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(RESEARCH ARTICLE)

Transmission patterns among freshwater snail hosts of schistosomiasis in Bauchi area of Nigeria

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Abstract

Schistosomiasis is endemic in the Bauchi area of Nigeria but little information is available on transmission patterns on basis of which an effective strategy for control can be developed. Consequently, a longitudinal study on the population dynamics of freshwater snails was under taken in 10 sites selected after a preliminary study. Three schistosome intermediate host snails namely *Bulinus globosus, Bulinus truncatus* and *Biomphalaria pfeifferi* all of which carried patent infections were encountered. The population of infected snails showed similar patterns of fluctuation among the different sites. Population density generally increased following the rains and peak densities occurred during the last part of the raining season and/or beginning of the dry season. This was followed by a decline during the dry season owing to an increase in temperature and dessication in some sites. Transmission was observed to be generally focal. In the temporary habitats, transmission was highly seasonal having a short duration of three months spanning from October to December. However, in the few perennial habitats, there was prolonged transmission extending from October of one year to March of the succeeding year. Findings of this study would be invaluable in planning and implementation of schistosomiasis control in Bauchi area, Nigeria.

Keywords: Transmission; Bulinus species; *Biomphalaria pfeifferi*; Schistosomiasis

1. Introduction

The transmission of schistosomiasis is generally focal and seasonal owing to the focal nature of human water contact and due to changing environmental conditions, in particular rainfall and temperature regimes respectively. The pattern of transmission can be highly variable between different areas or regions [1].

Many snail populations in various areas have been studied for period of one year or more [2-7]. As several and various types of habitats have been studied, the details of population dynamics of both uninfected and infected snails in relation to climate vary considerably. The effect of rainfall on transmission of infection and populations of the intermediate host snails depend on the type of habitat and on the magnitude and intensity of the rainfall, which vary from year to year.

It is therefore of practical importance to have an understanding of the distribution and density of snail intermediate hosts as well as of disease transmission in an area in order to implement measures for their control. It is on this background that we report here information on transmission patterns of schistosomiasis within the Bauchi area of Nigeria.

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2. Material and methods

2.1. Description of study area

The area studied was approximately 32,396 km^2, which is situated around latitude 10˚ 17' N and longitude 90˚ 49' N (Fig. 1). It lies within the middle climatic belt of Nigeria experiencing a dry season of about seven months (October-April) and rainy season of about five months (May- September). It receives a mean annual rainfall of 1015 mm and temperatures are generally high over the entire area. The hottest months are March and April when temperatures often reach an average of 40.6 ˚C while the coldest months are December and January during this time, the range in mean minimum temperature is between 6.1 ˚C and 7.1 ˚C. The mean maximum and minimum temperatures are approximately 32.4 ˚C and 18.3 ˚C, respectively.

2.2. Snail sampling and identification

Snail samples were collected at monthly intervals using a scoop net in ten sites identified during a preliminary survey. At each site, a total of 50 random scoops (equivalent to sampling for 20 minutes) were made on every sampling occasion. The snails collected were kept in separate, well labeled, wide mouth plastic containers with aquatic vegetation in order to maintain good aeration. All snails collected were subsequently transported to the laboratory of the Department of Biological Sciences, Abubakar Tafawa Balewa University, Bauchi for further examination. Identification of the snail species was done by use of morphological characteristics with reference to the standard keys of [8]. The sizes of the snails collected were determined by use of a vernia caliper.

2.3. Snail infection rates

Snail samples were examined for patent infection in the laboratory on the day of collection. Infection rates were determined for each snail species by exposing 10 snails in glass beakers (250 ml capacity) containing about 100 ml dechlorinated tap water to sunlight during the day. Snails were exposed for 3 hours and containers were subsequently examined for the presence of cercariae under a dissection microscope. Individuals in batches that were positive for cercariae were separated and further examined individually under a dissection microscope so as to determine the number of snails that were shedding cercariae. At sunset, snails were stimulated to shed by exposing them to a 60-watt bench lamp. This was necessary in order to minimize delay in returning snails to sites where they had been collected early the next day. Cercariae that emerged from the snails were identified with reference to the keys of [9].

2.4. Statistical analysis

Data obtained on snail abundance were analysed using the Friedman Two-way Analysis of Variance in SPSS computer software version 21 (2012) in order to establish if differences between and within sites were significantly different. The similarity of fluctuations in relative density either comparing one species between sites or different species in a given site was also analysed using the same software by use of the Kendall's Coefficient of Concordance. Snail counts for different species or different sites were ranked over the months and these ranks were then compared between sites or species.

