PREDICTING THE GEO-SPATIAL DISTRIBUTION OF *BULINUS* SNAIL VECTOR OF URINARY SCHISTOSOMIASIS IN ABEOKUTA, SOUTH-WESTERN NIGERIA

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Abstract

Bulinus spp, are freshwater snails that serve as intermediate hosts of *Schistosoma heamatobium* which cause urinary schistosomiasis in human beings. The knowledge of their spatial distributions can be used to map the extent and risk of the disease in endemic areas. This paper therefore, presents the geo-spatial distribution of *Bulinus* sp. in Abeokuta in Ogun State. *Bulinus* snails collected from 31 water bodies consisting of 19 rivers, 9 streams, 2 dams and 1 canal were examined for infection. A total of 58 *Bulinus* snails made up of *Bulinus forskalii* 2 (3.4%*)*, and *Bulinus truncatus* 56 (96.4%) were collected respectively. The *B. truncatus* was collected from 15 sites out of which infected *B. truncatus* was collected from 12 sites. The regression analysis of *Bulinus* distribution using remotely-sensed environmental data showed that rainfall was the only significant predictor of the distribution of *B. truncatus* (B= 26.690, Sig= 0.040). (B= -3.182, Sig= 0.050). A predictive risk map constructed for *B. truncatus* indicated the probability presence of 1.0 for Abeokuta area. These results suggest a likelihood and potential spread of urinary schistosomiasis into other areas of Abeokuta in the absence of snail control measures or mass chemotherapy.

Keywords: geo-spatial distribution, *Bulinus truncatus*, *Schistosoma heamatobium,* Abeokuta, Nigeria.

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Introduction

Freshwater snails of the genus *Bulinus* serve as snail intermediate hosts of *Schistosoma haematobium,* the causative agent of urinary schistosomiasis in Africa. Globally, more than 200 million people are infected with schistosomiasis and an estimated 779 million are at risk of infection predominantly in sub-Saharan Africa (Steimann *et al* 2006). In many parts of Nigeria, water projects such as mini-dams, irrigation canals, continue to proliferate, with its potential danger for the spread and maintenance of endemic parasitic diseases, where freshwater snail serves as intermediate hosts (Ejeize *et al* 1991). In the absence of safe and potable water supply, many communities in Nigeria still depend on surface water from rivers, streams, canals and dams for their daily water needs. This often exposed them to water transmitted infections.

Although the control of schistosomiasis in sub-Saharan Africa is based on mass chemotherapy of school-aged children. This has resulted few in studies aimed to provide prevalence data and risk maps to guide drug administration in Nigeria (Ekpo *et al* 2008).

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However, the knowledge of the extent of the distribution of its snail vector is also essential for the epidemiology of the disease and mapping area for control programme (Brooker, 2002). Computer-based geographic information systems (GIS) have been used to digitally map and predict snail distribution in Egypt and China, (Malone *et al* 1997; Seto *et al* 2002). Consequently, there is the need to assess and define the current distribution of *Bulinus sp* as it will help in designing intervention strategies and to optimize the use of available resources for control. This paper therefore mapped spatial extent and distribution of *Bulinus* snail vector of urinary schistosomiasis, indentify active transmission sites, in Abeokuta, Nigeria using known environmental variables that influence the distribution of *Bulinus* snails.

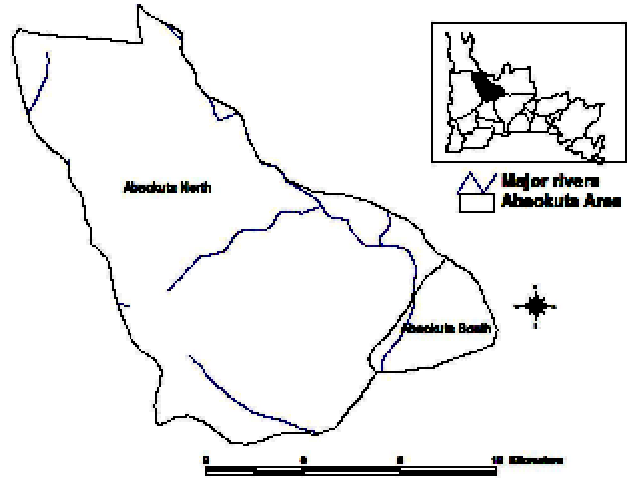

Figure 1: Map of study area with Ogun State as insert.

