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Identification and mapping of some potential transmission foci of schistosomasis in Maroua, Far North Region, Cameroon

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ABSTRACT: Like many African cities affected by urban schistosomiasis, Maroua in the Far North Region of Cameroon has a moderate level of schistosomiasis transmission, as indicated by human infections. This study was designed to identify and map some potential transmission sites of schistosomiasis in Maroua. Water ponds were surveyed for snail intermediate host of schistosome and mapped using a handheld Global Positioning Systems (GPS). Snail status was assessed via cercaria shedding procedure. The vegetation cover, human water contact activities and some physico-chemical characteristics of the water including pH, temperature, salinity, total dissolve solute (TDS) were measured and documented. Twenty two water ponds were surveyed and 21 of them were found to have at least one of the two identified schistosome snail host species. A total of 658 specimens of snails were collected: 57.45% *B. senegalensis* and 42.55% *B. globosus*. Eleven water ponds were found to have both snail host and the 10 other have single species (8 with *B. senegalensis* and 2 with *B. globosus*). Ten (1.56%) of the 642 snails were found to shed *Schistosoma* cercariae: 2.21% in *B. senegalensis* and 0.71% in B. *globosus* and they were not significantly different (χ^2 = 1.431, p= 0.232). The presence of *B. senegalensis* and *B. globosus* (two known intermediate snail host of *S. haematobium*) snail and their infections with *Schistosoma* suggest possible local transmission of human schistosomiasis in Maroua. Exposure to these water environments may pose infection risk to general population, in particular children who seem to have greater water contact.

KEYWORDS: Mapping, *Bulinus senegalensis*, *Bulinus globosus*, schistosomiasis, Maroua, urban area.

1 BACKGROUND

Schistosomiasis, a water-associated parasitic disease and part of neglected tropical diseases, still poses a significant public health threat to many parts of developing countries [1]. More than 90% of infected cases are from sub-Saharan Africa [2]. Of the six species of *Schistosoma* affecting humans, four are known to occur in Africa: *Schistosoma haematobium* that causes urinary schistosomiasis, *S. mansoni*, *S. intercalatum* and *S. guineensis* (formerly *S. intercalatum* [3], [4]) which cause intestinal schistosoimiasis. People become infected when they contact freshwater containing *Schistosoma* cercariae, shed by infected intermediate host snails, which in Africa are fresh water pulmonate snails belonging to the family Planorbidae [5]. The species belong to two genera, *Biomphalaria* (host of *S. mansoni*) and *Bulinus* (host of *S. h*aematobium, *S. intercalatum* and *S. guineensis*). Transmission can take place both in natural and man-made water bodies and it may occur in almost any type of habitat from large lakes to the small seasonal ponds or streams [6].

Infections with schistosomes are particularly abundant among people living in rural or deprived urban settings with low socio-economic status, such as lack of clean water and poor sanitation [7]**.** Urban foci of schistosomiasis in tropical areas are generally given little attention by control programs, largely due to that transmission is less intense in urban settings than in surrounding rural areas. Cases of urban schistosomiasis have been reported in several areas of Africa, e.g. Nigeria [8], Mali [9] as well as Zambia [10].

In Cameroon schistosomiasis is an important public health problem particularly in the northern tropical climatic zone of the country where the highest transmission levels of schistosomiasis have been reported [11]. The country has also faced urban schistosomiasis, particularly in the town of Yaoundé where the transmission of *S. mansoni* has extended beyond its former transmission points of Melen and Nkolbisson [12] to reach other quarters such as Mballa1 – Dragage and Obobogo, partially as consequences of poor sanitation ([13], Tchuem Tchuenté, personal communication). The town of Maroua in the Far North Region is also concerned with urban schistosomiasis. Indeed, a parasitological survey for urinary schistosomiasis conducted on schoolchildren of Maroua town showed that about 22.90% of them have *S. haematobium* eggs in urine [14]. However, nothing was done to identify potential schistosomiasis transmission water points in the town. This information is important as it may be useful to enhance the effect of mass praziquantel distribution implemented by Ministry of Public Health through the National Program in charge of schistosomiasis control in Cameroon.

The objective of this study was to determine the presence and geographical distribution of snail intermediate hosts for schistosome, and their infection status among freshwater bodies in the urban area of Maroua town. In addition, we also assessed the environmental and physico-chemical factors that may influence snail distribution, and some human activities that may be related to the transmission.