3. Results

3.1. Occurrence of snails during the preliminary studies

Table 1 Occurrence of freshwater pulmonate snails among different habitat types examined during a preliminary survey

Habitat type	No. of sites examined	Snails spp.			
		B. globosus	***B. truncatus***	***B. pfeifferi***	***L. natalensis***
Ditch/Drainage canal	12	3	0	0	0
Pond	16	10	8	1	5
Stream	3	0	0	0	0
Total	31	13	8	1	5

Four pulmonate snail species were encountered during the preliminary study. These are shown in Table 1. *Bulinus globosus* was the most widespread species occurring in 13 of the 31 sites sampled. *Bulinus truncatus* occurred in 8 of

the sites while *Lymnea natalensis* was found in 5 of total sites examined. *Biomphalaria pfeifferi* was far less common being confined to only 1 of the sites.

3.2. Prevalence of infected snails

The density of infected snails during this study showed considerable variation over time within and between each of the sites studied. Details are shown in Table 2. Although *Bulinus globosus* was found in all the 10 sites, infected samples occurred in only 6 of them. No snail released more than one type of cercariae. Fig 1 shows the variation in snail density in the 6 sites where site 1 showed the highest number of infected snails followed by site 8, 5, 6, 9 and 10 in that descending order. However, on the whole, the same pattern of variation occurred; numbers of infected snails were just moderately high in site 8 (i.e. 50-60 month) it appeared to be sustained for a longer time. Conversely, at site 1 the density was relatively higher (generally between 90-100 month) but such level was apparently maintained for only 2 months. Consequently, it would generally appear that site 1, 8 and to a lesser extent 9 may contribute more towards transmission of infection in Bauchi area than the other sites.

Table 2 Comparison of total snail counts and abundance of infected snails between sites for schistosome intermediate hosts encountered during the study

Site No.	Snail species					
	B. globosus		*B. truncatus*		*B. pfeifferi*	
	Total	**No. Infected (%)***	**Total**	**No. Infected (%)***	**Total**	**No. Infected (%)***
1	1858	877(47)	1279	283(22)	0	0(0)
2	702	0(0)	628	0(0)	0	0(0)
3	169	0(0)	0	0(0)	0	0(0)
4	175	0(0)	0	0(0)	0	0(0)
5	1508	352(23)	1110	215(19)	592	156(26)
6	349	86(27)	317	74(23)	0	0(0)
7	642	0(0)	241	0(0)	0	0(0)
8	2282	667(29)	1141	658(57)	0	0(0)
9	504	84(17)	489	73(15)	0	0(0)
10	705	100 (14)	737	118(16)	0	0(0)

* Total snail counts and snail infection rates differed significantly at $p < 0.001$

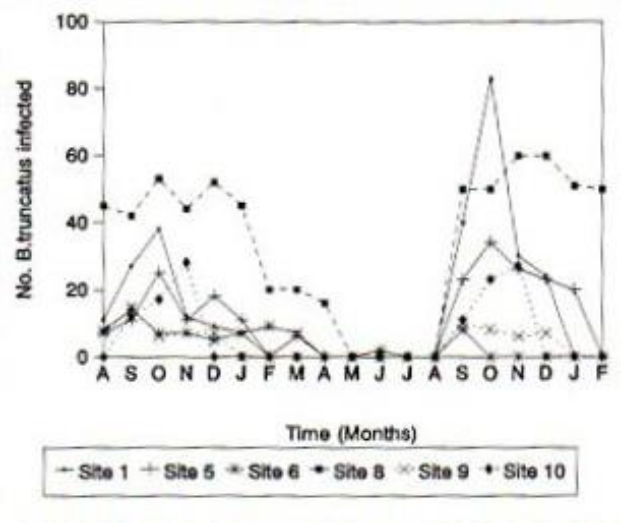

Figure 1 Comparison of number of schistosome infected *B. globosus* between sites

Infected *Bulinus truncatus* was similarly recorded in only 6 of the sites. Fig 2 shows the variation observed between the sites with site 8 recording the highest number of infected snails than the other sites. Although a similar pattern of variation was observed between the sites ($W = 0.5244$, $P < 0.001$), there was a significant variation in the density of infected snails within site ($P < 0.001$). Of the *Biomphalaria pfeifferi* encountered only 26% carried patent infection which lasted for only a few months (i.e. October-November/December). The period for transmission of *Schistosoma mansoni* in the study area would appear to be very short.

