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Preliminary study on ecology of *Bulinus jousseaumei* in *Schistosoma haematobium* endemic rural community of Nigeria

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Abstract

The endemicity of schistosomiasis depends to a large extent on the presence of appropriate freshwater snail species with latent infection, and the quality of the microhabitat of the snails may favour or hinder their development and growth. Monthly *in situ* determinations of water temperature, pH, total dissolved solid (TDS), conductivity and dissolved oxygen were carried out. Monthly sampling of snails was also conducted. The planorbid snail species morphologically identified were *Gyraulus costulatus, Biomphalaria pfeifferi, Bulinus globosus, B. senegalensis, B. jousseaumei, Segmentorbis augustus, Ferrisia* sp and *Lymnaea natalensis*. The most abundant snail species was *Gyraulus costulatus* (62.2%). Snail density correlated positively with dissolved oxygen ($r = 0.349$; $P = 0.266$), while a negative relationship occurred between snail density and conductivity ($r = -0.064$; $P = 0.843$). None of the *B. globosus* examined shed cercariae, while 12.5% of *B. jousseaumei* shed cercariae. The occurrence of *B. jousseaumei* in this study proves its presence in Nigeria and suggests its combined roles with *B. globosus* in the transmission of urogenital schistosomiasis in the endemic rural communities of Yewa North Local Government Area of Ogun State, Nigeria. Further studies on the geographical distribution of *B. jousseaumei* are recommended for better understanding of its epidemiological contribution to schistosomiasis in Nigeria.

Key words: B. globosus, B. jousseaumei, endemic rural communities, Nigeria, urogenital schistosomiasis

Résumé

Le caractère endémique de la schistosomiase dépend dans une large mesure de la présence d'espèces de mollusques d'eau douce adéquates avec infection latente, et la qualité du microhabitat des mollusques peut favoriser ou entraver leur développement et leur croissance. Nous avons procédé chaque mois à la détermination *in situ* de la température, du pH, du total des solides dissous (TDS), de la conductivité et de l'oxygène dissous de l'eau. Il y eut aussi un échantillonnage mensuel des mollusques. Les espèces de planorbes identifiées morphologiquement furent *Gyraulus costulatus, Biomphalaria pfeifferi, Bulinus globosus, B. senegalensis, B. jousseaumei, Segmentorbis augustus, Ferrisia* sp. et *Lymnaea natalensis*. L'espèce la plus abondante était *Gyraulus costulatus* (62,2%). La densité des mollusques était positivement liée à l'oxygène dissous ($r = 0{,}349$; $P = 0{,}266$) alors qu'il y avait une relation négative entre la densité des mollusques et la conductivité ($r = -0{,}064$; $P = 0{,}843$). Aucun des *B. globosus* examinés ne répandait de cercaires alors que 12,5% des *B. jousseaumei* en déversaient. L'occurrence de *B. jousseaumei* dans cette étude prouve sa présence au Nigeria et laisse penser qu'il partage avec *B. globosus* le rôle de transmettre la schistosomiase urogénitale dans les communautés rurales endémiques de l'Aire gouvernementale locale de Yewa-nord dans l'État d'Ogun, au Nigeria. L'on recommande de nouvelles études sur la distribution géographique de *B. jousseaumei* afin de mieux comprendre sa contribution épidémiologique à la schistosomiase au Nigeria.

Introduction

Freshwater snail species vary widely in their adaptations to the various biotic and abiotic factors that govern their population and distribution in space and time. One of the goals of freshwater ecology is therefore to understand how communities of freshwater species are structured in space

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and time, and how environmental factors affect their distribution (Chyleh *et al.*, 2006) and growth.

There are currently 37 recognized species of *Bulinus* (Brown, 1994), but only a few species are involved in the transmission of schistosome species. The genus *Bulinus* can be divided into four major group of species; *Bulinus africanus* group, *Bulinus forskalii* group, *Bulinus reticulatus* group and the *Bulinus truncatus/tropicus* complex (Rollinson, Stothard & Southgate, 2001).

B. jousseaumei has been reported in Senegal, Gambia, Mali and Congo (Brazzaville). It is small sized with almost obsolete truncation and frequently feeble microsculpture. *B. jousseaumei* has been regarded as a regional form of *B. globosus* and that it scarcely merits a subspecific status (Wright, 1961). However, this supposition was contradicted by the distinctness of *B. jousseaumei;* occurrence of true *B. globosus* of typical form and normal size in West Africa (Kristensen & Christensen, 1989). *B. jousseaumei* has not been reported in Nigeria or probably often wrongly identified as *B. globosus*; hence, its role in *Schistosoma* transmission had not yet been fully appreciated. The aim of this study is to provide baseline data on environmental factors that influence the occurrence and population dynamics of *B. jousseaumei* in an endemic community in Nigeria.

