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PARASITIC AND ECOLOGICAL FACTORS ASSOCIATED WITH TRANSMISSION OF UROGENITAL SCHISTOSOMIASIS IN OWENA RESERVOIR AREA, ONDO STATE, NIGERIA

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Abstract

Human urogenital schistosomiasis caused by infection of the trematode worm *Schistosoma hematobium* is a major source of morbidity and mortality in Ondo State especially in Owena Reservoir Area, Ondo East Local Government Area, Ondo State, Nigeria. The aim of this study was to investigate: (i) the seasonal and spatial distribution, infection and cercariae shedding patterns of identified local *Schistosoma* intermediate snail host(s); (ii) to determine the influence of ecological factors on the identified intermediate snail species in the transmission of urogenital schistosomiasis along the Owena Reservoir and river courses. All the snails collected were placed in pre-labeled plastic containers and were transported to a Malacology Laboratory at Ile-Ife, Osun State, Nigeria. The snails were identified to species level, counted and recorded as number of snails, per site, per date. The snails were identified using standard identification keys. Examination of snails for *Schistosoma* infection was carried out by crushing method. Cercariae were identified to genus level. However, only snails shedding *Schistosoma* cercariae were recorded as infected. Each of the eight sites was sampled once monthly for twenty-four months. Eight stations (sites) of diverse ecological characteristics were selected along the Owena Reservoir and monitored for snails species' diversity, distribution and infection patterns, physicochemical properties of H_2O, macrophyte types and coverage in relation to the transmission of urogenital schistosomiasis. Seven snail species representing two sub-classes, three families and five genera were identified in Owena Reservoir Area. *Bulinus globosus and Bulinus truncatus* were the only established *Schistosoma* intermediate snail hosts in site 4 (KAJ 1) located in Kajola community. Out of the eight sites studied, site 4 in Kajola community had the highest infection rate while Embankment/Dam (site 8) had the least. Site 4 in Kajola community is therefore the major transmission site. All the snail species correlated positively with alkalinity conduction, negatively with air temperature. *Bulinus globosus* correlated significantly positive with *Ludwiga erecta, Ludwiga decurrens, Commelina africana,* and *Berberis calamus* (p<0.05) but correlated significantly negative with *Panicum maximus* and *Ervatomia hirta* (p>0.05). *Bulinus truncatus* correlated significantly positive with *Aspillia africana, Ludwiga decurrens, Emilia occinina,* and *Crosus sativue* (p<0.05) but correlated significantly negative with *Ludwiga erecta, Panicum maximus,* and *Commelina africana* (p>0.05). This study recommends environmental management and manipulation using water level regulations to render water contact sites environmentally unfriendly for both snail growth and human recreational activities during the period of high risk transmission since chemical control (the use of molluscicide) poses a risk to health, not only to the snail intermediate hosts but also to the inhabitants of the communities who commonly depend on reservoirs, streams, rivers, dams for their domestic water supply.

Keywords: *Bulinus globosus, Schistosoma hematobium, ecology, physicochemical parameters, hydromacrophytes, urogenital schistosomiasis, Owena Reservoir Area, Ondo State, Nigeria*

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Introduction

Schistosomiasis is a snail-borne, water-based parasitic infection caused by blood dwelling (hence called blood fluke) trematode worms of the genus *Schistosoma* [52]. The infection is now commonly known as Katayama's fever, swimmer's itch, Tsargiyya in Hausa language and Atosiaja in Yoruba language spoken in Nigeria [2, 32, 34, 54]. Out of the five species casing human Schistosomiasis, *Schistosoma mansoni,* and *Schistosoma hematobium* are of great medical importance [1, 33, 35]. *S. mansoni* and *S. hematobium* cause intestinal schistosomiasis and urogenital schistosomiasis respectively. The parasite, *S hematobium* is found in the venous plexus draining the urinary bladder of humans [6]. *S. hematobium* is transmitted by the intermediate snail host belonging to the genus, *Bulinus* [3, 8, 34].

