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Distribution, Abundance and Infection Rate of Water Snails in Hadejia River Valley, Jigawa State, Nigeria

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Abstract

This study was carried out to determine the distribution, abundance and infection rate of water snails in Hadejia river valley, Jigawa State, Nigeria. A total of 150 and 437 snails were collected during dry and rainy season respectively. Snail species collected in rainy season were higher than those collected in the dry season. Pila ovata was the only snail species collected during the dry season. The Highest abundance (56.7%) of Pila ovata was collected in the month of May and least (19.3%) snail collection was in March. Pila ovata and Lanistes varicus are the snail species collected during the rainy season. Higher snails collection was in July (37.9%) followed by August (36.1%) and least snails species collection was in September (26.0%). There was an association between the two snail species in monthly collection ($p<0.05$). Pila ovata was the most abundant snail species during rainy season (370) and Lanistes varicus was the least abundance (57). Distribution of 150 Pila ovata collected among three sites of collection during dry season showed (42.0%) of snails species were collected in the farm, followed by river (30.7%) and least snails' collection was in the dam (27.3%). There was no association between the two snails species collected from the sites ($p>0.05$). Out of 150 snails collected in the dry season the

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overall infection rate of snails by cercariae was 7.33%. Highest infection rate was recorded in the farm 5.33%, followed by river with infection rate of 1.33% and least infection rate was 0.67% in the dam. During the rainy season, overall infection rate by cercariae was 12.2%. Highest infection rate of P. ovata was 7.9% in the river, followed by the farm with 1.87% and least infection rate was 0.23% in the dam. Higher infection rate by cercariae of Lanistes varicus in both farm and dam recorded 0.4% each and least infection rate of 0.23% was in the river. There was significant difference in seasonal infection rate of snails (p>0.05) by cercariae based on sites of collection. Surface temperature of water during dry season ranges between 22 and 25°C and surface temperature of water during the rainy season ranged between 19 and 21°C. Seasonal abundance of snails increased with decreased in temperature in both dry and rainy seasons. The pH of water ranged between 10.0 and 11.5 and snail abundance increased with increased in the pH in both dry and rainy season. The mean rainfall ranged between 144 and 198.5 mm and snails abundance decreased with increased in rainfall. Mean relative humidity ranged between 1.599 and 2.420 in dry season, while in rainy season mean relative humidity ranged between 2.019 and 2.060 and snails abundance increased with increased in relative humidity during dry season, but in rainy season snail abundance decreased with increased in relative humidity. There was no significant difference between seasonal abundance snails (p>0.05)in relation to physico-chemical parameters.

Keywords: Abundance, Distribution, Infection, River, Snails, Hadejia, Valley

INTRODUCTION

Schistosomiasis which is also known as bilharzias, is a water borne disease caused by the parasites of the genus schistosomes (Noble and Glem, 1982). It is one of the 20 tropical diseases on the World Health Organization (WHO) list of neglected tropical diseases (WHO, 2018). It is a digenetic trematode that resides in the blood vessels of man and other livestock. Four species of schistosoma are common to man; *Schistosoma haematobium*(*S. haematobium*), *Schistosoma mansoni* (*S. mansoni*), *Schistosoma japonicum* (*S. japonicum*)and *Schistosoma intercalatum* (*S. intercalatum)* (WHO, 2013). Schistosomiasis is one of the most important tropical diseases in terms of public health affecting more than 200 million people and is second only to malaria in terms of public health importance, killing an estimated 280, 000 people each year in the African region alone (Akineye *et al*., 2018).

Globally, schistosomiasis affects 78 countries, out of which 52 are at risk of the infection (WHO, 2013). About 243 million people are infected and more than 700 million lives in endemic area of the disease and of those numbers, about 200 million to 300 million people die annually and most affected people are in the developing countries (Yusuf *et al*., 2015). *Schistosoma haematobium* occurs in Africa and middle East, where as *S. mansoni* occur in America and Africa, *S. japonicum* is located in Asia, primarily the Philippines and China (Omenesa *et al*., 2015). Those three species are more localized and distributed species also caused human disease. Others are *S. mekongi* found in the Mekong river basin and *S. guineensis* and *S. intercalatum* found in West and Central Africa respectively (Colley *et al*., 2014).In Nigeria, schistosomiasis is due to *S. haematobium* which is wide spread constituting a public health problem particularly in children (Bala *et al*., 2012). Schistosomiasis has been on the increase in Nigeria due to inadequate prevention, control and treatment (WHO, 2013). Nigeria is one of the highly endemic countries where the disease has been reported and large areas remain where the disease is known. An estimated 120 million suffer severe consequences of the infection with an estimated annual mortality rate of about 20, 000 worldwide. An estimated 20 million Nigerians need to be treated annually for the disease. In most endemic areas the highest intensities of the infection are found in children between 5 and 15 years of age. In Sub Saharan Africa alone, it is estimated that 70 million individual experience haematuria, 32 million difficulty in urination (dysuria), 18 million bladder wall pathology and 10 million major hydronephrosis from infections caused by *S. haematobium* annually. The

