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Vector snail fauna and *Schistosoma haematobium* transmission patterns in freshwater systems of Ishielu Local Government Area, Ebonyi State, Nigeria

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Abstract

Freshwater snails are widespread in tropical and temperate regions of the world where they serve as intermediate hosts for larval stages of parasitic trematodes which cause schistosomiasis that is endemic in Nigeria. Snail fauna and patterns of *Schistosoma haematobium* transmission were determined in flowing water habitats (FWH) and stagnant water habitats (SWH) in Ishielu, Local Government Area, Ebonyi State, Nigeria. Snail collection was done using scoop-net and hand-picking techniques. *Bulinus* species collected were exposed to sunlight/light-induced in laboratory for cercarial shedding. Cercariae were then observed under microscope. 923 snails were collected, 67.7% *Lymnaea natalensis*, 23.1% *Bulinus globosus* and 9.2% *Bulinus truncatus*. Their relative abundance was significantly different (P<0.05). 31.6% *Bulinus* snails from FWH were infected by *S. haematobium* whereas 18.5% from SWH were infected. Infectivity of *Bulinus* spp in each habitat group was not significantly different but was when compared the two groups of habitats (P<0.05). Highest infectivity (45.8%) occurred during dry season peaking in February (45.8%) for FWH and for SWH, highest infectivity occurred during rain peaking in July (26.8%). The transmission potential (T.P) was very high during dry season (93.0%) peaking in February (34.9%) in FWH and very low (0%) for SWH. During rain, the T.P was very high (100%) peaking in July (50%) in SWH and very low (7.0%) for FWH. Pools and rivers in Ishielu are suitable habitats for vector snails wherein season and habitat type influence snail abundance and transmission of Schistosomiasis, the findings of which can help in establishing programmes for proper health awareness and snail control.

Keywords: Flowing Water Habitat; Freshwater Snails; *Schistosoma haematobium*; Stagnant Water Habitat; Transmission Patterns

1. Introduction

A freshwater snail is a gastropod that lives in any naturally occurring liquid or frozen water containing low concentrations of dissolved salts and other total dissolved solids (freshwater habitat). They have been found to inhabit different freshwater bodies ranging from non-permanent pools to the largest lakes and from seeps and springs to large rivers.

Class Gastropoda which is divided into two subclasses, prosobranchia and pulmonata, constitute the majority of the freshwater snails of biomedical importance that inhibit different water bodies in Africa[1] and are present in Nigeria[2]. Approximately 5000 species of freshwater snails have been found to inhabit these freshwater bodies[3]. They serve as vectors (intermediate host(s)) for some major parasitic digenean trematode diseases including schistosomiasis[4].

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Schistosomiasis is water-borne pathological condition resulting from infection by parasitic worms (blood flukes) of the genus *Schistosoma*. It causes considerable morbidity and mortality in developing countries especially among children and the symptoms associated with it include abdominal pain, bloody stool, diarrhoea, or blood in the urine[5,9]. Estimates show that at least 251.4 million people required preventive treatment for schistosomiasis in 2021, out of which more than 75.3 million people were reported to have been treated[6]. At least 90% of those requiring treatment for it live in Africa[6]. Nigeria has been reported to be the most endemic country in the world for schistosomiasis and *S. haematobium* is widely spread mainly in riverine areas and communities around impoundment of river (dam)[7]. Schistosomiasis is common among poor communities that are without clean potable water and proper sanitation[8].

Urogenital schistosomiasis results when adult female *S. haematobium* worm pairs living in the veins draining key pelvic organs, including the bladder, uterus, and cervix, release terminal-spine eggs that penetrate the tissues and are excreted in the urine to allow propagation of the parasite life cycle[9].

Bulinus globosus is a major snail host of *S. haematobium* in Ishielu, Ebonyi State Nigeria[10]. Field observations in the area also show that humans are in frequent contact with the habitats from which *Bulinus (Ph.) globosus* that shed schistosome cercariae were isolated[10,11]. It is reasonable to expect that opportunities for transmission to human hosts would vary according to some environmental factors. Useful information can be obtained by calculating some indices especially those that help to determine the ecological and temporal aspects of the transmission patterns. This can help to identify the periods of the year when human population in endemic areas is at the greatest risk of acquiring schistosomiasis.