Schistosomiasis is a chronic disease of the poor and marginalized [30]. It remains a major public health problem globally with approximately 779 million estimated to be at risk [6, 9, 35, 54]. In Nigeria, it has been reported that the disease is endemic in 23 out of the 36 states [32]. Ondo State is one of the states where urogenital schistosomiasis occurs [36, 37, 38, 39, 40]. However, epidemiological information of the disease in Ondo State, especially in the three communities bordering Owena Reservoir/Dam, is still very scanty. Information on the transmission of urogenital schistosomiasis and human water contact patterns in Ondo State is scanty despite widespread distribution of the disease in some of its neighboring states [36].

Urogenital schistosomiasis is highly endemic in three communities (Owena, Baiken and Kajola) of Ondo State, Nigeria [37]. There is a need for sustainable controls targeted towards behavioral modifications by mass sensitization and provision of pipe-borne water facilities and modern toilet systems with a view to discouraging people from having contact with cercacriae-infected water bodies [37]. Urogenital schistosomiasis and its concomitant hematuria are prevalent in Owena, Baiken and Kajola communities of Ondo East Local Government Area, Ondo State, Nigeria. In all three communities of Owena, Baiken and Kajola, urogenital schistosomiasis would be most difficult to treat and/or eradicate in Baiken community [38, 40]. Efforts by stakeholders should be geared towards implementing full control strategies such as provision of pipe borne water, modern toilet facilities, regular chemotherapy controls to the school age children and adults of age group 21–30 years [38].

Water contact activities exposed the communities to urogenital schistosomiasis infection. It is recommended that health education on transmission of urogenital schistosomiasis should be focused on mass sensitization, to emphasize the role commonly played by water contact activities of snail host [39]. Contamination habits such as urination and defecation in the water bodies should be discouraged. People should avoid wading into infected water bodies indiscriminately [39]. *Bulinus globosus* and *Bulinus truncatus* are the only identified intermediate hosts of *Schistosoma hematobium* in Owena Reservoir Area*. Bulinus globosus* showed predominance compared to the other intermediate snail host species at Owena Reservoir Area [40]. Therefore, intervention strategies for sustainable control of urogenital schistosomiasis in Owena Reservoir Area should focus on the two snail host species [40].

In the last decade, there has been a considerable advancement in the knowledge of the basic relationship between *Bulinus spp.* and *S. hematobium.* The resolutions of snail populations in a given aquatic habitat are influenced by both abiotic factors (e.g. temperature, ions – such as sodium, calcium, Biochemical Oxygen Demand (BOD), Dissolved Oxygen (DO), sunlight, alkalinity, water current velocity, rainfall, etc) and biotic factors (e.g. predator-prey interactions, food availability, competition for hydromacrophytes) [34, 41, 42].

At present, the link between schistosomiasis and hyperuricemia is still being studied. It has been established that urogenital schistosomiasis can cause hematuria [38], indicating a kidney damage (nephropathy) [14, 15, 18, 20, 26, 44, 46, 51]. Hyperuricemia has also been implicated in kidney damage [28, 45, 47]. Features of kidney damage in other pathological conditions such as metabolic syndrome diseases e.g. essential hypertensive disease and type 2 diabetes mellitus have been extensively studied [10, 11, 13, 19, 24, 27, 43]. Nevertheless, sodium-glucose linked transporter-2 (SGLT-2) inhibitors and glucagon-like peptide-1 receptor agonists (GLP-1 RAs) have been found effective in treating patients with such co-morbid pathologies [12, 16, 17, 21, 25, 48, 49, 50].

Many ecological factors (both abiotic and biotic) go a long way to influence the density, distribution and abundance of intermediate host freshwater snails [31, 34]. The paramount abiotic factors are the physico-chemical properties of fresh water bodies inhabited by the snail host species, which have significant effects on the survival, bionomics, distribution, infection rates and density fluctuation of the snails [34, 35]. Important physico-chemical parameters such as alkalinity, temperature, conductivity water current velocity and a host of other physical and chemical factors affect snail distribution in water bodies. Local distribution of snails in reservoir is significantly influenced by conductivity, Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD). Major free radicals that are of physiological significance are superoxide anion, hydroxyl radical, and hydroperoxyl radical, while non-radical is hydrogen peroxide [22]. Temperature is particularly important in the regional distribution of snails. Rainfall affects snail density by regulating water current velocity and water levels of both lotic and lentic habitats, as well as the duration of desiccation and the prospect of recovery from aestivation [53].

