Association between *Schistosoma mansoni* Infection Rates in Humans and in *Biomphalaria pfeifferi* snails in Akwanga, Nasarawa State, Nigeria

J. I. Chikwendu¹, A. Onekutu¹, I. O. Ogbonna¹ and E. U. Amuta¹

¹University of Agriculture Makurdi, Nigeria.

Authors’ contributions

This work was carried out in collaboration among all authors. Author JIC carried out the field work and wrote the first draft of the manuscript. Author AO wrote the protocol and managed the statistical analysis. Author IOO managed the literature searches. Author EUA designed the study. All authors read and approved the final manuscript.

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ABSTRACT

Schistosomiasis is a neglected tropical disease of medical importance. Intestinal schistosomiasis caused by *Schistosoma mansoni* is less wide spread than urinary schistosomiasis in Nigeria. A study was carried out in Akwanga, Nasarawa State to determine the association between *S. mansoni* infection rates (prevalence) in humans and infection rates in *Biomphalaria pfeifferi* snails in Akwanga, Nasarawa State, Nigeria. The study was carried out in two communities: Gwanje community and MadaHills community in Akwanga. For infection rates in humans, four hundred (400) urine samples were tested for *S. mansoni* antigen using point of care circulating cathode antigen (POC-CCA) test kit. Infection rates in snails were determined by *S. mansoni* cercarial shedding by snails. *Biomphalaria pfeifferi* snails were more abundant and had significantly higher (p<0.05) infection rates in dry season than rainy season in both Gwanje and MadaHills. There was a positive correlation between infection rates in humans in Gwanje and MadaHills (21.5%) and (14%) and infection rates in snails in Gwanje and MadaHills (13.9%) and (9.6%) respectively. Snails collected close to portions of the river that community residents earmarked for open

*Corresponding author: Email: joy_chikwendu@yahoo.com;
defecation within freshwater bodies had significantly higher (p<0.05) infection rates (15.8%) than
snails collected from across river banks, (7.1%) and snail infection rates in areas designated for
fetching water for drinking and domestic use was (12.7%) . Health education, improved sanitation
practices and annual chemotherapy with praziquantel could help interrupt disease transmission
and bring about schistosomiasis control in both Gwanje and MadaHills communities.

Keywords: Schistosoma mansoni; urinary schistosomiasis; intestinal schistosomiasis; Biomphalaria
pfeifferi.

1. INTRODUCTION

Schistosomiasis is one of the most prevalent neglected tropical diseases and among parasitic
diseases, it ranks second only to malaria in terms of morbidity [1]. An estimated 206.4 million
people in 78 countries require preventive treatment for schistosomiasis and 91% of people
requiring treatment reside in Africa (WHO, 2018). In Africa, there are two (2) major forms of
schistosomiasis in humans: intestinal schistosomiasis caused by Schistosoma mansoni, and urogenital schistosomiasis caused
by Schistosoma haematobium [2]. The life cycle of Schistosoma mansoni involves a snail
intermediate host and a human definitive host; infective humans eliminate parasite eggs via
stool. It is estimated that one stool sample on reaching water may yield up to 2,500 S.
mansoni miracidia [3], therefore, the life cycle of schistosomiasis in itself reveals the importance
of proper Water sanitation and hygiene (WASH) as an important tool for transmission interruption
and control of the disease [4]. Detection of cercarial shedding is used to estimate snail
infection rates; but may grossly underestimate snail infection rates as a result of interv
mental and periodic shedding [5]. Abe et al. [6] reported zero cercariae shedding in snails in water bodies
across Nasarawa State where schistosomiasis is prevalent. Schistosoma mansoni diagnosis in
humans can be carried out with Kato katz technique, molecular detection of parasites in
stool and with circulating cathode antigens test. Like other rapid diagnostic test, POC-CCA does
not require sophisticated equipments, expertise or electricity and can be performed in less than
30 minutes (Colley et al., 2017). Point of care circulating cathode antigen test has high
sensitivity and specificity and can be successfully used to determine S. mansoni infection rates
(prevalence) in humans in field epidemiology and population studies (Weerakoon et al., 2017). This
research was aimed at determining Schistosoma mansoni infection rates in humans and in
Biomphalaria pfeifferi snails in Akwanga, Nasarawa State, Nigeria. Infection rates in

2. MATERIALS AND METHODS

2.1 Study Area

The study was carried out in Gwanje community and MadaHills community in Akwanga,
Nasarawa State, Nigeria. Nasarawa State is located in North Central Nigeria Fig. 1.

2.2 Sample Size

Two hundred (200) urine samples were collected from MadaHills Primary School, 100 urine
samples from Gwanje primary school and 100 urine samples from Junior Secondary School
(JSS). Ages of school children enrolled in the research ranged from 7 years to 23 years.