mortality rate caused due to non functioning kidneys (from *S. haematobium*) and haematomesis has been estimated to be 150, 000 per year (Charles *et al.,* 2019) .

Snails that are responsible for schistosomiasis in humans belong to one of the three genera: *Biomphalaria* species for *S. mansoni, Bulinus* species for *S. haematobium* and *Oncomelania* species for *S. japonicum* (Colley *et al.,* 2014). *Schistosoma haematobium* is transmitted by group of Planobid fresh water snails of the genus *Bulinus* found around sources of water such as streams, slow flowing rivers, ponds and irrigation canal s where the rural inhabitants rely on their recreation, occupational, domestic and agricultural activities (Houmsou *et al.,* 2016). Intermediate host of schistosomiasis breeds in slow flowing stagnant water, reservoir of dams provides favourable conditions for year round transmission of the disease, even in areas where snail distribution used to be seasonal (Charles *et al*., 2019). Infection occurs through contact with cercariae that penetrate the skin and develop in the human body with urine or excreta. They hatch in fresh water and infect the appropriate hosts of *Bulinus* species, the intermediate host of *S. haematobium* (Gryseels and Strickland, 2013). Within the snail they develop into cercariae which in turn release in to water to infect new human host (Colley *et al*., 2014). Transmission can take place in any type of habitat from large lakes or rivers, seasonal ponds or streams. In urinary schistosomiasis the worm lives in the blood vessels of the bladder, only about half of the eggs are excreted in the urine. The rest stay in the body, damaging other vital organs (Gryseels and Strickland, 2013). It has been reported by Bala *et al*., 2012 that the eggs and not the worms itself that cause damage to the bladder, intestines and other organs.

Snail transmitted diseases constitute an integral part of parasitic diseases transmitted to humans as many fresh water snails serve as intermediate host in the trematode-parasite transmission cycle (Rivas *et al*., 2014). Globally, many species of fresh water snails belonging to the class of highly infective flukes of veterinary importance cause severe debilitating illness in millions of animals (Njoku-tony, 2011). Many fresh water snails of clinically and veterinary importance, serve as intermediate hosts of different helminthic parasites of humans and animals (Abdulhamide *et al*., 2018; Abaje *et al*., 2019). The fresh water snails belonging to the *planobidae* family are mostly found intermediate hosts of the highly infective trematode lavae of the genus Schistosoma, the causative agent of the disease schistosomiasis. The spatial distribution of intermediate hosts determines the presence and prevalence of trematode infections larvae transmitted by the intermediate hosts (Nwosu *et al*., 2006). Most region of the world has specific snail hosts responsible for transmission of trematode infection, for example *Biomphalaria* Species *and Oncomelania* species transmitted parasite *S. mansoni and S. japonicum* while *Bulinus* species transmited *S. haematobium* parasite in Africa (Ayanda, 2009). Nigeria, the population dynamics of snail under both natural and experimental conditions and their cercarial release pattern, may be depended on the vegetative cover, physical and chemical properties of the environment (Joshua and Albert, 2015). The aquatic snails' hosts of schistosoma occur in shallow water near shores of lakes, ponds, marshes, streams and irrigation channel. They live on water plants and mud that is rich in decaying organic matter. The present of intermediate host in an area is one of the major factors in maintaining the transmission of schistosomiasis. The removal of vegetation cover changes the ecology of fresh water snails species population by increasing sun light penetration, encouraging growth of vegetation and changing water levels and flow rates with respect to different ecological zones (Opayemi and Alex, 2021). However, snail species do not survive those changes, but those that survive tend to be better hosts for the parasites worm (Molyneux, 2008). Snail species inhabit water bodies with a wide range of dissolved chemical contents and their abundance is dependent on water chemical content. Generally, rainfall among other factors affects the distribution of fresh water snails in different areas (Odongo-Adinya *et al*., 2008) Water, relative