As regards biotic factors, the principal biotic factors are the hydromacrophytes (aquatic higher plants). Hydromacrophytes play important roles in the distribution of intermediate snail host in rivers, lakes, reservoirs, dams, and other freshwater bodies [30, 31, 34]. Hydromacrophytes not only provide excellent breeding sites, but they also provide protection from direct sunshine and unfavorable water currents [35]. Alteration in the DNA sequence which produces new alleles [23] may also be a contributory biotic factor. Several research reports have shown that there is a significant association between some intermediate host species and some specific hydromacrophytes in different parts of the world [29]. In Nigeria, *Pistia stratiotes, Indoplanorbis exutus, Impatients irving* are associated with *Bulinus globosus* at Oyan Dam in Ogun State, Nigeria [31].

From the above, knowledge about the physico-chemical properties and hydromacrophytes in freshwater habitats inhabited by snail intermediate host of *Schistosoma hematobium* is necessary to plan sustainable control strategies of the disease in the study area. Hence, the aim of this study was to determine the parasitic and ecological factors associated with the transmission of urogenital schistosomiasis in Owena Reservoir Area.

Materials and Methods

Study area

The twenty-four month (August 2013 – July 2015) study was carried out in Owena Reservoir and its adjoining three randomly selected communities (Owena, Kajola and Baiken) which are rural to semi-urban settlements in Ondo East Local Government Area, Ondo State, Nigeria and lies between latitudes $7^{\circ}00'$ – $7^{0}30^{1}$N and longitudes $5^{0}00^{1}$ - $5^{0}30^{1}$E (see Fig. 1). National Population Commission reported in 2006 that the population of Owena Reservoir Area is approximately 9,000. The inhabitants are predominantly peasant farmers, petty traders, teachers, auxiliary health officers, oil mill workers, and fishermen.

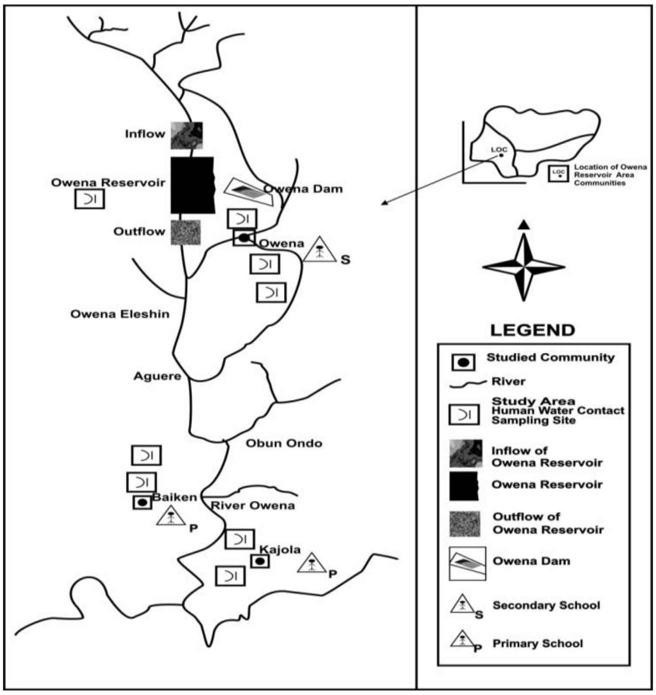

Fig. 1. Map of Owena showing Owena Reservoir, Owena Dam, Owena River and the eight sampling sites of Owena, Kajola, and Baiken communities

Source: Igboloro and Associates (Planners, Architects and Engineers), 3 Ayodele Awodeyi Street, Ketu, Lagos State, Nigeria (2012)

Selection of sampling site

Sites were selected on the basis that they are either potential snail-breeding sites, human water contact sites (where the frequency of visitations by the inhabitants and proximity to the residences was considered as topmost priority) or both.