Hence, this work determined the vector snail fauna and patterns of *S. haematobium* transmission in freshwater bodies of Ishielu Local Government Area of Ebonyi State, Nigeria. Among the objectives were to identify the freshwater vector snail species in Ishielu LGA, determine the relative abundance of snail species, the habitat and seasonal changes in the population of snails infected with *S. haematobium,* the prevalence of *S. haematobium* in the infected snails collected from the habitats and the cercarial transmission potentials of the water bodies.

2. Materials and Methods

2.1. Study area

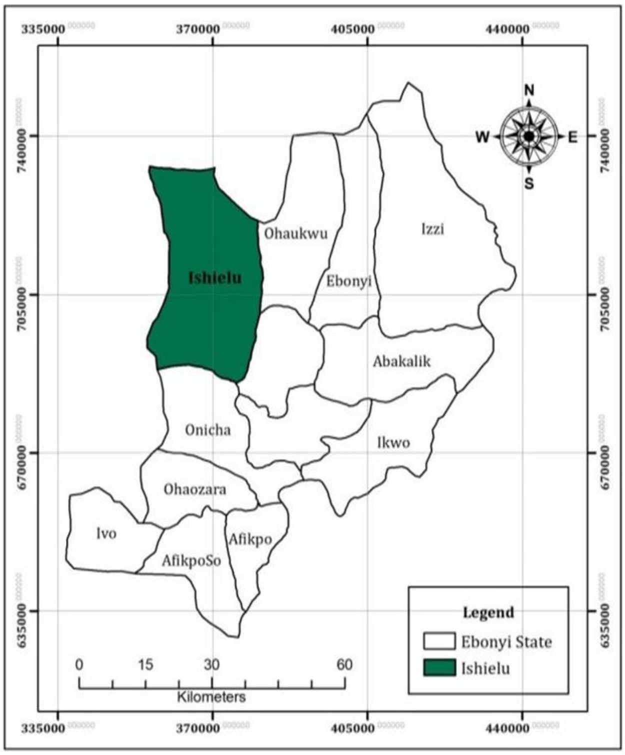

Figure 1 Map of Ebonyi State, Nigeria Showing Ishielu LGA

Source: GIS Surveying and Geoinformatics, NAU, AwkaNigeria[14]