humidity, temperature, pH, dissolved oxygen and conductivity have effects on the fecundity, mortality and death of planorbids (Hussain *et al*., 2011). Other factors that affect distribution of fresh water snails include light, water, velocity, vegetation and water depth. Snail collecting time is to be done in the morning hours between 8.00 am (minimum) to 12.00 pm (maximum). Method of collection was visual search for snail on vegetative cover, manual hand picking wearing protective hand gloves as protection against infection by cercariae and using scoop net at right angle to the banks of water body 2 meter deep (Oguoma *et al*., 2010).The aim of this study is to assess the distribution, abundance, effect of physical and chemical parameters and infection rate of water snails in the study area.

MATERIALS AND METHODS

Study Area

The study was conducted for three month in dry and rainy season in Hadejia river valley, Jigawa State; Nigeria. The area is endemic for urinary schistosomiasis infection. Hadejia Local Government is located in the north eastern corner of Jigawa State. It lies between 9^0 37′ E and 10^0 35′ E Longitude and 13^0 02′ N Latitude. The climate of the region is wet and dry type, rainfall spread between June to September with mean annual rainfall of 315 mm. The soil in the study area is sandy-loam. River Hadejia provides water for irrigation and fish production. People in the area are farmers that grow both rain fed and irrigated crops, some are animal breeders and businessmen (Gambo *et al*., 2020)

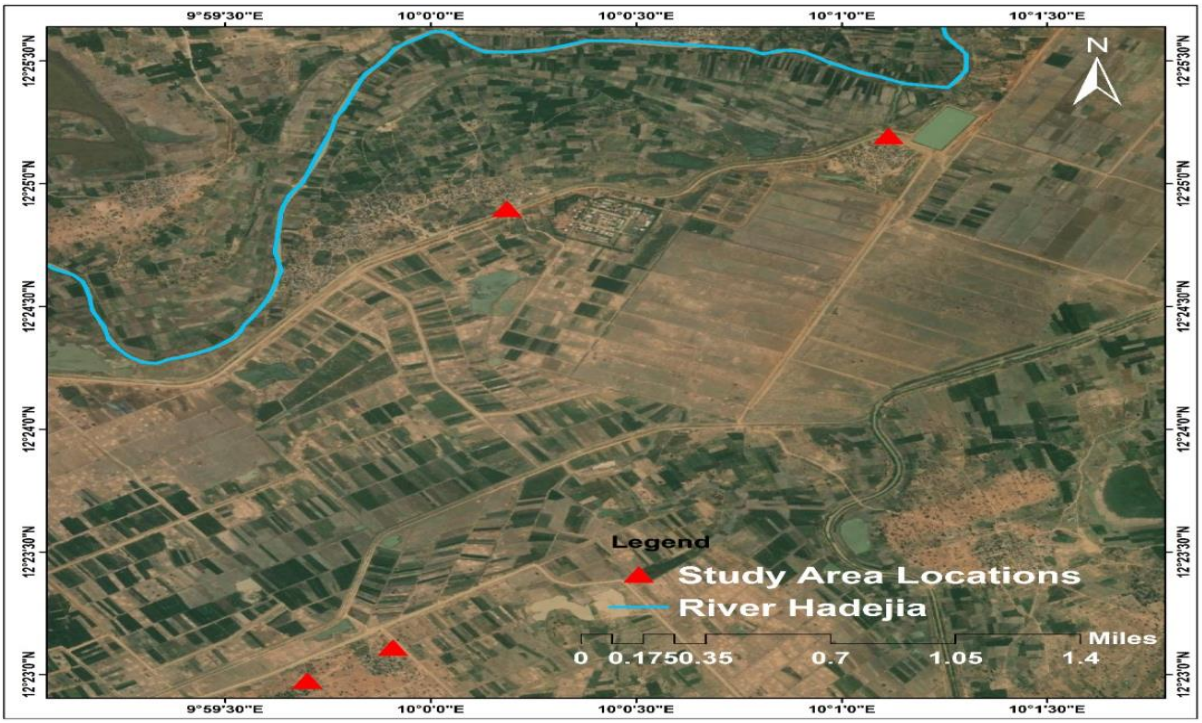

Figure 1: A map showing the study area

Water Quality Monitoring

During the period of this study (dry and rainy season) the physical parameters such as temperature and the pH were analyzed using thermometer with mercury in a glass container. The thermometer was held in water for 2 minutes and reading was taken while the pH meter type pH107was also held to a maximum immersion level and reading was taken. Rain fall and relative humidity of the study area was sourced from Jigawa State Agricultural and Rural Development Authority.