Snail sampling

Each of the eight sites (three sites from Owena community, two from Kajola community, two from Baiken community and one from Embankment) was sampled once monthly for twenty-four months, from August 2013 – July 2015. Sampling involved 30 passes of kitchen scoops and a manual search for 30 persons-minutes [4, 34, 53]. The snails were identified using standard identification keys to species level, counted and recorded as number of snails per site, per date. The number of each snail species was counted to determine the number of each species or genera, per month, per site. The snails were then grouped into <3.0mm, 3.0-5.9mm, and 6.0-9.0mm size classes.

Examination of snails for Schistosoma infection

Examination of identified snails for *Schistosoma* infection was done by the crushing method using a device [5]. Each of the snails was placed on a slide covered with another slide and minor pressure was applied on the top slide to gently crush the snail. Some drops of dechlorinated water was then added to the longer pieces of shell removed, using small forceps. The slide was then observed under a light microscope for the presence or absence of cercariae. The cercariae were identified to genus level [8]. However, only snails shedding *Schisosoma* cercariae were recorded as infected. Other data about size, species, date of collection and site of selection of infected snails were recorded.

Physico-chemical characterization of water

Water samples (surface samples only) were collected from each of the identified sites once every month for 24 months. Sample for Dissolve Oxygen (DO) determination was collected in 250ml white glass, light reagent bottles with a stopper and fixed immediately in the field using the Winker's reagent. Sample for Biochemical Oxygen Demand (BOD) determination was collected in dark reagent bottles as described for DO but fixed after five days incubation in the dark. Secchi disk was used to measure water transparency or turbidity. Water pH was determined using a pH meter. Conductivity was determined by an electric conductivity meter (mode 7020) and expressed in μScm^{-1}. Total alkalinity was determined by titration with sulfuric acid using mixed indicators, expressed as mg/L. $CaCO_{3,}$ DO and BOD were determined by titrating with 0.012SN sodium thiosulphate using an indicator. Ions of Ca^{2+}, K^{+}, Mg^{2+}. Na^{+}, $C1^{-}$, SO_4^{2-} and NO_3 were determined using analytical and instrumental methods.

Hydromacrophytes sampling

Aquatic macrophytes were sampled as described by Ofoezie [31] and Ekpo, *et al* [7]. All types of marginal, emergent and floating macrophytes found in each of the eight sites were collected, properly labeled and deposited at the Ife Herbarium located within Obafemi Awolowo University, Ile-Ife, Nigeria for identification to species or genera. Each macrophyte was monitored once monthly in each of the eight sites for presence, density and relative association with intermediate snail host species.

Ethical considerations

Heads of the communities, schools, teachers, students, and other adults in the communities were briefed about the twenty-four month study. Study respondents agreed to participate willingly and conclusively in the study. The respondents were assured that the information gathered from them would be kept confidential.

Results and Discussion

During the twenty-four month period of this study, a total of 25,482 snails, comprising 4,258 *Bulinus globosus* (16.7%)*,* 213 *Bulinus truncatus* (0.8%), 4,040 *Bulinus forsakalii* (15.9%), 4,770 *Biomphalaria pfeifferi* (18.7%), 6,024 *Melanoides tuberculata* (23.6%), 1,730 *Potadoma freethi* (6.8%) and 4,447 *Pila ovata* (17.5%) were collected. Thus, *Bulinus globosus* was the most abundant intermediate host snail collected and *Bulinus truncatus* the least. Out of the 4,258 *Bulinus globosus* snails collected and examined for trematode infection, only 136

(3.2%) were found to be shedding trematode cercariae. Only *B. globosus* greater than 3mm were found to be shedding cercariae. From the above, the overall infection rate among *Bulinus globosus* was 3.2% (136 were infected with cercariae out of 4,258 examined (see Table 1).