2 MATERIALS AND METHODS

2.1 STUDY AREA AND WATER CONTACT ACTIVITIES

Maroua, the capital city of the Far North Region of Cameroon is situated in the Sahelian zone of Cameroon, with a soudano-sahelian tropical type climate, characterized by more than 7 months of dry season with the highest temperature of about 45°C, and a short rainy season. The annual precipitation varies between 400 and 1100 mm, August being the rainiest month [15], [16]. The population of Maroua is estimated to 3 111 792 inhabitants with a density of 90.8 inhabitants per km^2 [17]. The town of Maroua is built on a plain surface area with the soil having about 40 % of clay. These soils which crack during the dry season have a hydric behavior characterized by total impermeability when they are saturated [18]**.** This favors the creation of temporary standing water ponds during the raining season, where people normally carry out their domestic activities. The hydrography of Maroua town is therefore made up of non-permanent flowing, or standing water.

2.2 PRELIMINARY STUDY

A preliminary survey in the Maroua urban area in October 2013 was carried out in order to identify all available surface water bodies where human activities occurred. These activities are: water collection, clothes washing, bathing, swimming or playing (by children) and car or motorbike washing. Based on personals observations and report from neighboring human habitation, we selected 15 different water ponds within the study area (Fig.1): seven additional water bodies were sample at Meskine neighboring village, situated at about 6 km from Maroua town. At Maroua, five of the sample water bodies were at Palar quarter (Massinika1, Massinika2, Massinika3, Palar 1, Palar 2, Palar 3); three at Dougoï (Lougguéo pont, commissariat, dix villas); two at Domayo (SODECOTON, papala), two at Ouro Tchédé (OT, OT1) and one respectively at Ouro lopé and

Makabaye. At Meskine, the sample water bodies are located at: hardé antenne, banka, CMAO, école publique d'application, dougoïwo 1, dougoïwo 2, dougoïwo 3.

2.3 SNAIL SURVEY AND GEOGRAPHIC DISTRIBUTION

During the month of November 2013, snail sampling was performed once in each of the selected water ponds at two different human contact points. This was performed using a standard kitchen sieve mounted on a 2m wooden handle or by hand picking [19]. The search and collection of snails were done by two collectors for 15 minutes between 7.00 and 10.00 AM. Sampling area per water pond was approximately 0.5 m^2 (1 m along water pond shoreline). At each water pond, all collected snails were placed in a single labeled container and transported to the laboratory where they were sorted and washed. Snail identification was based on shell morphology [20], [21]. After identification, potential intermediate hosts of schistosome were examined for infections status under a dissecting microscope. Individual snail was placed in a well of Disposo-Tray® plate containing 1ml of dechlorinated tape water and exposed to indirect sun light from 10.00 PM to 3.00 AM. Exposed snails were fist of all checked for cercarial shedding at 12.00. Snails that were found negative were re-exposed and check again for cercarial shedding at 3.00 AM. Snails that did not shed cercariae on the first day exposure were re-exposed and check the next day.

In order to determine the geographic distribution of snails, all sampled water ponds were mapped using a small hand-held Global Positioning System (GPS) device, and the snail abundance was determined for each sample water body by categorizing density of each species to fore groups: 0, 1-50, 51-100, and 101-150.

2.4 ENVIRONMENTAL AND PHYSICO-CHEMICAL PARAMETERS

Environmental and physico-chemical parameters recorded are among those suggested to be important for freshwater snail distribution [22]. So aquatic vegetation (present or absent) and different types of human activities conducted within the sampled water ponds were recorded as environmental data. The physico-chemical parameters recorded include level of water turbidity (classified as weak, average, and strong), pH, conductivity, salinity and total dissolved solutes (TDS).

2.5 DATA ANALYSIS

All data analyses were performed using statistical Software GraphPad (Instat. Version, 3.10.) and P values < 0.05 were considered statistically significant. Comparison of mean abundance for collected snail species in all the sampled water bodies was performed using Wilcoxon test. Comparison for prevalence of infection between snail host species was performed using Chi-square test. This test was also used to determine the association between snail abundance and environmental and physico-chemical parameters. All the sample water ponds with snail abundance were plotted on a map using Geographical Information System (GIS) software ArcGIS (ESRI Inc., Version 9.2).

3 RESULTS

3.1 SNAIL SPECIES, DISTRIBUTION AND ABUNDANCE

A total of 658 freshwater snail specimens were collected from 21 out of the 22 sampling water bodies, 14 in Maroua urban area and 7 at Meskine. All sample sites were temporary water bodies. On the basis of shell morphology, two species of snail potential host of schistosomes were recognized: 378(57.45%) of the snails collected were recognized as *Bulinus senegalensis* and 280 (42.55%) as *Bulinus globosus* (Table 1). At least one of these snail species was collected in each sample water body. Eleven of them were found to have both *B. senegalensis* and *B. globosus*. Of the 10 remaining water bodies with single snails species, *B. senegalensis* was present in 8 and *B. globosus* in 2. The only water pond where snails were not found is in Maroua town (papala) at Domayo quarter (Fig. 2). *B. senegalensis* was collected in 19 (86.36%) water ponds of the 22 surveyed, whereas *B. globosus* was present at 13 (59.09) water ponds (χ^2 = 2.865, p= 0.0905 with Yates correction).