Materials and methods

Study area

Abeokuta is a big commercial town with an area of 718.16 sq. km. and lies on 3.00′N and 7.15′E in Ogun State, south-west Nigeria. The area is politically divided into two local government areas namely: Abeokuta North and Abeokuta South Local Government Areas respectively see (Figure 1). The town serves as the capital of the state and is about 75 km from Lagos. Abeokuta, which accounts for about 16.1% of the human population in the state, is traversed by many streams and rivers, which are tributaries of Rivers Ogun and Oyan, the major river system in the area. About 95% of the inhabitants are Yoruba by tribe. Trading, fishing and farming activities are the main source of income in the area. A total of 31 freshwater sites were sampled for *Bulinus* snails. These were 19 rivers, nine streams, two dam sites and one canal.

Sampling for *Bulinus* snails

Snail sampling was done at selected sites along water bodies. These include sites where people wash clothes or utensils, collect water for domestic purposes, bathe, swim or fish and sites with no apparent human water contact. Each sampling site was visited in the morning and snail collection was made for 45 minutes at each of the site, using scooping net (diameter: 18 cm) supported by a frame mounted on a 2-metre long handle. Manual search with visual inspection and hand-picking was also employed at the various sites. The snails were identified using shell morphology following Brown and Kristensen (1993).

Screening for *Bulinus* for cercarial shedding

The snails were screened for cercarial shedding in the laboratory. Each individual snail was placed in a petri-dish containing aged tap water, and exposed to sunlight for one hour. The water was then examined for the presence of cercaria.

Environmental data

Remotely-sensed images of Normalized Difference Vegetation Index, Land Surface Temperature, and land cover data for the study-area and period were downloaded from the *Moderate-resolution Imaging Spectroradiometer* (MODIS) Satellites Data Archives webpage (http://wist.echo.nasa.gov). Rainfall data was downloaded from the *Africa Data Dissemination* Services (ADDS) (http://earlywarning.usgs.gov/adds). Other data collected were presence or absence of schistosomiasis infection in nearby communities (Ekpo and Mafiana, 2004). Level of sanitation, such as presence of toilets, safe water supply, use of water bodies were collected by physical inspection of these facilities in the communities. The location (Latitude, Longitude and Altitude) of snail collection sites were geo-referenced with a hand-held Garmin 12XL Global Positioning System (GPS) receiver (Garmin Corporation, USA). Readings were cross-checked for accuracy from topographical map of Abeokuta.

Extractions of data from remote sensed images

MODIS images for NDVI, LST and landcover from October 2008 to March 2009 were re-projected to Geotif Image Files using *MODIS* reprojection Tools version 4.0 (https://lpdaac.usgs.gov/lpdaac/tools/modis_reprojection_tool). The Geotif Files were imported into ArcView 3.2a (ESRI, USA) and the values corresponding to the snail collection sites were extracted and appended to the DBF file of snail location co-ordinates using the "extract data from grid" extension tool. The DBF file was imported into *Statistical Package for Social Sciences Software Version* 16 (SPSS Inc, Chicago, IL, USA) for further analysis. Rainfall data were downloaded as bil file, processed to extract values corresponding to snail collection site in Idrisi 32 (Clark Laboratory, USA).

