec. Bio.* 8(10): 99-106.

Ayanda, OI. (2009). Prevalence of snail vectors of schistosomiasis and their infection rates in two localities within Ahmadu Bello University (A.B.U.) Campus, Zaria, Kaduna State, Nigeria. *J. Cel. Ani. Bio.* 3(4): 058-061

Brown, DS (1994). Freshwater Snails of Africa and their Medical Importance, Revised 2nd Edition, Taylor and Francis Ltd., London, Pp. 609

Coulibaly, G; Diallo, M; Madsen, H; Dabo, A; Traoré, M; Keita, S (2004). Comparison of schistosome transmission in a single- and a double-cropped area in the rice irrigation scheme, ‘Office du Niger’, Mali. *Acta. Trop*. 91:15–25

Dabo, A; Diarra, AZ; Machault, V; Touré, O; Niambélé, DS; Kanté, A (2015). Urban schistosomiasis and associated determinant factors among school children in Bamako, Mali, West Africa. *Infect. Dis. Poverty*. 4: 4-21

Dida, GO; Gelder, FB; Anyona, DN; Matano, AS; Abuom, PO; Adoka, SO; Ouma, C; Kanangire, CK; Owuor, PO; Ofulla, AV (2014). Distribution and abundance of schistosomiasis and fascioliasis host snails along the Mara River in Kenya and

Tanzania. *Infec. Eco. Epide.* 4: 24-28 [PMC free article] [PubMed] [Google Scholar]

Ejehu, ZU; Ekwunifem, CA; Anumba, JU; Onyido, AE; Umeaneto, PU (2017). Snail fauna and investigations into the incidence of schistosoma infection in Lake of Oguta 1 Region, Imo State, Nigeria, *Nig. J. Parasit.* 38(2): 173-178

Ekwunife, CA; Ozumba, NA; Eneanya, CI (2008). Studies on the biology and population parameters of *Bulinus globosus* and *Bulinus truncatus* in the laboratory. *Nig. J. Parasit.* 29(1): 11-14

Eyo, EA; Paul, JA (2015). Planktonic Abundance and Diversity in Great Kwa River, Cross River State, Nigeria. *Int. J. inno. Sci. Eng. Tech.* 2 (9): 141-151

Gouvras, AN; Allan, F; Kinung'hi, S; Rabone, M; Emery, A; Angelo, T (2017). Longitudinal survey on the distribution of *Biomphalaria sudanica* and *B. choanomophala* in Mwanza region, on the shores of Lake Victoria, Tanzania: implications for schistosomiasis transmission and control. *Parasit. Vec.* 10: 316-333

Kerkhoff, P. (2010). Measuring Biodiversity of Ecological Communities. Ecology Lab Biology, Pp. 229

Kristensen, TK; Malone, JB; McCarroll, JC (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

Labbo, R; Ernould, JC; Djibrilla, A; Garba, A; Chippaux, JP (2008). Focalisation de la transmission de *Schistosoma haematobium* au sein des périmètres irrigués de la vallée du Niger: importance des facteurs malacologiques. *Rev. Epidemi. Sante. Publique*. 56: 3–9

Maiti, SK (2004). Handbook of Methods in Environmental Studies: Water and Wastewater Analysis. Second Edition ABD Publishers B-46

Masceline, JM; Xiao-Nong, Z; Cremance, T; Eniola, A; Justen, M; Tawanda, M; Fiona, A; Nyasha, C; Bonnie, W; Nicholas, M (2020). Molecular diversity of *Bulinus* species in Madziwa area, Shamva district in Zimbabwe: implications for urogenital schistosomiasis transmission, *Parasit. Vec.* 13:14-22 https://doi.org/10.1186/s13071-020-3881-1

Mereta, ST; Bedewi, J; Yewhalaw, D; Mandefro, B; Abdie, Y; Tegegne, D; Birke, W; Mulat, WL; Kloos, H (2019). Environmental determinants of distribution of freshwater snails and trematode infection in the Omo Gibe River Basin, southwest Ethiopia. *Infect. Dis. Pov.* 8: 93-103

Muhoho, ND; Katsumata, T; Kimura, E; Migwi, DK; Mutua, WR; Kiliku, FM; Habe, S; Aoki, Y (1997). Cercarial density in the river of an endemic area of *Schistosomiasis haematobium* in Kenya. *Am. J. Trop. Med. Hyg*. 57: 162–167

Muriel, R; Joris, HW; Fiona, A; Anouk, NG; Tom, P; Amadou, AH; Bonnie, LW; Rabiou, L; Aidan, ME; Amadou, DG; David, R (2019). Freshwater snails of biomedical importance in the Niger River Valley: evidence of temporal and spatial patterns in abundance, distribution and infection with *Schistosoma* spp. *Paras. Vec.* 12: 498 **https://doi.org/10.1186/s13071-019-3745-8**

Ngele, K; Kalu, E; Ukwey, M; Onyeukwu, C (2012). A Survey of freshwater snails: the intermediate hosts of schistosomiasis in Bende Local Government Area, Abia State, Nigeria. *Inter. J. Sci. Nat.* 3(4): 879-882

Nwoko, OE; Kalinda, C; Manyangadze, T; Chimbari, MJ (2022). Species Diversity, Distribution, and Abundance of Freshwater Snails in KwaZulu-Natal, South Africa. *Wat.* 14: 2267. https://doi.org/10.3390/w14142267

Okafor, FC (1984). The eco-physiology and biology of the snail hosts of *Schistosoma haematobium* with the observations on the epidemiology of the disease in Anambra State, Nigeria. PhD. Thesis, University of Nigeria, Nsukka, p. 208.