Physiology and Adaptation of Snails

Snails use water and vegetation for food, shelter and as substrate for laying their eggs. Absence of all or any of the above factors adversely affects the existence of snails. At low temperature of about 14^{o}C and a high photoperiod, the egg-mass production of snails ceases (Njoku-Tony, 2011). At pH of 6.0, egg-laying and hatching is maximal (Njoku-Tony, 2011). Generally, snail abundance was slightly higher in rainy season. But with increase in rainfall and relative humidity there is decrease in snail abundance (Opeyemi and Alex, 2021).

Collection of Snail Samples

Samples were collected from three different sites; site A is the dam, site B is the river and site C is the farm were studied accordingly. These are the major areas where human activities occur and are the sources of the infection. In each of the sites, snails were collected once monthly for a period of three months in dry and rain season. Snails were collected using scoop net and manual search was done using hand picking with a pair of hand gloves. Scoop net attached to a long wooden handle with fine meshed net tied to the frame. The scoop net was laid down into water edge near the vegetation (were the snail was found) by holding its handle and digging into water and was raised excavating up capturing the snails around the water banks. Each collection entails a 30 minutes kick sampling at a radius of 50 meters. The whole procedure was repeated for the other sites A, B and C respectively. Snails collected were transferred into plastic buckets half filled with water from the same habitat and labeled in the field. Snails were maintained and fed with lettuce leaves. Snails were now transported to the Biology Laboratory in the Department of Science Laboratory Technology, Binyaminu Usman Polytechnic, Hadejia, Jigawa State. In the laboratory snails, were washed to remove dirt. Snails samples were transferred into plastic tank of dimension 35cm by 75cm. The plastic tank contained water from bore hole and substrate of washed sand/gravels with some aquatic plants associated with the snails from the natural habitat.

Identification of Snail Samples

The snails were group based on their shells size, colour, shape, and position of the eye (Brown and Kristensen, 1993). Snails' samples were identified in the Department of Biological Sciences of Ahmadu Bello University Zaria.

Examination of Snail Cercariae

Snails were kept in the plastic tank for 2 days to acclimatize and fed with aquatic vegetation. Using forceps, the snail was placed individually into 250 ml beaker containing some water and leaves from the plastic tank. The beakers were covered with rubber net and tightened at the tip to prevent the snail from coming out of the beakers. The beakers were then kept inside the plastic tank (15 to 20 beakers per plastic tank). The plastic tank was then exposed to bright day light for two hours. Snail that did not shed cercariae was monitored for shedding cercariae at one hour interval (Taofiq *et al.,* 2017). The water was examined for cercaiae using hand lens. All the positive once were separated with negative once for recording. The cercariae were identified by observing the head and tail as described by Brown and Wright. (1980).

Statistical Analysis

Data was analyzed statistically using statistical package for social sciences (SPSS) software at $p<0.05$ level of significance to determine if there was an association between the variables. Chi-square(X^2) test was employed to determine the degree of association between prevalence of the infection, age, sex and occupation.

RESULTS

A total of 150 and 427 snails were collected in dry and rainy season respectively. Snail species collected in rainy season was higher than those collected in dry season. Table 1 shows

abundance of snails in the dry season in the study area. *Pila ovata* (Plate 1) was the only snail species collected in the dry season. The highest number (56.7%) of *P. ovata* was recorded in the month of May and least (19.3) snails collection was in March.

Table 2 summarized abundance of snails in the rainy season in the study area. Two different snails' species were identified during the rainy season in the study area. The two species identified are *Pila ovata* and *Lanistes varicus* (Plate 2). Highest number (37.9%) of snails recorded in the rainy season was in July and least (26.0%) snails' collection was in September. *Pila ovata* was most (370) abundant snails and *Lanistes varicus* was found to be least (57) abundant There was association between the two snail species ($p<0.05$) collected in this study. Table 3 shows distribution of snail species among the three sites of collection during the dry season. A total of 150 of *Pila ovata* were collected in the season. Higher numbers of snails were collected in the farm (42.0%), followed by snails' collection in the river (Plate 4) (30.7%) and least snails collected was in the dam (Plate 3) (27.3%).