GIS data analysis and models

The extracted environmental data (LST, NDVI, land cover, soil types) altitude and snail data set were analysed for relationship in *SPSS.* Analysis using binary logistic regression was performed to assess which environmental variable is associated with *Bulinus sp.* present. A model was established, defining *Bulinus sp.* present as cases, and incorporating NDVI, LST, rainfall, land cover and altitude variables. Then, the non-significant associations were removed with a forward step-wise elimination technique. For those associations that remained significant, their odds ratio at 95% confidence intervals, the likelihood ratio, and *p*-values were calculated. The same procedure was used in a second model that defined cases as infected or non-infected *Bulinus sp.* The best-fit logistic regression models were then entered into the map calculator module of ArcView GIS spatial analyst to generate predictive model maps of geo-spatial distribution of *Bulinus sp.*

Results

Fifty-eight *Bulinus* snails were collected between October 2008 and March 2009 from the 15 (48.4%) of the 31 sites surveyed in Abeokuta. The *Bulinus* snails consist of *B. forskalii* and *B. truncatus*. Eighty per cent of the 15 sites harbouring *B. truncatus* had infected snails. Table 1 shows the geographical co-ordinates of sites and the number of *Bulinus* snails collected and sites where infected snails were found.

Geo-spatial distribution of *Bulinus* snail

B. truncatus and *B. forskalii* snail species were found in the study. Only *B. truncatus* were infected. Point distribution of *Bulinus truncatus* and *B. forskalii* are shown in Figures 2 and 3 respectively. From the 31 sites surveyed, *B. truncatus* were found in 15 sites while *B. forskaii* were found in only 2 sites; Ita Iyalode Stream and River Arakanga (Figure 3). Of the 56 *B. truncatus* collected, 25 (44.64%) were infected. Infected *B. truncatus* were found in 12 sites, such as tributaries of River Ogun and in streams and rivers in Abeokuta North LGA. Figure 4 shows that infected *B. truncatus* was found in 11 sites in Abeokuta North LGA but was found only at Lafaru Stream in Abeokuta South LGA.

Predictive model spatial distribution map of *Bulinus truncatus*

A number of different logistic regression models were fitted to the data to identify best-fit models using remotely sensed environmental variables. The logistic binary regression analysis showed that rainfall (p=0.040), was the only significant variable in predicting the geo-spatial distribution of *B. truncatus*. Other

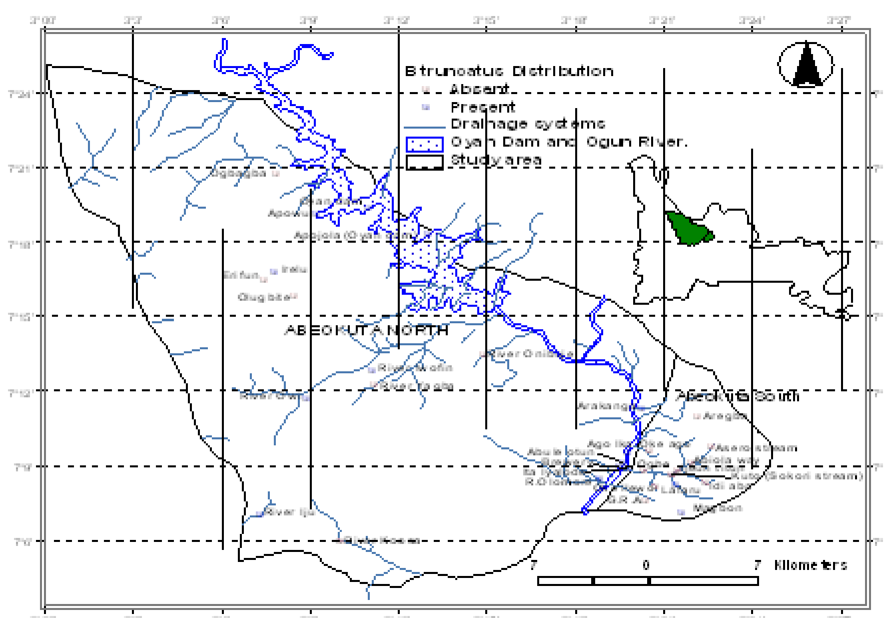

Figure 2: Point distribution of *Bulinus truncatus.*

Table 1: Geo-graphical co-ordinates of snail collection from sites surveyed.