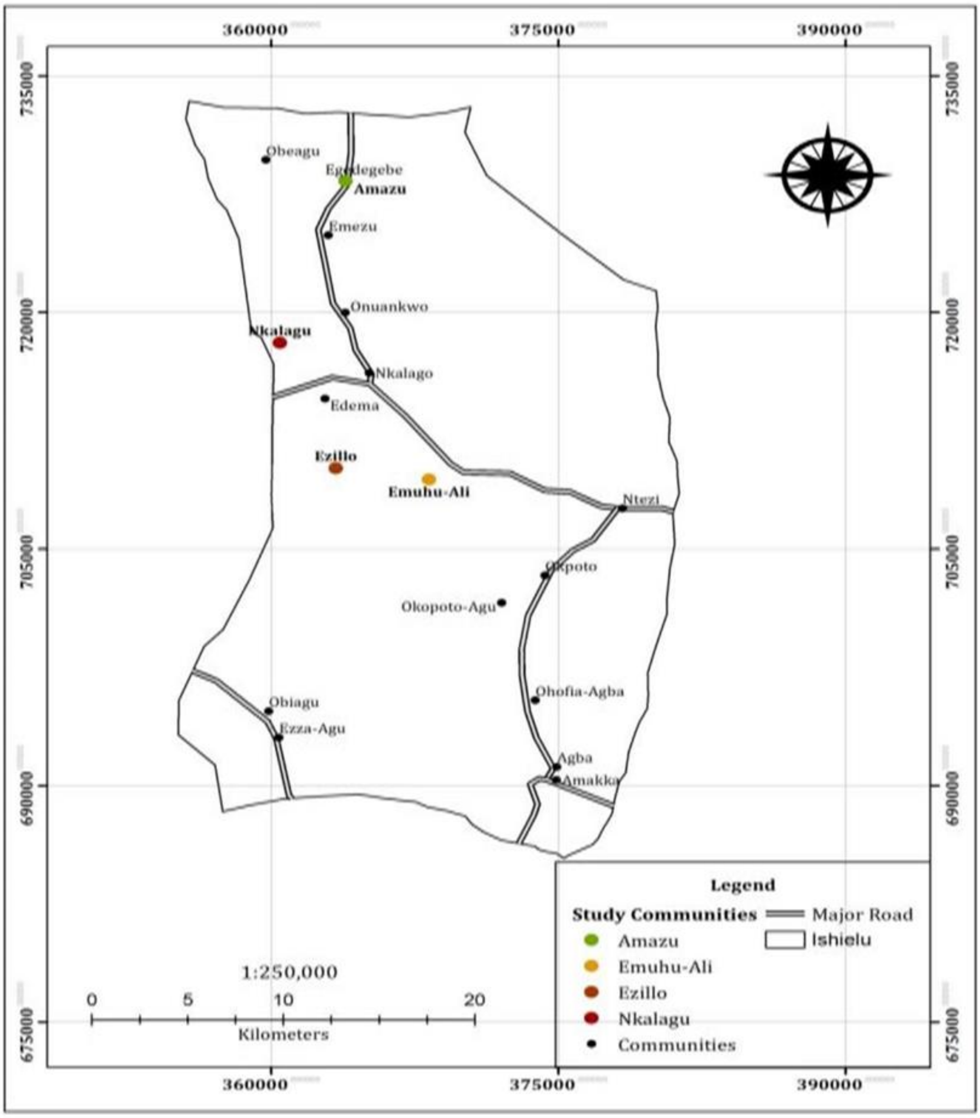

Figure 2 Map of Ishielu Local Government Area Showing the Study Communities

Source: GIS Surveying and Geoinformatics, NAU, Awka Nigeria[15]

This study was carried out at some freshwater bodies in Ishielu LGA of Ebonyi State, Nigeria. Some of the water bodies were flowing water habitats while others were stagnant water habitats. Ishielu LGA is located between latitudes 60 14’ 48˝ N and longitudes 70 51’ 36” E with an area of $872km^2$ (Fig. 1&2). The population is estimated at 152,581 people[12] and a projected population of 201,900 in 2016 according to National Bureau of Statistics and web records of National Population Commission of Nigeria[13]. In this area, there are several fresh water habitats including man-made pools, quarry pits, road ditches and irrigation canals. The climate of the area is tropical characterized by two distinct seasons, the rainy season and the dry season. The former takes place from April to October while the later spans five months from November to March. The environmental temperature ranges from $25^{0}C$ to $34^{0}C$. The majority of the inhabitants are farmers and petty traders, with a good number of civil servants, students and other professionals. More grasses and shrubs occur in areas where human activities take place often. The leaves of these plants often fall into the water bodies and together with the existing water microorganisms and food substances, arising from human processors, provide adequate food for snails and other aquatic organisms.

2.2. Snail collection

Snails were collected for twelve (12) months in the area starting from June 2018 to May, 2019. The collection of snails was done two times in a month at intervals of two weeks and was made on the arms, banks and other parts of the water bodies which are accessible to human and animal activities. Snails collected each month from each site were counted and their numbers recorded.

Using a long scoop net a number of stations were sampled in both habitats (Table 1). The snails collected were hand-picked using protective gloves and forceps. They were transferred into a moistened cloth bag together with the aquatic vegetation on which the snails clung. A visual search for snails in the surrounding was also made. Snails on the underside of the leaves, aquatic macrophytes, wood trunks, raffia and on decaying palm trees were collected using hand protected with gloves or forceps depending on the location of the snails. All the collected snail specimens were transferred into the moistened cloth bag and were taken to the laboratory of Department of Environmental Biology, Ebonyi State University, Abakiliki Nigeria for identification, measurement and check for shedding of cercariae of *S. haematobium*.