Table 1: Abundance of Snails during Dry Season in the Study Area

Sampling Months	***Pila ovata***	**Prevalence (%)**
March	29	19.3
April	36	24.0
May	85	56.7
Total	**150**	**100**

Key: (%) = Values in Parenthesis are Percentage

Table 2: Abundance of Snails during Rainy Season in the Study Area

Sampling Months	**Snails Collected** ***Pila ovata***	***Lanistes varicus***	**Monthly Total**	**Prevalence (%)**
July	138	24	162	37.9
August	123	31	154	36.1
September	109	2	111	26.0
Overall	**370**	**57**	**427**	**100**

Key: (%) = Values in Parenthesis are Percentage; there was an association between the two snails species in monthly collection ($p<0.05$).

Table 3: Distributions of Snail Species among the Three Sites of Collection during Dry Season

Dry Season	***Pila ovata***	**Total Collected**	**Prevalence (%)**
Dam	41	41	27.3
River	46	46	30.7
Farm	63	63	42.0
Total	**150**	**150**	**100**

Key: (%) = Values in Parenthesis are Percentage;

Table 4 shows distribution of snails' species among the three sites of collection during the rainy season. A total of 437 snails' species were collected in all the three sites. Higher number of snails' species collected was in the river (41.9%), followed by snails collected in the farm (32.8%) and least snails collected was in the dam (25.3%). *Pila ovata* was the most abundant snail species (370) in the rainy season while *Lanistes varicus* was least abundance snails in the season (57). There was no association between the two snails species ($p>0.05$) collected in the study area.

Table 5 shows seasonal (dry and rainy season) infection rate of snails by cercaria based on site of collection. During the dry season 150 *P. ovata* was recovered while in the rainy season two snails' species were recovered. The two species recovered in the rainy season are *P. ovata* (370) and *Lanistes varicus* (57). Out of 150 snails collected in the dry season, the overall infection rate

of snails by cercaria was 7.33% in the dry season. Highest infection rate of 5.33% was obtained in the farm, followed by the river with infection rate of 1.33% and least infection rate of 0.67% was observed in the dam. During the rainy season, the overall prevalence of the infection rate by cercaria was 12.2%. Highest infection rate of *P. ovata* was in the river recording 7.97% prevalence, followed by the farm with infection rate of 1.87% and least infection rate was in the dam with 1.17% prevalence. Higher infection rate of *Lanistes varicus* was obtained in both the dam and the farm recording 0.47% each and least infection rate of 0.23% was obtained in the river. There was significant difference in the seasonal infection rate of snails ($p<0.05$) by cercariae based on site of collection in both seasons.

Table 6 shows the seasonal(dry and rainy season) abundance of snails in relation to physico-chemical parameters. A total of 150 snails' species were recovered in dry season and 427 snails species were recovered in rainy season respectively. Surface water temperature of water observed during the dry season ranged between 22 and 25 ^{o}C, while surface temperature of water observed during the rainy season ranged between 19 and 21^{o}C. 'Snails' abundance increased with decrease in temperature in both dry and rainy season. The pH of water body ranged between 8.2 and 8.6 in dry season, while pH range during rainy season was between 10.0 and 11.5 and snails' abundance increased with increase in pH in both dry and rainy season. The mean rainfall ranged between 144 and 198.5 mm and snail' abundance decreased with increase in rainfall. Relative humidity ranged between 1.599 and 2.420 in the dry season, while in the rainy season the mean relative humidity ranged between 2.019 and 2.060 and snail abundance increased with increase in relative humidity during dry season, but in the rainy season, snail' abundance decreased with increase in relative humidity. There was no significant difference between seasonal abundance of snails ($p>0.05$) in relation to physico-chemical parameters.

Table 4: Distributions of Snail Species among the Three Sites of Collection during Rainy Season

Site	*Pila ovata*	*Lanistes varicus*	Total Collected	Prevalence (%)
Dam	80	28	108	25.3
River	169	10	179	41.9
Farm	121	19	140	32.8
Overall	**370**	**57**	**427**	**100**

Key: (%) = Values in Parenthesis are Percentage; there was no association between the two snails species collected from the sites ($p>0.05$).