Table 1. The relative abundance and rates of *Schistosoma* infection i.e. cercariae shedding patterns of small (3.0-5.9mm) and large (6.0-9.0+mm) *Bulinus globosus* collected in a total of twenty – four monthly site visit in Owena Reservoir Area

Sites	Small snails (3.0-5.9mm)			Large snails (6.0-9.0+mm)			Total		
	Total Collected	Total Infected	% Infection	Total Collected	Total Infected	% Infection	Total Collected	Total Infected	% Infection
Owena									
Site 1	113	0	0	408	11	2.7	521	11	2.1
Site 2	163	0	0	413	15	3.6	576	15	2.6
Site 3	154	0	0	378	12	3.2	532	12	2.3
Kajola									
Site 4	158	6	3.8	466	47	10.1	624	53	8.5
Site 5	176	0	0	504	6	1.2	680	6	0.9
Baiken									
Site 6	131	0	0	399	13	3.3	530	13	2.5
Site 7	121	0	0	357	24	6.7	478	24	5.0
Embankment/Dam - Owena									
Site 8	80	0	0	237	2	0.8	317	2	0.6
Total	1,096	6	0.6	3,162	130	4.1	4,258	136	3.2

Source: Peletu B.J. – Field snail sampling for *Schistosoma* infection at Owena Reservoir Area: Owena, Kajola and Baiken communities, Ondo State, Nigeria

The relative abundance of the combined small (3.0-5.9mm) and large (6.0-9.0+mm) *Bulinus globosus* was relatively comparable between Owena and Kajola communities but significantly different ($p<0.05$) between Baiken community. The overall infection rate among *Bulinus globosus* was 136 (3.2%) out of a total of 4,258 collected. The relative distribution of infection rates was significantly ($p<0.05$) different among the sites.

Table 2. Community ranking and important diseases in the three studied communities (Owena, Kajola and Baiken)

Variable	Cases	Owena (n=242)		Kajola (n=203)		Baiken (n=187)		Total		χ2	*df*	Sig.
		No.	%	No.	%	No.	%	No.	%			
Most important disease in community	Malaria	198	81.82	163	80.30	151	80.75	512	81.01			
	Schistosomiasis	39	16.12	34	16.75	30	16.04	103	16.30	0.662	4	0.956
	Others	5	2.07	6	2.96	6	3.21	17	2.69			
Significance of blood in urine	Not Infected	22	9.09	0	0.00	0	0.00	22	3.48	57.834	8	0.000
	Infected	24	9.92	30	14.78	50	26.74	104	16.46			
	Menstruation	18	7.44	15	7.39	18	9.63	51	8.07			
	Normal	45	18.60	38	18.72	29	15.51	112	17.72			
	Don't know	133	54.96	120	59.11	90	48.13	343	54.27			

Source: Peletu B.J. – Field administration of questionnaire for perception of *S. hematobium* infection at Owena Reservoir Area: Owena, Kajola and Baiken communities, Ondo State, Nigeria

Table 3. Summary of socio-demographic characteristics of Owena, Kajola and Baiken

Variable	Cases	Male (Average/ mean in %)	Female (Average/ mean in %)	Total (in %)	χ2	*d f*	*p*-value
How dangerous is Schistosomiasis?	Very dangerous	23.33	17.55	20.57	5.947	3	0.110
	Moderate	13.64	19.54	16.46			
	Not dangerous	34.85	34.11	34.49			
	Don't know	28.18	28.81	28.48			
Blood in urine	Yes	72.12	71.52	71.84	0.28	1	0.86
	No	27.88	28.48	28.16			
Snails seen around reservoir	Yes	87.58	90.07	88.77	0.98	1	0.322
	No	12.42	9.93	11.23			
Is snail related to Schistosomiasis infection?	Yes	12.42	9.60	11.08	1.27	1	0.259
	No	87.58	90.40	88.92			
Visit to Rerservoir/River/Stream	Yes	99.70	97.68	98.73	5.12	1	0.24
	No	0.30	2.32	1.27			
How is schistosomiasis transmitted?	Drinking of water	5.45	3.31	4.43	12.6	2	0.002
	Going into water	24.55	14.57	19.78			
	Don't know	70.00	82.12	75.79			
Toilet facility	Yes	96.06	92.05	94.15	4.595	1	0.32
	No	3.94	7.95	5.85			
Did you receive treatment for schistosomiasis infection?	Yes	72.12	71.52	71.84	0.28	1	0.86
	No	27.88	28.48	28.16			