Materials and methods

Study area

The study was conducted in Isopa River, a major water body with a very high degree of human–water contact in Ijoun, Yewa North Local Government, Ogun State, Nigeria. The Local Government Area (LGA) has the largest land area in the Ogun state and is located in latitude 7°15′N and longitude 3°3′E in a deciduous/derived savannah zone (Onakomaya, Oyesiku & Jegede, 1992). Various human–water contact activities like bathing, swimming and washing were frequently observed at various sites along the river. There was heavy dependence on this river for domestic purposes, as a result of inadequacy of potable water supply in the study area. Water from the dug wells was often not used for domestic purposes as the people complained of its hardness.

Snail sampling

Snail sampling was performed at each time for 20 min along the littoral zones by one person, at intervals, including human–water contact sites, using a long-handled scoop (0.2mm mesh) net once every month for 12 months (Olofintoye & Odaibo, 1999). Each scoop was thoroughly searched and all snails collected were kept in prelabelled plastic containers with damp cotton wool. The containers were then covered with perforated lids and transported to the laboratory where the snails were washed, identified and counted. Freshwater snails were examined for cercariae infestation by shedding and crushing. Using guidelines and reference specimens from the Danish Bilharziasis Laboratory Charlothenlund, Denmark (Brown & Kristensen, 1993) the snails were identified. Identified species were further kindly confirmed by Dr T.K. Kristensen of Mandahl-Barth Research Centre, DBL-Section of Parasitology Health and Development, Institute of Veterinary Disease Biology, University of Copenhagen, Denmark.

Measurement of physico-chemical parameters

Monthly in-situ determinations of some environmental parameters were determined in the study sites, including water temperature, pH, total dissolved solid (TDS) and conductivity using the electronic Combined Meter (model M1806). Dissolved oxygen (DO) was determined using DO meter (model MW600).

Data analysis

Data were entered into an Excel spreadsheet, checked for entry errors and transferred into Statistical Package for Social Science Windows (version 11.0, SPSS Inc, Chicago, USA) for analysis. Student's *t*-test was used to determine significant variations in the values of the physico-chemical parameters during the sampling months. Pearson's correlation analysis was used to determine relationship between freshwater snail density and the physico-chemical parameters of the river body. A P-value < 0.05 was considered indicative of statistical significance.

Results

Snail species

Eight different species of freshwater snails were encountered in the river. These include *Gyraulus costulatus, Biomphalaria pfeifferi, Bulinus globosus, B. jousseaumei* (Fig. 1), *B. senegalensis, Ferrisia* sp, *Lymnaea natalensis* and *Segmentorbis augustus*. A total number of 74 planorbid

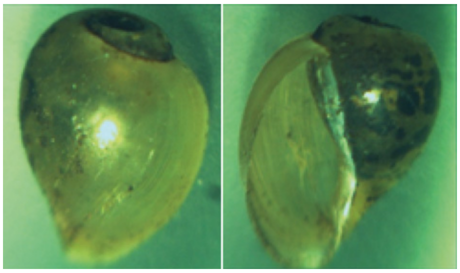

Fig 1 The abapertural and apertural views of *B. jousseaumei*

snails were sampled during the sampling periods. The highest number of snails sampled was in the month of July, 2011 (Fig. 2). *Gyraulus costulatus* was the most abundant snail species (62.2%), followed by *B. jousseaumei* (10.8%), while the least were *S. augustus* and *B. pfeifferi* with percentage abundance of 1.4% each (Fig. 2). None of the *B. globosus* examined shed cercariae, while one of the eight (12.5%) sampled *B. jousseaumei* (mean length = 6.6 ± 0.85 mm) shed short-tailed furcocercous cercariae.

Physico-chemical parameters

The results of the monthly variations in snail density with physico-chemical parameters were represented in Figs 3–6. The mean water temperature, dissolved oxygen (DO), pH, conductivity and total dissolved solid (TDS) were 26.0 ± 1.62°C, 8.4 ± 5.67 mg l^{-1}, 6.5 ± 0.72, 44.3 ± 17.54 μS cm^{-1} and 19.3 ± 7.60 mg l^{-1} respectively. Water temperature showed no significant variation with sampling months and the mean minimum and maximum temperatures recorded were 22.1 ± 0.31 and 28.1 ± 0.31°C respectively. Dissolved oxygen increased gradually from 1.5 mg l^{-1} in June, 2010 and reached its peak 17.3 mg l^{-1} in May, 2011. There were no significant