Table 1 Details of the number of stations in each site sampled

	Name of Habitat	**No. of Stations**
Flowing habitats	Uzuru Mmiri Ali River Ora	12 28 20
Stagnant habitats	Quarry Pits (Ezillo) Pools behind " Over Rail" Settlement	12 15

2.3. Identification of snails

Snails collected were washed with a saturated solution of oxalic acid. Foreign matters that stuck to the snails after washing were removed with a stiff paint brush. The snails were identified to the species level based on the shell morphology using standard identification keys[16].

2.4. Infectivity of Bulinus Species collected

The sizes of the *Bulinus* species collected were first measured. Each *Bulinus* snail was then put in a 10ml test tube containing 2ml of water. The test tubes and the contents were exposed for at least 2 hours to sunlight. This was done usually between 10.00am and 12.00noon to stimulate them for cercarial shedding (The cercarial shedding is at its peak at this time[17,18]). During rainy season, cercaria shedding was induced in the laboratory using bright bulb. After the exposure to light, the water from the various test tubes were put on a clean slide and viewed under the microscope for the presence of cercariae. The cercariae were identified using CDC guide[19]. Those found to be shedding bifurcate cercariae were recorded. After 12 days of observation, snails with no cercariae emergence were crushed individually and examined under the microscope. When at least one human schistosome type cercaria was seen, the crushed snails were considered infected. The number of infected snails for each month was recorded and prevalence determined.

2.5. Data analysis

Analysis of data was done using Statistical Package for Social Sciences (SPSS) software, version 24.0. Test of significance was carried out using chi-square (χ^2). A value of $P < 0.05$ was regarded as significant.

3. Results

A total of 923 freshwater snails were collected and identified during the study periods. The snails comprised three different species, *Lymnaea natalensis* 625(67.7%), *Bulinus globosus* 213(23.1%), and *Bulinus truncatus* 85(9.2%). Table 2 gives the monthly abundance of the snail species. Each of the species was most abundant during the rainy season whereas during the dry season, the snails were less with the lowest abundance during the onset of rain. The monthly abundance of the snail species were statistically different ($P<0.05$). There were no snails collected for all the species of snails in March.

Table 2 Monthly Abundance of each snail species collected from all the habitats in Ishielu Local Government Area

Month	*L. natalensis* No(%)	*B. globosus* No(%)	*B. truncatus* No(%)	Total No(%)
June	110(70.5)	35(22.4)	11(7.1)	156(16.9)
July	150(71.4)	45(21.4)	15(7.1)	210(22.6)
August	72(69.2)	25(24.0)	7(6.7)	104(11.3)
September	60(77.9)	12(15.6)	5(6.5)	77(8.3)
October	45(76.3)	10(17.0)	4(6.8)	59(6.4)
November	40(64.5)	13(21.0)	9(14.5)	62(6.7)
December	31(62.0)	11(22.0)	8(16.0)	50(5.4)
January	35(45.5)	30(39.0)	12(15.6)	77(8.3)
February	19(44.2)	17(39.5)	7(16.3)	43(4.7)
March	0(0)	0(0)	0(0)	0(0)
April	8(61.5)	3(23.1)	2(15.4)	13(1.4)
May	55(76.4)	12(16.7)	5(6.9)	72(7.8)
Total	625(67.7)	213(23.1)	85(9.2)	923(100)

($P<0.05$, df=11, $\chi^2 = 2.656$)

Figure 3 is the pie-chart showing the relative abundance of each of the snail species collected from all the habitats as calculated in table 2.