Site codes	Sites	Latitude	Longitude	Altitude	*Bulinus forskalii*	*Bulinus truncatus*	Total	With infection
1	Lafaru	3.35609	7.13639	87	0	2	2	Yes
2	Magbon+	3.36070	7.11822	89	0	4	4	No
3	Aregba (Labaiwa)	3.36943	7.18271	107	0	0	0	No
4	Oke Ilewo+	3.34579	7.13565	69	0	0	0	No
5	G.R.A+++	3.33949	7.12605	79	0	0	0	No
6	Ita Iyalode+	3.32931	7.14745	39	1	6	7	Yes
7	Ago Ika (R. Ogun)	3.32956	7.15842	42	0	4	4	Yes
8	Ogbe +	3.33829	7.14635	36	0	0	0	No
9	Ijeun Titun+	3.35789	7.14582	66	0	0	0	No
10	Abule Otun (R. Ogun)	3.32756	7.15159	36	0	3	3	Yes
11	Brewery (R. Ogun)	3.32514	7.14859	34	0	3	3	No
12	Abiola Way+	3.36500	7.15161	81	0	0	0	No
13	Idi Aba+	3.37381	7.13770	87	0	0	0	No
14	Olugbite	3.14080	7.26386	127	0	0	0	No
15	River Apowu	3.15329	7.31880	72	0	1	1	No
16	River Ogbagba	3.13028	7.34459	86	0	0	0	No
17	River Irelu	3.12967	7.28003	124	0	2	2	Yes
18	River Erifun	3.12393	7.27478	132	0	0	0	Yes
19	River Iwofin	3.18488	7.21319	89	0	2	2	Yes
20	Oke Ago	3.34134	7.15886	55	0	0	0	No
21	Asero	3.37647	7.16182	100	0	0	0	No
22	River Olomore	3.31389	7.14038	30	0	3	3	No
23	Apojola ++	3.21640	7.30448	78	0	6	6	Yes
24	Kuto+	3.35464	7.14347	59	0	0	0	No
25	River Arakanga	3.33788	7.18779	34	1	5	6	Yes
26	River Onibuje	3.24765	7.22366	58	0	0	0	No
27	River Koosa	3.16643	7.09931	67	0	0	0	No
28	River Owi	3.14694	7.19485	76	0	5	5	Yes
29	River Iju	3.12109	7.11672	88	0	5	5	Yes
30	Oyan Dam++	3.18175	7.32302	78	0	5	5	Yes
31	River Yagba	3.18530	7.20315	102	0	0	0	No

+ Stream; ++ Dam; +++Canal.