Table: 5 Seasonal Infection Rates of Snails by Cercaria Based on Sites of Collection

	Dry Season			Rainy Season		
Site	**NE**	**NI**	**PR (%)**	**NE**	**NI**	**PR (%)**
Dam						
Pila ovata	41	1	0.67	80	5	1.17
Lanistes varicus	-	-	-	28	2	0.47
River						
Pila ovata	46	2	1.33	169	34	7.97
Lanistes varicus	-	-	-	10	1	0.23
Farm						
Pila ovata	63	8	5.33	121	8	1.87
Lanistes varicus	-	-	-	19	2	0.47
Overall	**150**	**11**	**7.33**	**427**	**52**	**12.2**

Key: NE = Number Examined, NI = Number Infected, PR = Prevalence, (%) = Values in Parenthesis are Percentage; there was Significant Difference in Seasonal Infection Rate of Snails ($p<0.05$) by cercariae based on site of collection.

Table 6: Seasonal Abundance of Snails in Relation to Some Physico-Chemical Parameters

	Snail Species						
	Pila ovata	***Lanistes varicus***	**Total Snails**	**T^{O}C**	**pH**	**RF(mm)**	**RH**
Dry							
Mar	29	-	29	25	8.2	-	1.599
Apr	36	-	36	23	8.4	-	2.420
May	85	-	85	22	8.6	-	2.090
Rainy							
Jul	138	24	162	20	10.0	144	2.019
Aug	123	31	154	19	11.5	314	2.060
Sept	109	2	111	21	10.0	198.5	2.040
Overall	**520**	**57**	**577**	**22**	**9.45**	**656.5**	**12.228**

Keys: T = Temperature, ^{O}C = Degree Centigrade, pH = Acidity or Alkalinity of water, RF = Rain Fall, RH = Relative Humidity, There was no significance difference between seasonal abundance of snails ($p>0.05$) in relation to physico-chemical parameters.

Source: T, pH (Field Work), RF, RH (Jigawa State Agricultural and Rural Development Authority)

Plate 3: Showing Dingare dam

Plate 4: Showing river Hadejia

Plate 1: Showing *Pila ovata* (Apple Snail) (Oliver, 1804)

Plate 2: ***Lanistes varicus*** **(Muller, 1774)**

DISCUSSION

Abundance of snails in dry season revealed *P. ovata* as the only species available during the season. A total of 150 snails species were collected. Highest number (56.7%) of snails was collected in May, followed by April (24.0%) and least (19.3%) collection of snails was done in March. This findings are in concordance with the work of Abubakar *et al.* (2019) that collected more snails' species between March and June when there was less rainfall on average in the study area. Findings in the present study are also similar to the work of Pelete *et al.* (2019) that identified fresh water snails in Aponmu-lona river Basin Ondo State who collected *Bulinus globosus* in three different sites being the most abundant snails species. Findings in the present work disagree with the work of Abubakar *et al*. (2019) that recorded less of *B. globosus* along Kwanar Areh dam in Rimi Local Government Area of Katsina State. Similarly the findings in the current work contradict the work of Taopiq *et al.* (2017) who reported absence of snails' species from February to May (dry season) in the study area.

Abundance of snails in the rainy season revealed availability of two snails' species *Pila ovata* and *Lanistes varicus.* A total of 427 snails were collected with highest collection in July (37.9%) followed by August (36.1%) and the least (26.0%) snails were collected in September. The prevalence of snails at the beginning of the rainy season may be as a result of quick response of snails to favourable weather conditions (Taopiq *et al*., 2017). This finding conforms to the work of Opayemi and Alex (2021). that studied land use/and cover change, physico-chemical parameters in Tewa North, South Western Nigeria. those authors recorded higher number of snails (4, 716) in the rainy season and a total of 4, 657 snails in the dry season. In the present study *Pila ovata* (370) was more in abundance than *Lanistes varicus* (57) in the rainy season. This finding conforms to the work of Onyakachi *et al.* (2022) who reported *B. globosus* species to be more abundant compared to *B. feirfferi*. The findings in the present study are however different to the study of Njoku (2011) that recorded higher prevalence of snails' collection in the dry season (1, 961) than rainy season (419).