Source: Peletu B.J. – Field administration of questionnaire for perception of *S. hematobium* infection at Owena Reservoir Area: Owena, Kajola and Baiken communities

Physico-chemical characterization of water

The median and range values of the physico-chemical parameters determined in the eight sites at Owena-Ondo, Kajola and Baiken communities are illustrated in Table 4.14. The overall median range of air temperature was 25.5 – 27.75^{0}C, water temperature 25.5-27.75^{0}C, depth 35.0–57.50cm, transparency 31.5–46.0cm, DO 4.1-5.2mg/LO^2, BOD_2 1.7-3.2mgKO_2, potential hydrogenii (pH) 5.7–6.4, conductivity 82-297µSm^{-1}, alkalinity 28-110.5mgL $CaCo_2$, alkanility and conductivity values were higher in Owena Community than Kajola and Baiken. The values in Owena demonstrated seasonal variation unlike those one in Kajola and Baiken. The conductivity and alkalinity were higher in the November to February months (dry season months) with peak conductivity in January. At Kajola and Baiken sites, the values fluctuate around the annual mean, the highest conductivity value in February and least in August while the highest alkalinity value occurs in January and the least in June.

Table 4. Mean and range values of the physico-chemical characteristics of water collected from the 8 sites of Owena Reservoir Area

PARAMETER	OWENA			KAJOLA		BAIKEN		EMBANKMENT (DAM)
	S1	S2	S3	S4	S5	S6	S7	S8
Air temperature	24(15.5-28)	24.2(18-7.5)	27.9(22.5-38)	27(23-5.31)	28(23-31.5)	27.9(21.7-33.5)	23.6(17.2-33.5)	23.5(18.3-6.9)
Water	27.6(23.5-	27.8(23.8-	28.7(26-	27.8(26-	25.5(22-	26.5(22-29	26.7(26-	25.4(27.15-2)

temperature	1.5)	2)	34)	32)	29)		29.5)	
Depth	36(34-40)	42(38-51)	40.3(26-50)	41(27-50)	57.5(22-29	50(28-75)	45.5(31-63	45.5(21-66)
Transparency	31.5(28-38)	37.5(29-41)	36(19-46)	36.5(18-46)	39(18-12.7)	41.4(26-58)	37(29-60)	41.5(19-59)
DO	6.1(2.8-8.5)	6.2(3.2-8.4)	6.4(3.6-14.2)	5.9(4.6-11.4)	4.8(3.5-12.6)	5.3(3.1-9.1)	6(4.2-8.0)	5.1(3.5-8)
BOD	2(0.7-4.4)	1.8(0.6-3)	3.8(1.2-7.6	2.4(0.6-3.2)	4.2(0.2-6.7)	2.6(0.3-3.9)	2.7(0.6-5.4)	3.2(0.9-4.8)
pH	6.875(6.6-7.3)	6.8(6.5-7.5)	5.7(6.5-7.5)	6.8(6.7-7.2)	7.3(6.9-7.4)	6.7(6.9-7.5)	7.3(6.9-7.5)	7.3(7.0-7.5)
Conductivity	83(73-110)	84(71-104)	76(61-115)	77.5(66-160)	246(144-575)	298(189-630)	176.5(131-196)	183(128-290)
Alkalinity	33(20.5-38)	31.4(26.8-3	29(22-41)	29.8(23-50)	93(63.3-102)	110.5(77-221)	71.5(51,5-96)	72(59-90)

Source: Peletu B.J. – Field monitoring of water samples (physico-chemical characteristics) at Owena Reservoir Area: Owena, Kajola and Baiken communities, Ondo State, Nigeria

Matrix of Spearman rank-order correlation between physico-chemical parameters and snail density

The matrix of Spearman rank-order correlation between physico-chemical parameters and snail density in Owena, Kajola and Baiken communities showed that the snail species correlated positively with alkalinity, conductivity and negatively with air temperature but only *Potadoma freethi* and air temperature correlated to a statistically significant level (p<0.001). *Melanoides tuberculata* correlated positively and significant with both pH and conductivity. *Biomphalaria pfeifferi* correlated negatively and significant with BOD.