The mean abundance of snail per species in all the sample water bodies was 17±18 (0-61) snails for *B. senegalensis*, and 13±24 snails (0-83) for *B. globosus*, not significantly different (p = 0.161 by wilcoxon test). Eighteen (85.71%) of the sample water bodies have 1 – 50 snails and, just 2 (9.52%) and one (4.76%) have respectively 51 – 100 snails and 101 – 150 snails abundance (Fig. 3). Of the 19 water ponds with *B. senegalensis*, 89.47% (17) have 1- 50 snails; whereas 10.53% (2) have 51-100 snails (Fig. 4), and of the 13 with *B. globosus* snail specie, 84.42% (11) have 1 – 50 snails and 15.38% (2) have 51 – 100 snails (Fig. 5).

3.2 INFECTION IN SNAILS

Ten (1.56%) of 642 snails tested for infection were shedding *Schistosoma* cercariae. The mean percentage of snails shedding was not significantly different between *B. senegalensis* (2.21%) and *B. globosus* (0.71%) (χ^2 = 1.431, p= 0.232 with Yates correction). The ten infected snails were distributed in 6 water ponds: 2 at Dougoïwo 1 and hardé antenne at Meskine, 1 respectivelly at Palar3, Ouro tchédé, Ouro lope and dougoï 10 villas at Maroua. Hardé antenne at Meskine was the only water ponds with both *B. senegalensis* and *B. globosus* shedding *Schistosoma* cercariae (Table 2).

3.3 PHYSICO-CHEMICAL FACTORS OF WATER

The means, minimum and maximum values for chemical variables of sample water ponds are presented in Table 3. There was no association between water chemistry and the overall snail abundance. However water turbidity was associated with total snail abundant, in such a way that the total number of collected snails (abundance) seem to decrease significantly when the turbidity of the water increase (Table 4) (χ^2 = 275.6; p< 0.0001).

3.4 AQUATIC VEGETATION AND HUMAN WATER CONTACT ACTIVITIES

Three main aquatic vegetation types were identified (Table 5). They are: herbs (21 water ponds), *Numphea lotus* (12 water ponds) also known as lily, and *Ipomoea carnea* (18 water ponds). The total snail abundance increases significantly with the aquatic vegetation (p<0.0001).

Five main human activities were observed in the sample water ponds: fetching of water, swimming, washing clothes, washing dishes and fishing (as pleasuring activity for young boys and girls). Among those human activities, fishing, fetching of water and swimming were the most observed whereas washing clothes and dishes were the less within the 22 sampled water ponds (χ^2=27.427, p< 0.0001) (Table 5). For these three main water contact activities, only children were involved.

4 DISCUSSION

This study was an attempt to identified and map potential transmission water ponds for schistosomiasis in an urban area in Cameroon. This type of information is critical when a control measure other than mass drug distribution is needed [22]. Maroua town is surrounded by villages endemic for schistosomiasis and the presence of people infected with schistosomiasis raises the question of where they get the infection, as far as many of them are from those infected surrounding villages. Until now studies on schistosomiasis conducted in Maroua town were focused only on parasitological aspects (e.g. prevalence of infection), none was directed to transmission foci and snail host involved. It is well known that mapping prevalences does not necessarily indicate the origin of infections, particularly in urban areas, where the mobility of the population is high [23].

Results of our malacological surveys have shown that of the 22 water ponds surveyed, 21 were found to have at least one of the two identified snail species (*B. globosus* and/or *B. senegalensis*) and all the sample habitat were small temporary water ponds. These small temporary natural water ponds are known to be the main transmission sites for schistosomiasis in the Far North Region of Cameroon, where transmission goes for short season [11], [24]. Previous malacological surveys in the Far North Region of Cameroon reported the presence of *B. globosus*, *B. senegalensis* and *B. truncatus* (snails host of *S. haematobium*), *Biomphalaria pfeifferi* (snail host *S. mansoni*) and *B. forskalii* the only snail host of *S. guineensis* in Cameroon [24], [11]. Neither *B. truncates*, *Biomphalaria pfeifferi* nor *B. forskalii* were collected during our survey. This is not surprising for *B. truncates* and *Biomphalaria pfeifferi* as far as these species have been reported to be found mostly in permanent waters ponds in this region [20], [24]. However, *B. forskalii*, one of the most common and widely distributed of all the schistosome host species, was not found during our survey. When using shell morphology as identification means, confusion could happen between snail of *B. forskalii* group (which members found in Cameroon are *Bulinus forskalii* Ehrenberg, 1931; *B. senegalensis* Muller, 1971 and *B. camerunensis* Mandahl-Barth, 1975), particularly when they overlap in their distribution as it seem to be the case for *Bulinus forskalii* and *B. senegalensis* in the Far North Region of Cameroon [24]. One of the distinguishable morphological differences between these two species is the lack of shoulder angle (characteristic of *B. forskalii*'s shell) on the upper whorls of the shell of *B. senegalensis* [21]. During our survey all the snail identified as *B. senegalensis* was lacking the shoulder angle.