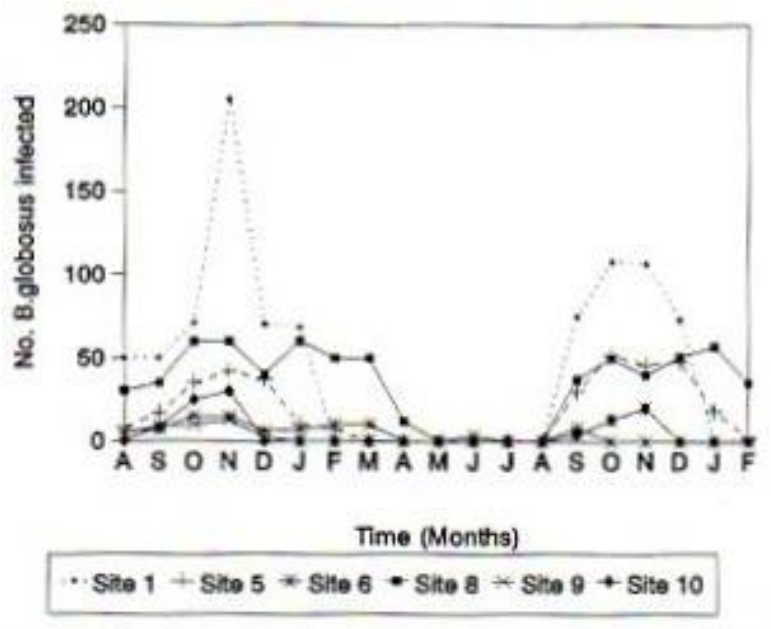

Figure 2 Comparison of number of schistosome infected *B. truncatus* between sites

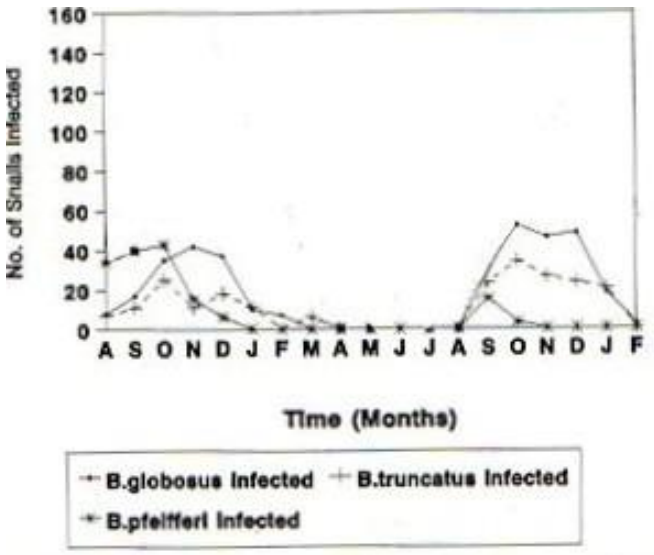

Figure 3 Comparison of number of infected snails among species recovered at site 5

The seasonal variation in density of infected snails was similar among different species between the different sites. The peak levels were observed between September and November. The pattern that appeared for *Bulinus globosus* for example was that the populations built up during the rainy season and peak density was observed during the last part of the rainy season or beginning of the dry season. The peak was followed by a decline during the dry season resulting in almost elimination in some sites or to comparably low densities in others. This decline in density of snails coincided with the increase in temperature during the dry season and drying up of some sites. The density of schistosome infected

Bulinus globosus was significantly different within sites as well ($P < 0.001$). The abundance of infected *Bulinus truncatus* showed the same basic pattern with peak levels observed between September to November. The density of infected *Biomphalaria pfeifferi* in the only site it occurred apparently built up during the rainy season as well with peak density observed in October but declined rapidly and by January of the following year, no snails were found altogether until the population built up again during the succeeding rainy season (Fig. 3).

4. Discussion

The trematode infection pattern in this study was quite variable with differences among sites depending on whether the habitats were temporary or permanent. In the temporary habitats which formed the majority of sites examined, transmission was highly seasonal. In these habitats the main transmission period was observed to be short (about 3 months) extending from October to December. However, in the few perennial habitats examined, infected snails were found throughout the year. Transmission of infection would appear to be sustained over a longer time. The period extending from October to March was observed to be the most intense transmission period. The last part of this period (March) coincided with the time of the year which is normally very hot. This weather condition tends to increase recreational activities like swimming in order to cool the body. For this reason, these perennial habitats would appear to be the most important transmission foci in the area. Sites with more seasonal patterns are still important in transmission as well but it would be to a lesser degree. Aside from the nature of the habitats, the differences observed in transmission pattern among sites, may be an indication of the water-contact activities at these sites. Observations at one of the sites revealed that a great deal of contamination occurs at the sites frequented by people. Since all sites are not equally visited and population density of the intermediate hosts differs markedly between sites, differences in transmission intensity should be expected.