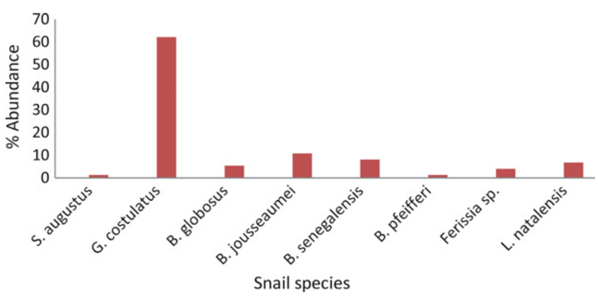

Fig 2 Abundance (%) of freshwater snails by species in river

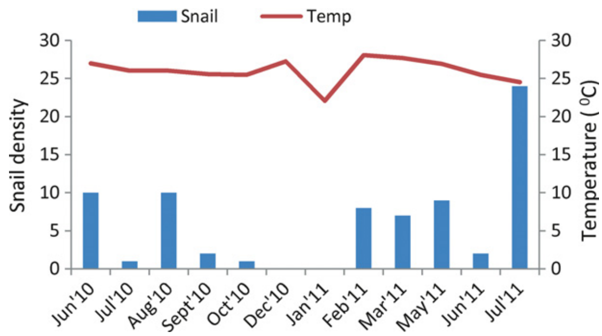

Fig 3 Monthly variations in snail density with temperature

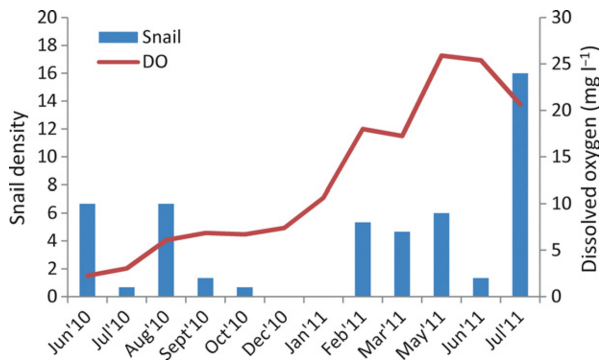

Fig 4 Monthly variations in snail density with dissolved oxygen

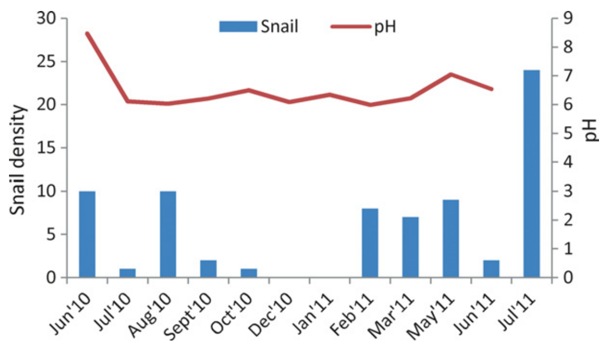

Fig 5 Monthly variations in snail density with pH

spatial variations in pH during the study period. Snail density correlated positively with dissolved oxygen (r = 0.349; P = 0.266) and pH (r = 0.423; P = 0.195). Relationships between physico-chemical parameters varied with dissolved oxygen showing negative correlations with conductivity (r = −0.487; P = 0.108) and TDS (r = −0.339; P = 0.282), but positively correlated with temperature (r = 0.062, P = 0.848).

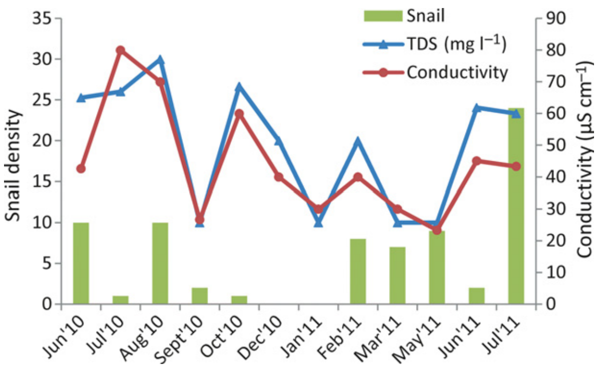

Fig 6 Monthly variations in snail density with conductivity and TDS

Discussion

This, to our knowledge, is the first report on the occurrence of *B. jousseaumei* in Nigeria. The occurrence of these several species of snails in river Isopa, in Yewa North Local Government Area is an indication of stable coexistence of multiple species in the habitat. Out of these eight species of snails encountered in this study, *B. pfeifferi* and *B. globosus* are established intermediate hosts of intestinal and urogenital schistosomiasis in Nigeria respectively. The presence of *B. jousseaumei* shedding forked-tail cercariae in this study could be an indication of its potentiality in schistosomiasis transmission in the river. The study shows that *B. jousseaumei* is sympatric with *B. globosus* in the study area.