A relatively low percentage of snails tested for *Schistosoma* cercariae were found positive, and shedding rates were not quite different between the two snail species tested. It is generally agreed that snail population density and infection rates undergo great seasonal variations in all type of habitat and that rain fall and/or temperature are the main causative factors [22]. Indeed, studies on population dynamic of snails in temporary water ponds in the Far North of Cameroon have shown in general that, the population density increases modestly during the rainy season and then rapidly declines after torrential rains have ended in September or October [25]. Our snail collection was performed during the month of November not far from the period were snail population variation is assumed to be relatively low.

Our results show that snail abundance seems to be higher when aquatic vegetation was present suggesting a positive association between these two variables. Similar observations were reported in Niger, where *Biophalaria pfeifferi* and *Bulinus truncatus* were found to be associated with submerged aquatic macrophytes or emergent hydrophytes [26]. Aquatic vegetation constitutes an important element in the habitat of snail schistosomes host and controlled of this aquatic vegetation is likely to have profound effect on the intermediates host snail [6].

Of the 5 human water contact activities observed during our malacological surveys, fishing (as entertainment activity), fetching of water and swimming were the main exposure activities and children were the one involved. Similar observation was done in Nigeria where swimming, fetching of water and cleaning clothes played important role in the spread of the urinary schistosomiasis in Ibadan, and young boy are more engaged than girl in water contact activities [27].

5 TABLES AND FIGURES

5.1 TABLES

Table 1. Summary of the distribution of snail species abundance in all the visited quarter

Quarters	**Number of surveyed Water pounds**	**Snail species**		**Total snail abundance**	**Mean snail Abundance**[1]
		B. globosus	***B. senegalensis***		
Domayo	2	0	2	2	1 ± 1
Dougoï	3	14	29	43	14 ± 8
Makabaye	1	1	16	17	17
Ouro lopé	1	0	29	29	29
Ouro tchédé	2	20	40	60	30 ± 8
Palar	6	56	108	164	27 ± 27
Meskine	7	189	154	343	49 ± 51

Values are means ±SD

Table 2. Percentage distribution of infected snails shedding Schistosoma cercariae in sample water ponds

	B. globosus		***B. senegalensis***		**Total snail**	
Name of Water pounds	NE	NP (%)	NE	NP (%)	NE	NP(%)
Massinika 1	0	0	21	0	21	0
Massinika 2	21	0	0	0	21	0
Massinika 3	1	0	22	0	23	0
Palar 1	2	0	0	0	2	0
Palar 2	8	0	8	0	16	0
Palar 3	24	0	55	1.82	79	1.3
Ouro lopé	0	0	29	3.45	29	3.4
Lougguéo pont	0	0	9	0	9	0
Dougoï commissariat	13	0	1	0	14	0
Dougoï dix villas	1	0	19	5.26	20	5
(OT1) Ouro tchédé collège Espoir	20	0	4	0	24	0
(OT) Ouro tchédé	0	0	36	2.78	36	2.8
Makabaye	1	0	16	0	17	0
Papala	0	0	0	0	0	0
SODECOTON	0	0	2	0	2	0
Banka	0	0	4	0	4	0
Hardé antenne	80	2.5	56	3.57	136	2.9
CMAO	83	0	9	0	92	0
EP d'application	0	0	3	0	3	0
Dougoïwo1	0	0	31	6.45	31	6.5
Dougoïwo2	10	0	34	0	44	0
Dougoïwo3	16	0	3	0	19	0
Total	**280**	**0.71**	**236**	**2.21**	**642**	**1.56**

NE: number of snail examined for cercaciae shedding; NP: Number of snail positive

Table 3. Summarizing values of water chemistry variable in all the sample water ponds