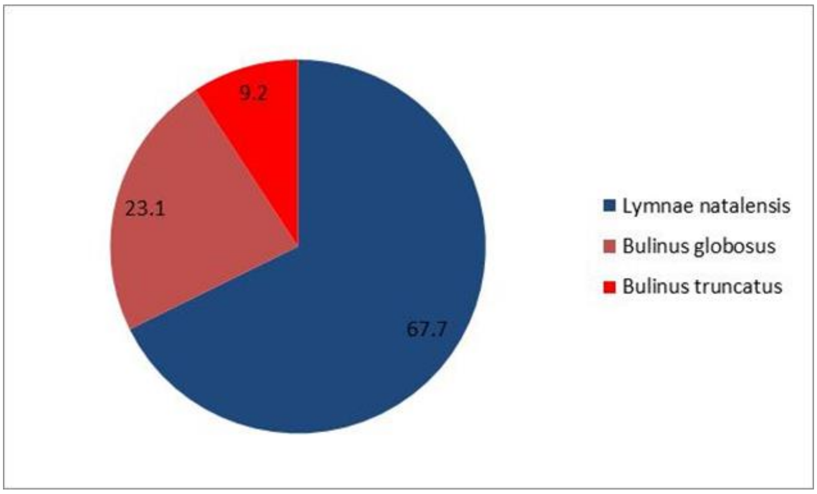

Figure 3 Relative abundance of the snail species encountered

Table 3 shows that the population of *Bulinus* spp from different sampling habitats was significantly different ($P < 0.05$).

The seasonal changes in the number of *Bulinus* species collected from all the habitats are presented in Table 4. For FWH, the number of *Bulinus* snails collected was high during the dry season and for SWH, the number collected was high during the rainy season. More *B. globosus* were collected in each season than *B. truncatus* for both groups of habitats. The monthly collections of *Bulinus* species for each group of habitats were significantly different ($P<0.05$).

Table 3 Total number of *Bulinus* snails collected from each sampling habitat for both groups of habitats

(FWH)		**(SWH)**	
Habitat	No. of *Bulinus* spp collected	Habitat	No. of *Bulinus* spp collected
Mmiri Ali (Nkalagu)	76(55.9)	Quarry Pits (Ezillo)	25(15.4)
Uzuru(Emuhu-Ali)	45(33.1)		
River Ora (Amazu)	15(11.0)	Natural Pools behind "Over Rail" Settlement (Nkalagu)	137(84.6)
Total	136(100.0)		162(100.0)

FWH ($P<0.05$, df=4, $\chi^2=16.389$); SWH ($P< 0.05$, df=4, $\chi^2=16.389$)

Table 4 Number of each of the *Bulinus* species collected from Each Group of habitat during the 12 months of study

	Flowing water habitats		***Stagnant water habitats***	
	No. of *B. globosus*	**No. of *B. truncatus***	**No. of *B. globosus***	**No. of *B. truncatus***
June	0	0	35	11
July	2	2	43	13
August	3	2	22	5
September	7	3	5	2
October	8	3	2	1
November	11	8	2	1
December	10	8	1	0
January	29	11	1	1
February	17	7	0	0
March	0	0	0	0
April	3	2	0	0
May	0	0	12	5

FWH ($P<0.05$, df=8, χ^2=-0.628) SWH ($P<0.05$, df=8, $\chi^2=0.682$)

Table 5 Prevalence of *S. haematobium* infections in *Bulinus* spp collected from the sampling habitats

Flowing water habitats(FWH)			**Stagnant water habitats(SWH)**		
Habitat	No. of *Bulinus* spp collected	No.infected (%)	Habitat	No. of *Bulinus* spp collected	No. infected(%)
Mmiri Ali (Nkalagu)	76	25(32.9)	Quarry Pits (Ezillo)	25	2(8.0)
Uzuru (Emuhu-Ali)	45	17(37.8)	Natural Pools behind "Over Rail" Settlement (Nkalagu)	137	28(20.4)
River Ora (Amazu)	15	1(6.7)			
Total	136	43(31.6)		162	30(18.5)

FWH ($P>0.05$, df=2, $\chi^2=1.266$); SWH ($P>0.05$, df=1, χ^2=-1.468)