Distribution of hydromacrophytes in Owena Reservoir Area

49 hydromacrophytes were found in sites 1 to 3 (Owena), 39 in sites 4 and 5 (Kajola), 29 in sites 6 and 7 (Baiken), and 6 in site 8 (Embankment). In terms of site distribution, *Ludwigia erecta, Aspilia africana, Paspalum polystachyum, Paspalum conjugatum, Basil ocinum, Lemna hispora* were found in all the three sites of Owena. *Ludwigia erecta, Panicum maximus, Ludwigia decurrens, Valeria offucinalis, Vernonia amydalina, Paspalum polystachyum, Nasturtium officinate, Leersia hexandria, Paspalum conjugatum, Berberis calamus, Impatiens irvingil* were found in all two sites of Kajola. *Ludwigia erecta, Panicum maximus, Vernonia amydalina, Emilia occinia, Berberis calamus, Paspalum orbiculare, Impatiens irvingil, Polygonum lanigerum, Ceratophyllum demersum, Pistia stratioites* were found in the two sites of Baiken and *Ludwigia erecta, Urena nobata, Emilia occinia, Ervatomia hirta, Berberis calamus, Crosus sativus* were found in site 8 (Embankment). However, in terms of hydromacrophyte population, site 4 in Kajola was the most densely populated of all the sites with 23 hydromacrophyte species, while site 8 (Embankment) was the least populated with 6 hydromacrophyte species.

Table 5. Results of statistical correlation analysis of temporal variations in physico-chemical properties (ions) and biological properties (snail density) measured in all three communities (Owena, Kajola and Baiken)

Parameter	All sites combined
Physico-chemical properties (ions)	
Calcium (Ca^{2+})	Ns
Magnesium (Mg^{2+})	0.005**
Nitrate ($N0_3^-$)	Ns
Sulfate (SO_4^{2-})	Ns
Chloride (Cl^-)	Ns
Potassium (K^+)	Ns
Sodium (Na^+)	Ns
Snail density	
Bulinus globosus	Ns
Bulinus truncatus	Ns
Bulinus forskalii	Ns
Biomphalaria pfeifferi	0.024*
Potadoma freethi	Ns
Melanoides tuberculata	Ns
Pila ovata	Ns

** - Correlation is significant at 0.01 level;
* - Correlation is significant at 0.05 level;
Ns - Correlation is not significant

Source: Peletu B.J. – Field monitoring of water samples (ion characteristics) at Owena Reservoir Area: Owena, Kajola and Baiken communities, Ondo State, Nigeria

All seven snail species in Owena Reservoir Area showed seasonal variety in density. *Bulinus globosus, Bulinus truncatus, Biomophalaria pfeiferri,* and *Mellanoides tuberculata* followed common bimodal pattern with peaks in July/August and November/December. The pattern of fluctuations in snail density may result from variations in the reservoir, physico-chemical parameters, hydromacrophytes, surface water temperature, and water levels.

Conclusion

Bulinus globosus and *Bulinus truncatus* play an important role in the transmission of *Schistosoma hematobium* in Owena Reservoir Area. Therefore, intervention strategies for sustainable control of the disease could focus on these two snail species. *Bulinus globosus* density correlation with some specific hydromacrophytes, and physico-chemical properties could be a viable intervention strategy for snail control in Owena Reservoir Area. Ecological factors - both abiotic (e.g. water temperature, rainfall, water discharge patterns, etc) and biotic e.g. (hydromacrophytes, etc) influence snail density in Owena Reservoir Area. The ecological variations of both snail density and *Schistosoma hematobium* infection rates are focal and seasonal.

Prospects for further research

Further research should be aimed at finding effective treatment regimens for people infected with schistosomiasis.

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Conflict of Interest

The authors guarantee responsibility for everything published in this manuscript, as well as the absence of a conflict of interest and the absence of their financial interest in performing this research and writing this manuscript.

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Authors Contribution

All authors contributed in different aspects of the research.

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