	Water chemistry				
	Temperature	pH	Conductivity	TDS	Salinity
Mean ± SD	28.54 ± 3.796	7.895 ± 0.776	236.024 ± 143.87	162.895 ± 88.198	11.664 ± 66.587
Minimum	20.40	6.82	94.2	69.3	46.200
Maximum	33.50	9.90	591.00	413.00	295.00

Table 4. Level of turbidity of sample water ponds in relation with total snail abundance in all sample water ponds

Level of turbidity	**weak**	**average**	**strong**
Total snail abundance	329	270	59

Table 5. Frequency distribution of different human water contact activities present in sample water ponds

Human activities									
fetching water		washing clothes		washing dishes		swimming		fishing	
P	P (%)	P	P (%)	P	P (%)	P	P (%)	P	P (%)
16	72.73	5	22.73	6	27.27	10	45.45	19	86.36

P: present; P (%): percentage of present

5.2 FIGURES

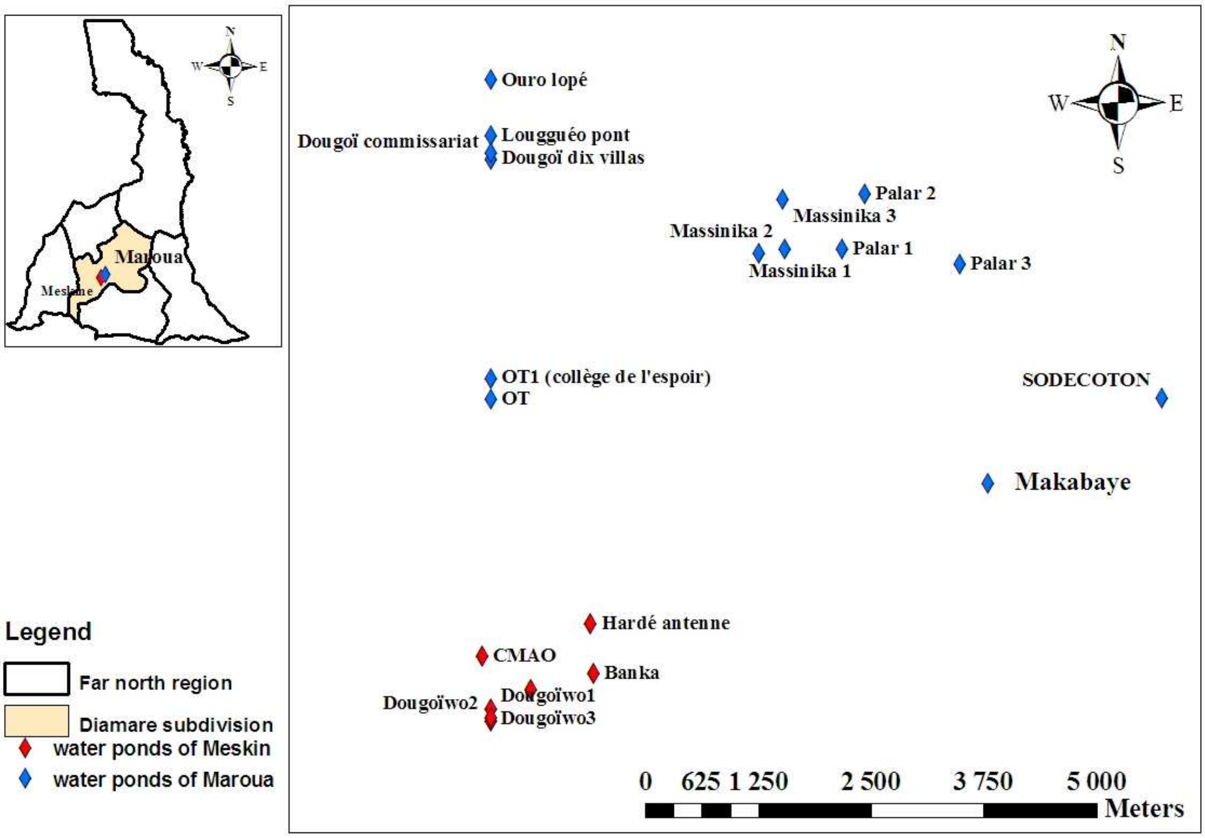

Fig. 1. Spatial distribution of sample water ponds within the studied area

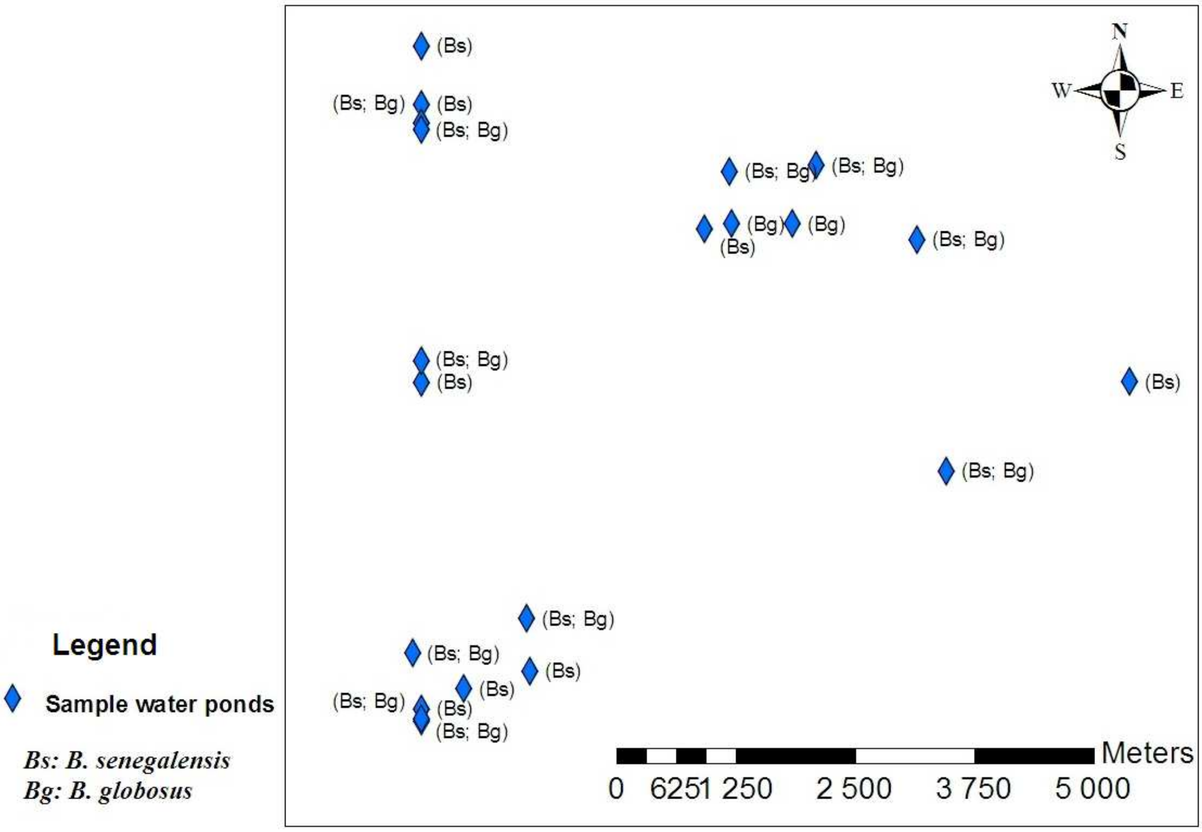

Fig. 2. Spatial distribution of collected snail host of Schistosoma within the studied area