Research subjects who tested positive for intestinal schistosomiasis were treated with
praziquantel by a clinician; drug dosage was administered based on body weight 40 mg/kg.

2.3 Questionnaire Forms

Questionnaires were administered in English and where necessary in local dialect to obtain
information on knowledge, attitudes and practices of the residents of the area, and data
on age, sex and location.

2.4 Time of Sample Collection

Terminal urine was collected from research subjects using a 20 ml plastic universal bottle
bearing a unique identification number which tallied with the subject’s questionnaire and
consent/assent form number. Time of sample collection was between 10 am and 2 pm which is
the peak egg shedding period for Schistosoma species. Urine samples upon collection, were transported to the laboratory for diagnosis.

2.5 Diagnosis of S. mansoni in Urine

Diagnosis for intestinal schistosomiasis was done using Point of Care Circulating Cathode Antigen (POC CCA) Test Kit. A straw pipette from within the kit was used to suction and place two drops of the urine into a pit on the POC-CCA cassette and the results were read after 20 minutes. The appearance of two lines (the control line and another red line) was interpreted as positive and the appearance of a single line (only the control line) was interpreted as negative.

2.6 Health Education

A brief health education was done for school children and teachers in schools where the study was carried out, informing them on the disease, its symptoms, how it is transmitted, and the importance of annual chemotherapy with praziquantel and proper water sanitation and hygiene for the control of the disease.

2.7 Snail Collection

Snails were collected in the early hours of the mornings from River Gwanje and River MadaHills between 6 am-7 am when the water was undisturbed [7] and transported to the laboratory; snails were sampled across water bodies using scoop nets and hand picking wearing rain boots and thick hand gloves to protect from accidental infection of the collectors by cercariae shed by the snails. In the laboratory the snails were washed twice in tap water to rid them of the layers of algae and debris around them which could obstruct cercariae shedding. After washing, the snails were placed in Petri dishes one snail per dish, submerged in tap water and placed under direct sunlight for two (2) hours to stimulate cercariae shedding in infected snails [8]. After two (2) hours, each dish was examined for shed cercariae under a dissecting microscope. Where present, cercariae were identified by their characteristic head, neck and bifurcate tail and active swimming. Snails that did
not shed on the first day (day 1), were again placed in direct sunlight the next day for two hours and the process repeated daily until the snails aestivated. The shedding experiment lasted for 15 days, within which period all snails collected aestivated.

2.8 Statistical Analysis

Chi-square test was used to verify the homogeneity of the disease in the different schools. Associations between S. mansoni infection rates in B. pfeifferi snails, and S. mansoni infection rates in humans was tested using Spearman’s correlation (rho) at P< 0.05 significance level.

Infection rates in snails was calculated as:
\[
\frac{\text{No. of snails infected}}{\text{Total No. of snails collected}} \times 100
\]

Infection rates in humans were calculated as:
\[
\frac{\text{No. of people infected}}{\text{Total No. of people tested}} \times 100
\]

3. RESULTS

Table 1 showed infection rates in snails and humans in Gwanje and MadaHills. Infection rates in humans was 21.5% in Gwanje and 14% in MadaHills. Infection rates in snails was 13.9% in Gwanje and 9.6% in MadaHills. Table 2 showed seasonal abundance of B. pfeifferi snails. In wet season the total infection rates in snails was 3.3%, and in dry season the total infection rate in snails was 12.3%. Table 3 showed infection rate of B. pfeifferi snails by collection location within freshwater body in Gwanje and MadaHills. Total infection rates in snails collected in both Gwanje and MadaHills from toilet areas was (15.8), from across river banks was (7.1), and (12.7) from across areas earmarked for fetching drinking water. Figure 2 showed a positive correlation of \( r^2 = 0.828\) between S. mansoni infection rates in snails and S. mansoni infection rates in humans in Gwanje and MadaHills, Nasarawa State.

4. DISCUSSION

4.1 High S. mansoni Infection Rates (Prevalence) in Humans

Our study revealed high S. mansoni prevalence rate in both Gwanje and MadaHills. High prevalence rate in humans is a call for treatment with praziquantel. Praziquantel is aimed at reducing both morbidities and transmission (WHO, 2016). Pam et al. [9] reported prevalence of 3.19 % in Keffi LGA, Nasarawa; and Okwori et al. [10] reported 5.3% S. mansoni prevalence in Gadabuke district, Nasarawa State. Prevalences from this study was however higher than reported by the above mentioned researchers. This could be as a result of the use of Kato-katz technique which relies solely on egg detection which could underestimate S. mansoni infection due to intermittent release of parasite eggs. For this reason, the use of up to three serial stool samples is recommended to increase sensitivity. Spencer et al. [11] and Woldegerima et al. (2019) reported higher prevalences of 93.7% in Madagascar and Ethiopia respectively using point of care circulating cathode antigen test kit for diagnosis.