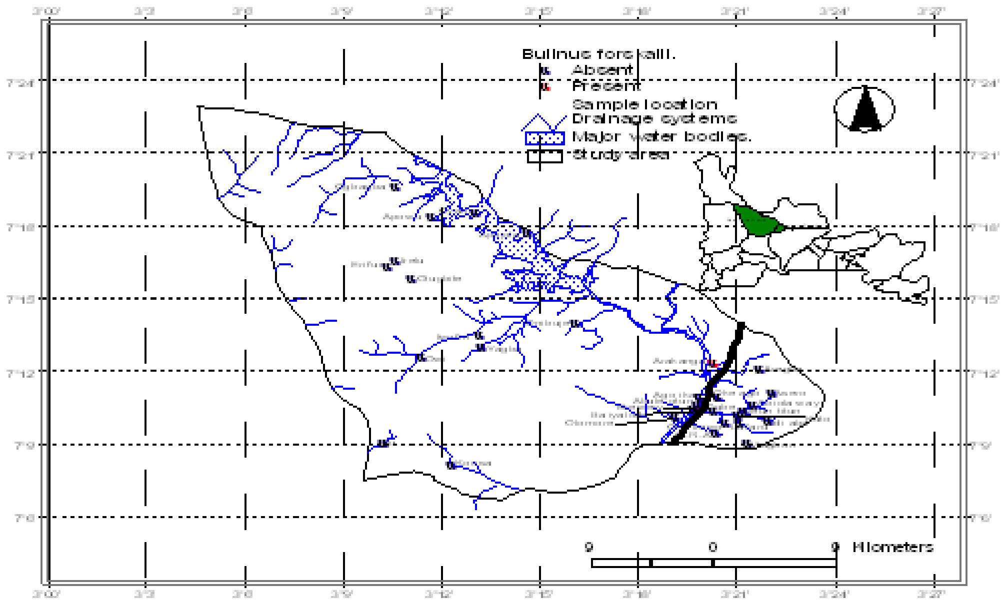

Figure 3: Point distribution of *Bulinus forskalii.*

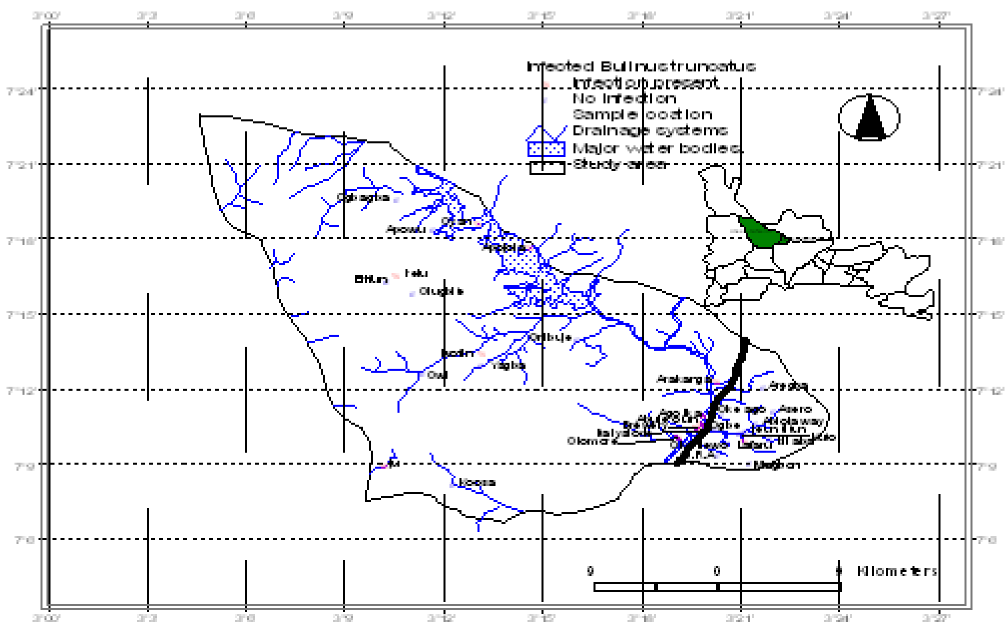

Figure 4: Point distribution of infected *Bulinus truncatus.*

environmental variables such as NDVI, land cover, temperature, altitude and soil types were not significant in the final model. Figure 5 shows the predictive model map of the distribution of *B. truncatus* in Abeokuta area. The binary logistic model of the probability of presence of *B. truncatus* at sites is:

$$\text{Probability } (p) = 1 / (1 + e^{-z})$$

Arising from the logistic regression analysis shown in Table 2, Z is calculated as follows: $Z = 26.690 + (-0.19 \times \text{Rainfall})$ where 26.690 = Regression coefficient constant, -0.19 = Regression coefficient of Rainfall. The p-values of the final binary model, using forward step-wise elimination technique, are listed in Table 2. The model map predicts the potential presence of *B. truncatus,* the snail intermediate host of *S. haematobium* in every water bodies in Abeokuta Area of Ogun State. A second model shows the predictive spatial distribution of infected *B. truncatus* (Figure 6). The only covariate in the final model was presence or absence of *B. truncatus*. The final model equation was $Z = -2.530 + (1.068 \times Truncatus)$ where -2.530 = Regression coefficient constant, 1.068 = Regression coefficient of *B. truncatus* (Table 3). The