Distribution of snails' species among the three sites during the dry season shows higher prevalence of snails collected in the farm (42.0%) followed by river (30.7%) and least snails were collected in the dam (27.3%). The availability of snails in the irrigated farm may be because of availability of water and abundance of organic matter that serves as food for the snails and this makes the environment favourable for snails' proliferation (Abdulkadir *et al*., 2013). Findings in the present study conform to the work of Salawu and Odaibo. (2013) which reported snails might prefer aquatic vegetation, which will provide them with available food and shelter. This means that farm habours many snails' species because of some conditions favouring for their survivals, also increased farming activities help to provide enough vegetation to the snails against predator or natural enemy (Abubakar *et al*., 2018).

Distribution of snails' species among the three sites of collection during the rainy season shows highest snails collection was in the river (41.9%), followed by the farm (32.8%) and least snails' collection was in the dam (25.3%). Two snails' species identified are *Pila ovata* with highest abundance (370) and *Lanistes varicus* with least abundance (57). The high snails' collection in the river during rainy season may be because river flooded water to the farm and this makes farm that is closer to the river rich in vegetation and organic matter, that provide suitable habitation to snails in the river (Taopiq *et al.* (2017). The prevalence of snails during the rainy season shows the aestivation action of the snails. Nevertheless, the availability of snail' vectors to survive adverse conditions such as aestivation and hibernation for prolong period constitute one of the major problems in the control of snails (Taopiq *et al*., 2017). The findings in this study agree with the finding of Njoku-Tony. (2011) that shows water habitat that over flood tend to show stable snails population all year round. The findings also agree with the work of Opayemi and Alex. (2021) that recorded snails' abundance slightly higher in the rainy season with a total of 4, 716 than the dry season that recorded 4, 657 snails (Opayemi and Alex, 2021).

Seasonal infection rate of snails by cercaria based on sites of collection shows collection of 150 *P. ovata* in dry season while in rainy season two snails species (427) were also recovered. The two species recovered in the rainy season are *P. ovata* and *L. varicus*. . Out of 150 snails species collected and assessed in the dry season, the overall infection rate of snails by cercaria was 7.33%. Higher infection rate of (5.33%) was obtained in the farm, followed by river with infection rate of (1.33%) and least infection rate of (0.67%) was in the dam. During the rainy season, the overall prevalence of the infection rate by cercaria was 12.2%. Higher infection rate *P. ovata* of was recorded in the river (7.9%) followed by the farm (1.8%) and least infection rate was in the dam (1.7%), while higher infection rate of *Lanistes varicus* observed in both the dam and farm was (0.4%) and least infection rate was in the river (0.23%). The overall infection rate

by cercaria in both dry and rainy season was moderate. The moderate infection rate by cercaria obtained in the present study might be associated by moderate prevalence of schistosomes in the communities. Those differences might also be associated with the level of environmental sanitation, suitable climate for the snails, level of human exposure to surface water and season of the snails' collection (Tamirat *et al*., 2020). The overall prevalence of the infection rate reported in the present study during dry season was similar to the work of Tigga, *et al.* (2014) that determined the prevalence of intermediate hosts infected with cercariae around the Ranchi, those authors reported prevalence (7.33%). The findings in the present study was lower than the report of Uthpala *et al.* (2010) that work on fresh water snails in Sri Lanka, who reported prevalence of 16% infection rate. Infection rate by cercariae obtained in the present study was higher than the report of Tamirat *et al.* (2020) who reported infection rate of 6% on fresh water snails in Africa. In the present study, P. *ovata* was found to have high prevalence rate by cercariae in both dry and rainy season, which is an indication of active schistosomiasis transmission of the disease. This finding is consistent with the work of Peleta *et al.* (2019) that found cercarial shedding in *B. globosus* (4.5%) while no infection rate was recorded among *Biophalaria* snails examined. Distribution of snails based on ecological sites in the present study disagrees with the work of Josua and Albert (2015) that determined cercarial shedding of trematode and snails intermediate host in Borno State. Those authors reported that out of 180 species of *B. globosus* investigated in the study, an infection rate of 1.1% was recorded in the dam. However they did not find any snail in the river and vegetation cover habitat. Seasonal abundance of snails in relation to physico-chemical parameters shows that a total of 150 and 427 snails were recovered in the dry and rainy season respectively. More snails were recovered in the rainy season than dry season in the present study. This conforms to the work of Abdulkadir *et al.* (2013) that collected 2,572 fresh water snails in dry season and 5,769 snails in rainy season in a work conducted from Monchok water, Kaduna State, Nigeria. Similarly results in the present study are consistent with the work of Taufiq *et al.* (2017) that collected large snails population at the beginning of rainy season than dry season. This may be as a result of quick response of the water snails to favourable weather condition. Results in the present study disagree with work of Njoku-Tonny (2011) that collected a total of 1, 961 snails during dry season respectively.