The seasonality of transmission as recorded during this study was mainly caused by rainfall which usually exerts a negative impact on intermediate host populations sometimes eliminating them altogether. However, this depends on the type of habitat, intensity as well as the amount of rain received. Thus, transmission can occur in the rainy season if the rains are light. In the Bauchi area, the seasons are distinctly divided into a rainy season which normally extends from May to September and a longer dry season which cover the period from October to April. Rains in this area seem to promote the reproduction and population build up during the rainy season and peak density is achieved towards the end of the rainy season. Similarly, the density of infected snails of all species peaked in October/November which coincided with the beginning of the dry season in the area. This suggests that contamination of these habitats with infected feces or urine probably occurred during the rainy season. This observation is consistent with those of previous workers like [10] who similarly noted that *Schistosoma mansoni* eggs reach natural water bodies from pollution of their banks with feces or urine during the rainy season. The observation of seasonal transmission is also consistent with that of [11] who similarly reported that transmission of some schistosomes in the Highveld region of Zimbabwe was seasonal. It is also in agreement with the report of [12] who noted that schistosome transmission in two areas of Machakos District in Kenya was highly seasonal with infected snails being encountered immediately after the rains.

During the present study, infected snails were not found in all the sampling sites although all of the sites had thriving snail populations. This in line with the view expressed by [1] that transmission of Schistosomiasis is generally focal rather than widespread. The focality of transmission is generally due to variation in human-water contact patterns and subsequent contamination of water bodies by schistosome eggs which is the causative factor of snail infection. Preliminary studies on human-water contact activities conducted at site six (6) in the study area [13] revealed that recreational activities were responsible for contamination of the water body with schistosome eggs which brought about snail infection. The focality of transmission observed in the current study also agrees closely with the situation reported for some part of Taraba state, Nigeria by [14]. Aside from recreational activities others like farming, fishing, washing of utensils and vehicles, fetching of water for domestic uses etc. were found to contribute significantly to the contamination of snail habitats with eggs. Thus, it was observed that during such activities, indiscriminate urination and defecation around the banks of the reservoirs was common. These materials often get washed into the water body thereby enhancing snail infection. This was further enhanced during the dry season when water sources had diminished and those available became more frequented.

This study had shown that *B. globosus* and *B. truncatus* are very important in schistosome transmission in the Bauchi area as appreciable numbers of both species were found with infections. Although the cercariae produced by infected specimens were not quantified for which reason the cercarial density is unknown. However, both snails species encountered were generally large and larger snails have been reported to produce more cercariae than small ones [8, 15].

The restricted occurrence of *Biomphalaria pfeifferi* in this investigation is consistent with an earlier observation by [16] who reported a patchy distribution of this species in Kano, northern Nigeria. In a review by [17], it was also shown that intestinal schistosomiasis had limited foci in northern Nigeria and the distribution of its intermediate host *B. pfeifferi* was probably limited as well. The results of the present work agree closely with this assertion and further emphasize the limited distribution of *B. pfeifferi* and that of *S. mansoni* in northern Nigeria. Since this parasite is known to be more virulent than the more widespread and frequently occurring *S. haematobium*, its spread could constitute a more serious schistosome problem in the Bauchi area. Further work on the distribution of *B. pfeifferi* and hence that of *S. mansoni* in the Bauchi area is consequently desirable.

The temperature levels recorded in the present investigation were generally high. This would appear to account at least in part for the generally high infection rates observed among the snails. High temperatures are known to shorten the pre-patent period of schistosome infection in snails thereby enhancing transmission [18] whereas low temperature prolong the pre-patent period. This prevailing environmental temperature would appear to favour schistosome transmission in the Bauchi area.

5. Conclusion

The findings in this study should be useful in designing an effective strategy for snail control for the Bauchi area. A focal application of molluscicide twice a year is suggested. The first application should be at the onset of rainfall to suppress population build up by post-aestivating snails and the second application should be towards the end of the rainy season to drastically reduce the snail population before the most intense transmission period.

Compliance with ethical standards

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Disclosure of conflict of interest

We declare that there are no conflict of interest in connection with this paper.

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