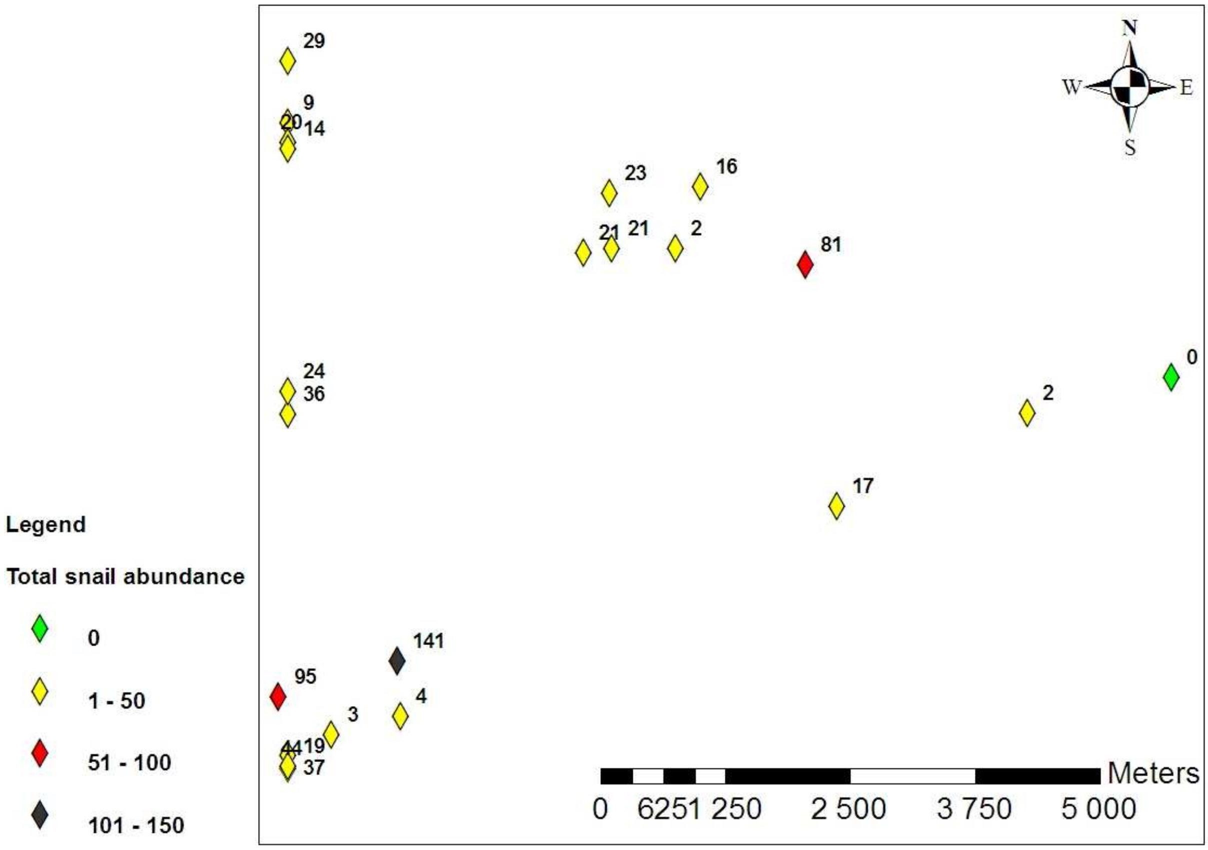

Fig. 3. Spatial distribution of total snail abundance within the studied area

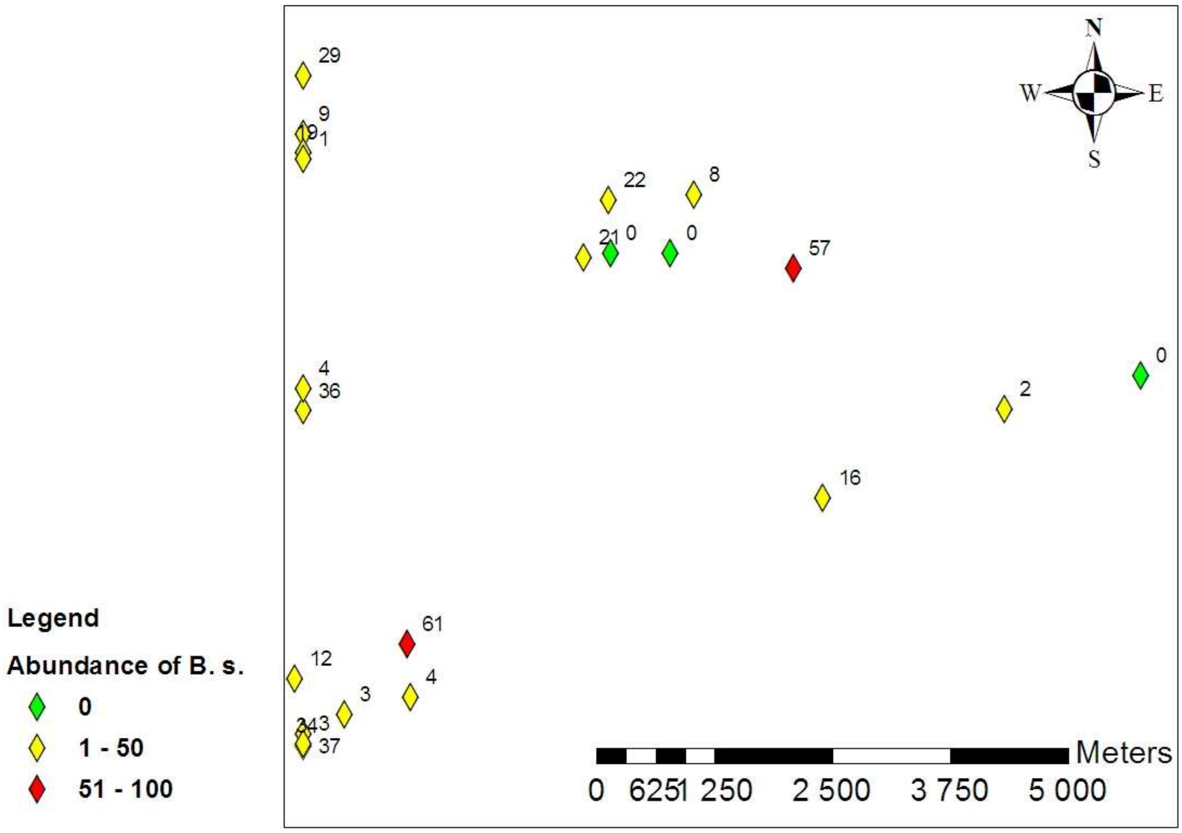

Fig. 4. Spatial distribution of B. senegalensis abundance within the studied area