Surface water temperature observed in the present work ranged between 19 and 21^{o}C. Snails' abundance increased with decrease in temperature in both rain and dry season. Temperature has been recognized as an important factor on any biotype especially fresh water (Kalinda *et al*., 2017) High temperature causes thermal stress in snails vector, it also reduces dissolved gas content of the water body (McCreesh *et al*., 2014). Results in the present study are in concordance with the work of Kalinda *et al.* (2017) who reported that many snails investigated in their natural habitat tolerated minimum/maximum temperature of 19 – 25^{o}C. The work in the present study contradict the work of Opayemi and Alex (2021) that retrieved many snails despite high temperature between 24.3 and 32.3 ^{o}C in Euro River, in Yewa North, South Western Nigeria.

The pH of water body in t he study area ranged between 8.2 and 8.6 in dry seasons, while pH range during the rainy season was between 10.0 and 11.5.and snails' abundance increased with increase in pH in both dry and rainy season. The pH of an aquatic habitat is an indication of the water quality and external pollution (Levits *et al.,* 2023). Unpolluted river normally shows a neutral or slightly alkaline pH (Levits *et al.,* 2023). The finding in the present study was in agreement with the work of Njoku-Tonny. (2011) that reported increase in pH with increase in rain while pH decreased in the dry season. The work in the present study Agrees with the work of Onyekachi (2022) that recorded positive correlation between pH and *B. globosus*. Report in the present study contradicts Levits *et al.* (2013) that reported high snails' collection with lower pH (more acidic). Similarly the values reported in the present study

disagree with the work of Opayemi and Alex (2022) that recorded high snails' collection in Iju river with pH of 6.8.

Dry season start between March to May and there was no rainfall in the study area. Rainfall starts in July and end in September. The mean rainfall ranged between 144 and 188.5 mm and snail' abundance decreased with increase in rainfall in the present work. Rainfall was identified as the key climatic factor affecting snails' diversity negatively (Onyekacchi *et al*., 2022). In addition snail' abundance and diversity reduce with high rainfall as snails cannot attach themselves to water vegetation and are washed away due to high water velocities (Onyekacchi *et al*., 2022). The work in the present study was in agreement with the work of Ndione *et al*. (2019) that reported higher snails' abundance with low rainfall or at the beginning of the rainy season.

Mean relative humidity obtained in the present work ranged between 1.599 and 2.420 in the dry season, while in the rainy season the mean relative humidity ranged between 2.019 and 2.060 and snail' abundance increased with increase in relative humidity during the dry season. However, in the rainy season snails' abundance decreased with increase in relative humidity. This is in agreement with the work of Cejka and Humerlik (2009) that observed positive correlation between total snails abundance and moisture in Danubian Woodland. The decrease in snails' abundance with increase in relative humidity during rainy season could be as a result of flood that washed away water snails thus decreasing the snail' abundance.

CONCLUSION AND RECOMMENDATIONS

This study revealed that the study area has water contact sites that are surrounded with vegetations which hold high density *of* snails' populations. *Pila ovata* was found to be the most abundant species in both dry and rainy season. Higher snails' abundance was recorded in the month of May (pre-dry season) and month of July (beginning of rainy season). Higher snails' distribution and infection rate were found to be in the farm and river, while least distribution and infection rate were recorded in the dam. Snails' abundance decreased with increase in temperature, snails' abundance increased with increase in pH. Snails abundance equally decreased with increase in rainfall and relative humidity.

There is a need to enhance health education programmes by environmental health workers and civic societies among local inhabitants about the potential risk of contact with water body. Adequate snail vector control programme should be mounted to check snail population expansion in the study area.

Conflict of Interest

The authors have not declared any conflict of interest

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