The prevalence of *S. haematobium* infections in both *Bulinus* spp collected from the sampling habitats was determined. The detailed monthly prevalence was also measured (Tables 5&6). There was no significant difference in prevalence of *S. haematobium* infection in *Bulinus* spp in each group of habitat, FWH (P>0.05) and SWH (P>0.05) but there was significant difference in the infection when compared the two groups of habitats (P<0.05). 43(31.62%) of the *Bulinus* snails collected from FWH were infected whereas from SWH, 30 (18.51%) were infected (Table 5). The monthly prevalence of *S. haematobium* infections (Table 6) in *Bulinus* snails was not statistical different (P>0.05) and showed that for FWH, infections in *Bulinus* spp was high during the dry season whereas for the SWH infections in *Bulinus* spp was high during the rainy season.

Table 6 Monthly prevalence of *S. haematobium* infections in *Bulinus* spp collected from flowing and stagnant water habitats

	Flowing water habitats			**Stagnant water habitats**		
	No. of *Bulinus* spp collected	**No. infected**	**Infection rate (%)**	**No. of *Bulinus.* spp**	**No. Infected**	**Infection rate (%)**
				Collected		
June	0	0	0	46	9	19.6
July	4	0	0	56	15	26.8
August	5	0	0	27	4	14.8
September	10	0	0	7	1	14.3
October	11	3	27.3	3	0	0
November	19	6	31.6	3	0	0
December	18	8	44.4	1	0	0
January	40	15	37.5	2	0	0
February	24	11	45.8	0	0	0
March	0	0	0	0	0	0
April	5	0	0	0	0	0
May	0	0	0	17	1	5.9
Total	136	43	31.6	162	30	18.5

FWH (P>0.05, df=8, χ^2=-2.373); SWH (P>0.05, df=8, χ^2=1.8)

The monthly transmission potentials (T.P) in FWH and SWH as calculated in table 7 are shown on the bar-charts on figures 4a&b. The T.P varies with month. For FWH, T.P increases from rainy months to dry months and decreases with the onset of rain. The months with no bar indicate zero transmission potential. In the SWH, T.P increases from dry months to rainy months.

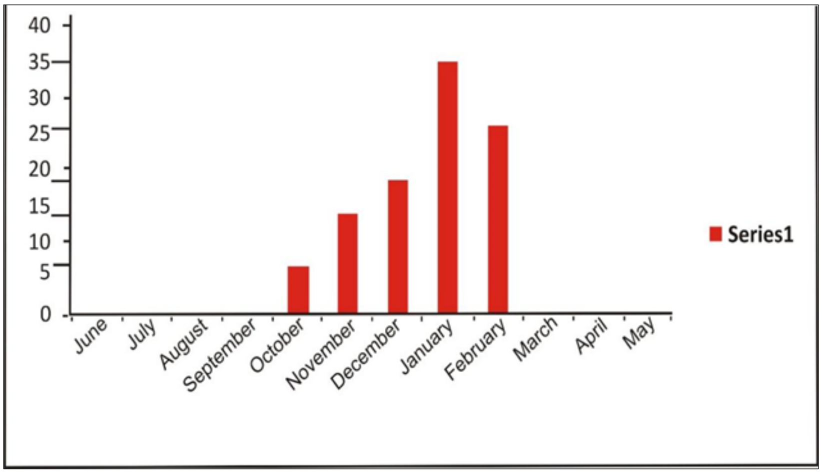

Figure 4a Monthly transmission potential based on the number of infected *Bulinus* species per month for flowing water habitats