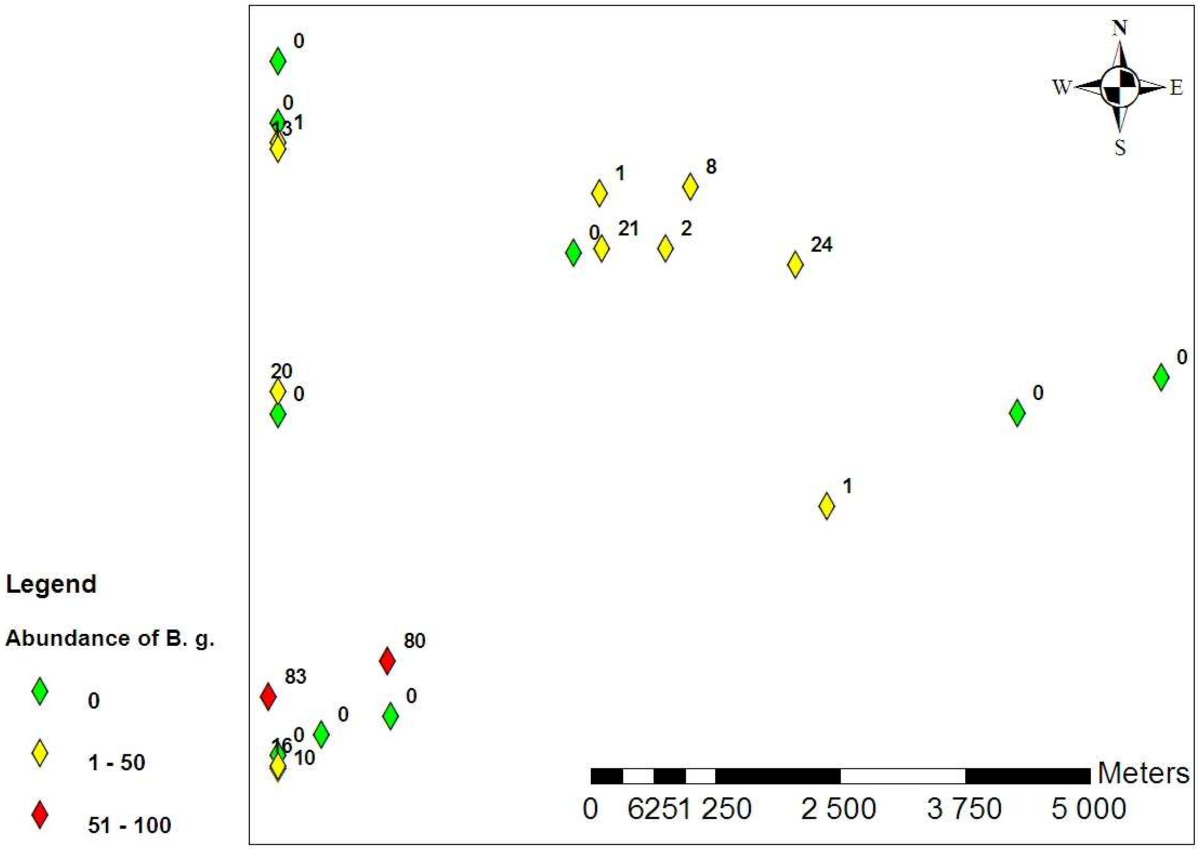

Fig. 5. Spatial distribution of B. globosus abundance within the studied area

6 Conclusion

In conclusion, our findings indicate that temporary standing water ponds in Maroua town are potential transmission sites for schistosomiasis and *B. senegalensis* and *B. globosus* are the potential snail host, in addition, the study also indicates that of the environmental factors observed, turbidity of water and aquatic vegetation were associated with snail abundance in the sampled water pond. Although the study doesn't provide a full picture of schistosomiasis transmission dynamic in Maroua town, it heds insights into malacological aspects that may underlie the schistosomiasis in the Far North Region of Cameroon. Further studies using frequent sampling covering the whole rainy season are needed to understand the dynamic of transmission. These will provide information on the most important transmission sites and seasons, and which indicators should be used to identify transmission sites in order to determine whether or not to carry out snail control in an identified site at a given time. Human water contact pattern also need to be screen in details in order to determine the socio-demographic and reasons of water contact that can be use for control purpose.

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