4.2 Presence of Biomphalaria pfeifferi Snails in Gwanje and MadaHills

Biomphalaria pfeifferi fresh water snails were present in Gwanje and MadaHills, Nasarawa State. The presence of Biomphalaria snails have been reported across freshwater bodies in Nasarawa State (Abe et al., 2016), Kaduna State [12]; Osun State [13] and Ebonyi State [14]. Schistosomiasis epidemiology and distribution in humans is associated with the presence and distribution of the freshwater snail host [15]. For this reason xeno-surveillance (snail host monitoring/surveillance) and snail control is necessary in areas where B. pfeifferi snails host are present as their presence presents potential risk of transmission of schistosomiasis.

4.3 Snail Infection with S. mansoni Parasite

Biomphalaria pfeifferi snails in both Gwanje and MadaHills were shedding S. mansoni cercariae. Snail infection rates were higher in Gwanje than MadaHills. When people come in contact with S. mansoni cercariae, it could infect them by penetrating their skin. Therefore, high infection rates in snails are a critical indicator of transmission risk and could have dire implications for annual mass drug administration with praziquantel because in communities with high snail infection rates, reinfection could occur soon after praziquantel drug treatment; thereby making MDA a futile routine. High infection rate in snails as observed in this study is also indicative of poor hygiene practices of residents of both communities. Moser et al. [16] and
Table 1. *Schistosoma mansoni* infection rates in humans and in snails

<table>
<thead>
<tr>
<th>Location</th>
<th>Infected humans</th>
<th>Infected snails</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No examined</td>
<td>No Infected (%)</td>
</tr>
<tr>
<td>Gwanje</td>
<td>200</td>
<td>43 (21.5)</td>
</tr>
<tr>
<td>MadaHills</td>
<td>200</td>
<td>28 (14)</td>
</tr>
<tr>
<td>Total</td>
<td>400</td>
<td>71 (17.8)</td>
</tr>
</tbody>
</table>

$X^2 = 6.592, p<0.05, DF=1$

Table 2. Seasonal abundance of *B. pfeifferi*

<table>
<thead>
<tr>
<th>Location</th>
<th>Wet season</th>
<th>Dry season</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No coll</td>
<td>No inf (%)</td>
<td>No coll</td>
</tr>
<tr>
<td>Gwanje</td>
<td>46</td>
<td>3 (6.5)</td>
<td>455</td>
</tr>
<tr>
<td>Mada Hills</td>
<td>7</td>
<td>0 (0)</td>
<td>118</td>
</tr>
<tr>
<td>Total</td>
<td>53</td>
<td>3.3</td>
<td>573</td>
</tr>
</tbody>
</table>

$p= 0.00, DF=2$

Table 3. Infection rate of *B. pfeifferi* snails by collection location within freshwater body

<table>
<thead>
<tr>
<th>Location</th>
<th>Gwanje</th>
<th>Mada hills</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No exam</td>
<td>No Inf (%)</td>
<td>No exam</td>
</tr>
<tr>
<td>Toilet</td>
<td>188</td>
<td>31 (16.5)</td>
<td>46</td>
</tr>
<tr>
<td>Across riverbank</td>
<td>62</td>
<td>5 (8.1)</td>
<td>22</td>
</tr>
<tr>
<td>Drinking area</td>
<td>251</td>
<td>35 (13.9)</td>
<td>57</td>
</tr>
<tr>
<td>Total</td>
<td>501</td>
<td>71 (14.2)</td>
<td>125</td>
</tr>
</tbody>
</table>

$p<0.05$

Abdulkadi et al. [12] both reported cercariae shedding in *B. pfeifferi* freshwater snails in Chad and Kaduna respectively. In contrast, Abe et al. (2016) reported zero cercaria shedding in *B. pfeifferi* snails in water bodies in Nasarawa. Opisa et al. [5] also reported very low cercaria shedding in areas of high schistosomiasis transmission and opined that cercarial shedding could grossly underestimate snail infection rates.

4.4 Seasonal Abundance of *B. pfeifferi* Snails

In both study areas, *B. pfeifferi* snails were more abundant in dry season and in rainy season the snail population declined significantly. This could be because in rivers, water currents are higher during rainy season than dry season. *Biomphalaria pfeifferi* snails anchor on algae mats, plant vegetation and rocks present in and around rivers and streams but may be washed off by high water velocities experienced in rainy season. Abe et al. (2016) and Okpala et al. [17] found similar findings of lower snail abundance during rainy season than dry season which the former attributed to heavy rain droplets washing off snails to bottom of streams/rivers and the later to warm temperature and nutrient availability prevalent in dry season. Abdulkadir et al. [12] on the other hand, reported no significant difference in *B. pfeifferi* abundance between rainy and dry seasons in Gimbawa Dam, Kaduna State.