Okeke, OC; Ubachukwu, PO (2013). Urinary schistosomiasis in urban and semi-urban communities in South-Eastern Nigeria. *Ira. J. Paras.* 8 (3): 467-473

Omonijo, AO; Asaolu, SO; Ofozie, IE (2016). Ecology of Schistosoma Snail Vectors in Ado-Ekiti Local Government Area of Ekiti State Nigeria, *Inter. J. Pur. Appl. Zool*. 4(1): 77-84

Opisa, S; Odiere, MR; Jura, WG; Karanja, DM; Mwinzi, PN (2011). Malacological survey and geographical distribution of vector snails for schistosomiasis within informal settlements of Kisumu City, western Kenya. *Paras. Vec.* 4(1).

226. doi: 10.1186/1756-3305-4-226. [PMC free article] [PubMed] [CrossRef] [Google Scholar]

Owojori, OJ; Asaolu, SO; Ofoezie, IE (2006). Ecology of freshwater snails in Opa Reservoir and research from ponds at Obafemi Awolowo University IleIfe, Nigeria. *J. Appl. Sci.* 6 (15): 3004-3015

Panda, SM; Istifanus, WA; Suleiman, MM (2014). Observations on some morphological variations among different *Bulinus globosus* populations in North Eastern Nigeria. *Inter. J. Advan. Bio. Sci.* 6 (2): 65-75

Perez-Saez, J; Mande, T; Ceperley, N; Bertuzzo, E; Mari, L; Gatto, M; Rinaldo, A (2016). Hydrology and density feedbacks control the ecology of intermediate hosts of schistosomiasis across habitats in seasonal climates. *Proc. Natl. Acad. Sci. USA*. 113: 6427–32

Rollinson, D; Stothard, JR; Southgate, VR (2001). Interactions between intermediate snail hosts of the genus *Bulinus* and schistosomes of the *Schistosoma haematobium* group. *Parasit.* 123: S245–60

Sanu, KM; Istifanus, WA; Musa, MS; Mao, PS (2020). The diversity of fresh water snail fauna in Kiri dam, Adamawa State, North Eastern Nigeria. *GSC Bio. Pharm. Sci.* 11(02): 099–104

Sharma, KK; Bangotra, K; Saini, M (2014). Diversity and distribution of Mollusca in relation to the physico-chemical profile of Gho-Manhasan stream, Jammu (J & K). *Inter. J. Biodiv. Conserv.* 5(4): 240-249, DOI: 10.5897/IJBC12.127 ISSN 2141-243X

Siama, A; Enama, SE; Kalmobe, J; Abah, S; Foutchou, A; Michel, A; Nloga, N (2023).Abundance, Distribution, and Diversity of Freshwater Snail and Prevalence of their Infection by Cercaria of *Fasciola gigantica* and *Schistosoma* spp at Mayo-Vreck River, Far North Region of Cameroon, *J. Trop. Med.* 2023 (1): 9527349

Sunday, ID; Istifanus, WA; Adamu, BS (2019). The Freshwater Snail Fauna of Dadin-kowa man made Reservoir, Gombe State Nigeria. *Inter. J. Faun. Bio. Stu.* 6(5): 31-35

Taofiq, S; Bunza, MDA; Majeed, Q; Abubakar, MB; Ladan, MU (2017). Studies on Snail Vectors of Helminth Disease Agents along Rima River Valley at Kwalkwalawa Village, Wamakko Local Government Area, Sokoto State, Nigeria. *SM. Trop. Med. J*. 2(1): 10-11

Thomas, JD; Tait, AI (1984). Control of the snail hosts of schistosomiasis by environmental manipulation: A field and laboratory appraisal in the Ibadan area, Nigeria. *Philos. Trans. R. Soc. Lond. B. Biol. Sci*, 305*:* 201-253

Utzinger, J; Keiser, J (2004). Schistosomiasis and soil-transmitted helminthiasis: common drugs for treatment and control. *Exp. Opin. Pharma.* 5: 263-285

Van Schayck, CP (1985). Laboratory studies on the relation between aquatic vegetation and the presence of two bilharzia bearing snail species. *J. Aqua. Plan. Manage.* 23: 87-91

Wood, CL; Sokolow, S; Jones, I; Chamberlin, A; Lafferty, KD; Kuris, AM (2019). Precision mapping of snail habitat provides a powerful indicator of human schistosomiasis transmission. *Proc. Natl. Acad. Sci. USA* (in press).

Wosu, LO (2003). Commercial snail farming in West-Africa - A guide. Ap Express Publishers, Nsukka-Nigeria.

W.H.O., (2008). Fact sheet on fascioliasis. World Health Organization, 1-8.

W.H.O., (2010). Côte d'Ivoire - Index of country profile preventive chemotherapy and transmission controle. World Health Organization.

Yirenya-Tawiah, DR; Abdul-Rashid, A; Futagbi, G; Aboagye, I; Dade, M (2011). Prevalence of Snail Vectors of Schistosomiasis in the Kpong Head Pond, Ghana. *Wes. Afr. J. Appl. Eco.* 18: 39-45