The exotic snail species *B. jousseaumei* could have been introduced to these river body from the bordered countries through water current. Yewa North LGA, Ogun State, Nigeria shared boundary with the Republic of Benin in the west. However, as the snail species are not native of the Republic of Benin, other sources of dispersal are suggested. The influence of dispersal agents of aquatic snails such as migratory birds cannot be overemphasized. Small and young planorbids have been reported to be good colonizers because they are able to disperse on the feet and feathers of birds (Wesselingh, Cadée & Renema, 1999). Once in a new environment, their ability to self-fertilize, in addition to their wide tolerance of alkalinity, salinity and pollution, facilitates propagation and spread (Gérard, Carpentier & Paillisson, 2008; Zalizniak, Kefford & Nugegoda, 2009).

The environmental parameters affecting the distribution of aquatic molluscs are not well understood; however, it is generally accepted that the distribution of freshwater snails varies with physical, chemical and biological characteristics (Giovanelli *et al.*, 2005). Primary factors reported to restrict molluscan occurrence are pH, total dissolved solids, dissolved oxygen, water temperature, substrate, water depth, food supply, competition and predation. Temperature is considered as the key determinant of snail abundance (Opisa *et al.*, 2011). Temperature influences the distribution and the density of aquatic snails, and the rate of schistosomal development in the snail host, and probably influences the distribution of schistosomiasis (Sturrock, 1993). High temperature causes thermal stress in snail vectors. It also reduces dissolved oxygen content of the water body (Hofkins, Mokoji & Keochi, 1991). Temperature range of 22.1–28.1°C recorded in the Isopa river during the study appears therefore to be favourable to the aquatic snails, as there were no significant changes in temperature throughout the study. The insignificant link between snail abundance and water temperature in our study perhaps reflects the narrow range of temperatures observed (Kariuki *et al.*, 2004).

The aquatic snails require oxygen for their metabolic activities. This study recorded mean dissolved oxygen of 8.4 mg l^{-1}. This finding is in consonance with other findings that the desired concentration of dissolved oxygen for snail intermediate host is between 0.4 and 16.0 mg l^{-1} (Harman & Berg, 1971). The high dissolved oxygen content in this study is expected as the water body is a fast flowing type with a very low level of pollution. A positive relationship between snail density and dissolved oxygen observed in this study is similar to the earlier report (Boelee & Laamrani, 2004). The sharp reduction in conductivity observed at some points may be due to uptake of the ions by the organisms for their metabolism. A pH range of 6.2–7.4 has been reported to be favourable for most intermediate snail hosts (Brown, 1994; Boelee & Laamrani, 2004). As the pH in this study (mean value, 6.5 ± 0.72) was within this range, it is conducive for the snail intermediate hosts' development and growth. Low pH value, on the other hand, may be harmful to snail intermediate hosts of schistosomiasis, as they result in the coagulation of the mucus on exposed skin surfaces (Jordan & Webbe, 1982).

The higher conductivity values reported in the wet-season months (June 2010 to October 2010) contradicts other reports which favoured the dry season (Tubonimi, Omubo & Herbert, 2010). They attributed this increase in the dry season to combination of low precipitation, higher atmospheric temperatures resulting in higher evapotranspiration rates and higher ionic concentration and saline intrusion from underground sources. However, the run-off from the surrounding environments depositing solute particles into the water bodies couple with instability in the microhabitat of the snails and other macrobenthos leading to reduction in the uptake of ions by the organisms could have resulted in the variations observed in our study. The inverse relationship observed in snail abundance and conductivity is expected as increase in conductivity resulted in oxygen depletion. Monthly variation in TDS was similar to that of conductivity. The higher TDS load recorded in the wet-season months could be attributed to turbulence created by increase in water volume, especially after a heavy downpour. Its relationship with snail abundance is also similar to that of conductivity as high TDS causes oxygen depletion leading to asphyxiation in aquatic habitat.

All the environmental factors showed significant spatial variations and they play important roles in freshwater snail abundance, but their relationships with snail density varies from one niche to another. This could be perhaps due to the consequence of the influence of some other important factors, not measured in this study, such as for example the abundance of aquatic plants (Opisa *et al.*, 2011).

It is important to note that *B. jousseaumei* was recovered along with *B. globosus* when DO content, pH and temperature were within the tolerable limits. The origin of *B. jousseaumei* is yet to be unravelled. Further studies are therefore recommended to trace their origin. The role of the exotic snail species on the epidemiology of human schistosomiasis is worth re-evaluating. Studies on spatial distribution of freshwater snails in Nigeria and the vectoral capacity of potential snail hosts of schistosomiasis will provide information on areas of high risk of infection for adequate control of the disease.

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