4.5 Seasonality in *Biomphalaria pfeifferi* Infection Rates (Prevalence)

*Biomphalaria pfeifferi* snails had higher infection rates in dry season. *Schistosoma* parasite is a tropical parasite known to show periodicity. Both Gwanje and MadaHills communities rely on wells and streams/rivers for water, but wells dry up in the dry season causing people to visit streams/rivers more frequently. Increased human traffic in the river could be responsible for the increased snail infection rates. Snail control and praziquantel treatment efforts could therefore be carried out pre-dry season to make maximum impact as snail population and snail infection rates peak in dry season. Seasonality in snail infection rates was reported by Opara et al. (2010). Abdulkadir et al. [12] however reported no significant difference in infection rates in rainy and dry season. Seasonality in human infection with the
practice and health education of the residents of
There is therefore need for proper sanitation
domestic use and for defecation, is grossly
like "damming" portions of a water body for
of swimming upstream and that simple measures
all three locations were infected even though the
dammed by residents for fetching water for
river (shorelines), and snails collected in areas
higher infection rates than snails collected across
earmarked for defecation (toilet) had significantly
were collected within the water bodies. Snails
found a positive correlation between infection
snails in Gwanje than in MadaHills. We also
Our study revealed higher mean infection rates in
transmission in both communities. Opisa et al. [5]
also reported significant difference in snail
infection rates by location, with higher infection
rates in snails collected from inland water bodies
than in snails collected from lake shore sites in
Western Kenya.

4.6 Differences in Infection Rates in
Snails by Collection Location

Our study revealed higher mean infection rates in
snails in Gwanje than in MadaHills. We also
found a positive correlation between infection
rates in snails and the location from which they
were collected within the water bodies. Snails
collected closer to where residents of the area
earmarked for defecation (toilet) had significantly
higher infection rates than snails collected across
river (shorelines), and snails collected in areas
dammed by residents for fetching water for
drinking and domestic use. However, snails from
all three locations were infected even though the
drinking water area was upstream from the toilet
area. This goes to show that miracidia is capable
of swimming upstream and that simple measures
like "damming" portions of a water body for
domestic use and for defecation, is grossly
insufficient to protect from S. mansoni infections.
There is therefore need for proper sanitation
practices and health education of the residents of
both Gwanje and MadaHills in order to control
parasite was reported among rice farmers in
Cote d'Ivoire by Gbalegba et al. [18]. In this case
however, the rice farmers were more infected in
rainy season than in dry season because they
only spent more time in freshwater during rainy
season when they cultivated their rice paddy.

4.7 Correlation between Infection Rates in
Snails and Infection Rates in Humans

We found a positive correlation between infection
rate in snails and infection rate (prevalence) in
humans in the two schistosomiasis endemic
communities (Gwanje and MadaHills). The
higher infection rates in snails in Gwanje
correlated with higher infection rates in residents
of Gwanje community and lower infection rates in
snails in MadaHills correlated with lower infection
rates in residents of MadaHills. Infected
individuals visit and contaminate water bodies,
high infection rates in snails maybe responsible
for higher infection risk and rates in individuals in
Gwanje community, and higher infection rates in
people may be the reason for high infection rates
in snails in Gwanje. This shows the importance
of a combination of control measures like MDA to
too control the disease in humans, snail control
and public health education on proper WASH
practices in endemic communities. Bakuzza et al.
(2017) also reported positive correlation between
infection rates in snails and infection rates in
humans in Gombe State, Nigeria, with corresponding high S. mansoni infection rates occurring in humans in areas where infection rates in snails were higher and low infection rates occurring in humans in places where zero infection rates were found in snails. In contrast, Opisa et al. [5] reported low infection rates in B. pfeifferi snails in areas where schistosomiasis was known to be endemic; which the author attributed to intermittent release of cercariae by snails which could have led to underestimation of snail infection rates.

5. CONCLUSION

Schistosoma mansoni is endemic in Gwanje and Madai Hills Nasarawa State, and there is positive correlation between infection rates in snails and infection rates in humans. Reducing infection rates in snails may complement MDA with praziquantel aimed at reducing infection rates in humans. Health education on proper WASH practices may lead to reduced infection rates in snails and humans in endemic communities and could go a long way in improving the efficiency of praziquantel MDA in endemic communities thereby bridging an implementation gap.

CONSENT AND ETHICAL APPROVAL

Ethical clearance was obtained from ministry of health research ethics board. Informed consent and accent were obtained from parents, school authorities and research subjects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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