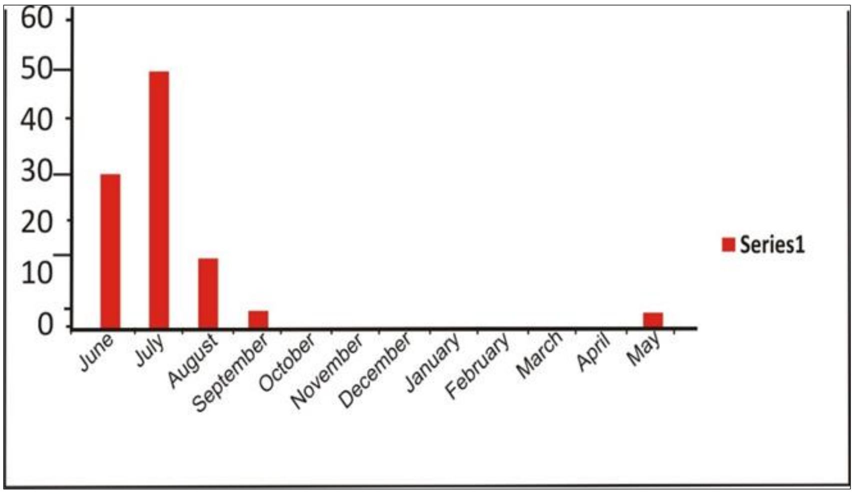

Figure 4b Monthly transmission potential based on the number of infected *Bulinus* species per month for stagnant water habitat

The transmission potentials in Table 7 varied with season and habitat type. It is shown to be very high during the dry season (a total of 93.0%) and low in rainy season (a total of 7.0%) for FWH and a zero potential during the dry season months and very high in the rainy season months (a total of 100.0%) for SWH.

Table 7 Seasonal transmission potential (T.P) based on the number of infected *Bulinus* spp collected from all habitats

Month	Flowing water habitats					Stagnant water habitats				
	No. of *Bulinus* spp collected	**No. infected**	**Infection rate (%)**	**Monthly T.P (%)**	**Seasonal T.P (%)**	**No. of *Bulinus* spp collected**	**No. infected**	**Infection rate (%)**	**Monthly T.P (%)**	**Seasonal T.P (%)**
June	0	0	0	0	Rainy season 7.0	46	9	19.6	30	Rainy season 97.0
July	4	0	0	0		56	15	26.8	50	
August	5	0	0	0		27	4	14.8	13.3	
September	10	0	0	0		7	1	14.3	3.3	
October	11	3	27.3	7.0	Dry season 93.0	3	0	0	0	Dry season 0
November	19	6	31.6	14.0		3	0	0	0	
December	18	8	44.4	18.6		1	0	0	0	
January	40	15	37.5	34.9		2	0	0	0	
February	24	11	45.8	25.6		0	0	0	0	
March	0	0	0	0	Rainy season 0	0	0	0	0	Rainy season 3.0
April	5	0	0	0		0	0	0	0	
May	0	0	0	0		17	1	5.9	3.3	
Total	136	43	31.6			162	30	18.5		

4. Discussion

The presence of three freshwater snails (*L. natalensis, B. globosus* and *B. truncatus*) suggests that some pools and rivers in Ishielu LGA are suitable habitat for these snails, hence supporting the development and transmission of their respective trematode parasites. This finding is similar to the previous report of Umechukwu[20] in a study at Agulu Lake, Anambra State, Nigeria. Ibikounle *et al.*[21] in a similar study in Republic of Benin (West Africa) found four species of human schistosome transmitting snails and seven species of non-human schistosome-transmitting snails. The total number of freshwater snails collected in this study (923) is less than the number collected in other areas in previous studies[2-3,22] which could be due to differences in the time, place and season of collection.

Studies on the relative abundance of the three snail species showed that *L. natalensis* had 67.7%, *B. globosus* 23.1% and *B. truncatus* 9.2%. This is comparable to Umechukwu[20], the noticeable difference probably being as a result of the environmental factors like increased sunshine, less rain, rocky terrain and hills, guinea savannah vegetation, slightly higher temperature in Ishielu than in Agulu which may have favoured *B. globosus* in the area than *B. truncatus* in terms of number. More *Bulinus* snails were found in Nkalagu for both flowing and stagnant water habitats than were found in Emuhu-Ali, Amazu and Ezillo which conforms to the findings of Okafor and Ngang[22]. Nkalagu has more detritus, rotten leaves and raffia as vegetative cover than the other communities. They serve as food for the snails, and also help to maintain optimum temperature.

The findings of this study showed that some of the *Bulinus* snails were infected by *S. haematobium.* The role of *Bulinus* spp as the snail host of *S. haematobium* in Nigeria has been previously recorded[8,10,23-25].The dynamics of cercarial transmission is very likely to be influenced by the infection rates of snails in individual habitats. This in turn, would affect the epidemiology of schistosomasis in a geographical area[23]. Thus, seasonal population changes in snail hosts, and their larval schistosome parasites are of great importance in the study of the epidemiology of the infection.

In this study, the infectivity rates of the *Bulinus* species were generally low for stagnant water habitats. This is also similar to studies made in stagnant waters by [20,26-27] and who found infectivity rate of *Bulinus* species to be generally low. However, the infectivity rate obtained in this work is noticeably higher than the ones cited above. The difference can be attributed to low intervention schemes. Public health enlightenment campaign and control of the vector snails are at low ebbs in the study area.

Furthermore, in Ishielu many rural dwellers still visit pools, streams and rivers for various activities, and it is possible they still defecate in and around the water bodies. Ecological factors such as irrigation and construction of dams which are evident in the area may also have contributed. In Ishielu, snails found at water banks or edges with more vegetation including detritus, rotten leaves and raffia were larger in size than those found in less vegetation areas suggesting that the large snails fed better and enjoyed more favourable temperature than the smaller snails. Greater numbers of larger snails were infected meaning that *S. haematobium* may have preferred and thrived more in large snails where penetration of the miracidium is more likely to be successful and encystations, formation of sporocysts and cercariae are more efficient. This finding lends credence to the report of Okafor[23] that snail size affects its infection.

Infection rate and prevalence of both *Bulinus* species tend to fluctuate during the months under study for both types of habitats. The increase in abundance of snail species during the dry season can be attributed to the more stability of the aquatic habitat in terms of water level and velocity. Incidentally, during the hot weather there was an increase in human-water contact activities in all the sites studied in Ishielu LGA as most people had used up their stored-up domestic water and needed the water bodies to continue to carry out their daily domestic tasks. There was need to cool the body equally especially in the afternoon and evening time. A similar observation was made by Idris and Ajanusi[28]. For the SWH, the highest prevalence of *Bulinus* and infection rates coincided with the rainy season with a peak in July whereas, during the dry season, both prevalence of snail and infection by the *S. haematobium* were low.

The monthly and seasonal transmission potentials of FWH in the study area were high during the dry season whereas those of SWH were high during the rainy season. This could also be attributed to the more stability of the aquatic habitat in terms of water level and velocity resulting in an increase in human-water contact activities.

5. Conclusion

In conclusion, identified vector snails in freshwater bodies in Ishielu LGA of Ebonyi State, Nigeria are *Lymnaea natalensis*, *Bulinus globosus* and *Bulinus truncatus* of which some of the *Bulinus* were infected with *Schistosoma haematobium*. Both season and habitat type have clear influence on the abundance of the snails, prevalence and transmission of cercariae showing when the human populations can be at the greatest risk of infection and must be considered before any controls targeted at the snails are made in order to optimize scarce resources and achieve massive results.

Compliance with ethical standards

Acknowledgments

Special gratitude goes to the Chief Technologists, Department of Environmental Biology, Ebonyi State University, Abakiliki Nigeria for his assistance in the identification of snails, preparation of slides, and observation of cercariae.

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval and informed consent

A letter of approval was collected from the Head of Department, Parasitology and Entomology, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria and was taken to the leaders of the communities where the study was carried out at Ishielu LGA and their consents sought before visiting their major water bodies. The letter was also taken to the Chief Technologist, Department of Environmental Biology Laboratory, Ebonyi State University, Abakiliki Nigeria for permission to use the laboratory.

Authors' contributions

UAU and CAE conceived the study and designed the study protocol; UAU and CIN and OAO carried out sample collection and laboratory liaison; CAE provided academic support and supervision; PCE, CBU and ESO carried out the analysis and interpretation of data; UAU, ESO, CAI and CIN drafted the manuscript; UAU, ESO and CAE critically revised the manuscript for intellectual content; All authors read and approved the final manuscript.

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