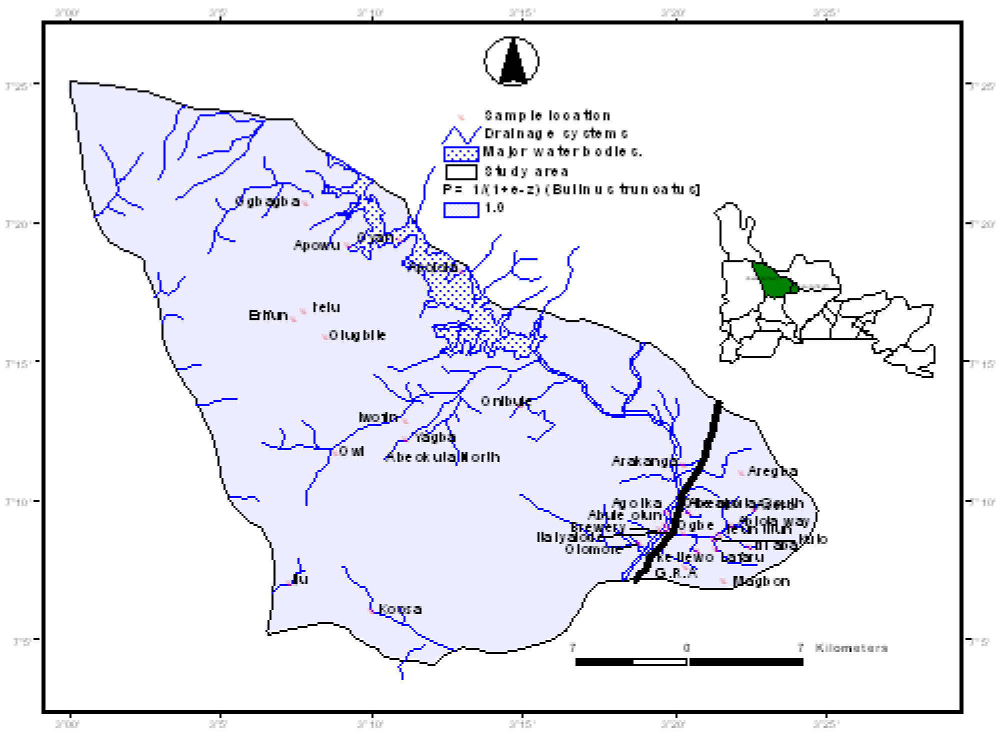

Figure 5: Probability distribution of *B. truncatus* in Abeokuta area. (Z=26.690+(-0.19* Rainfall).

Table 2: *P*-values of logistic regression analysis *Bulinus* snails and environmental variables.

Snail species	Rainfall	NDVI	Land cover	LST	Altitude	Soil
Bulinus truncatus	0.040	0.185	0.775	0.436	0.229	0.314

Table 3: Coefficients and goodness of fit of a logistic binary model predicting presence and absence of infected *B. truncatus* in different sites of Abeokuta area of Ogun State.

	B	S.E	Wald	*Df*	Sig	Exp (B)	95.0% C.I for EXP (B)	
							Lower	Upper
Sanitation	-8.159	62.091	.017	1	.895	.000	.000	2.04E
Truncatus	1.068	.338	9.963	1	.002	2.910	1.499	5.648
Endemic	-.067	.038	3.089	1	.079	.935	.868	1.008
Constant	-2.530	.851	8.829	1	.003	.080	-	-

**df* = degree of freedom; SE =standard error; Sig= significance; B = regression coefficient; EXP B= odd ratio.

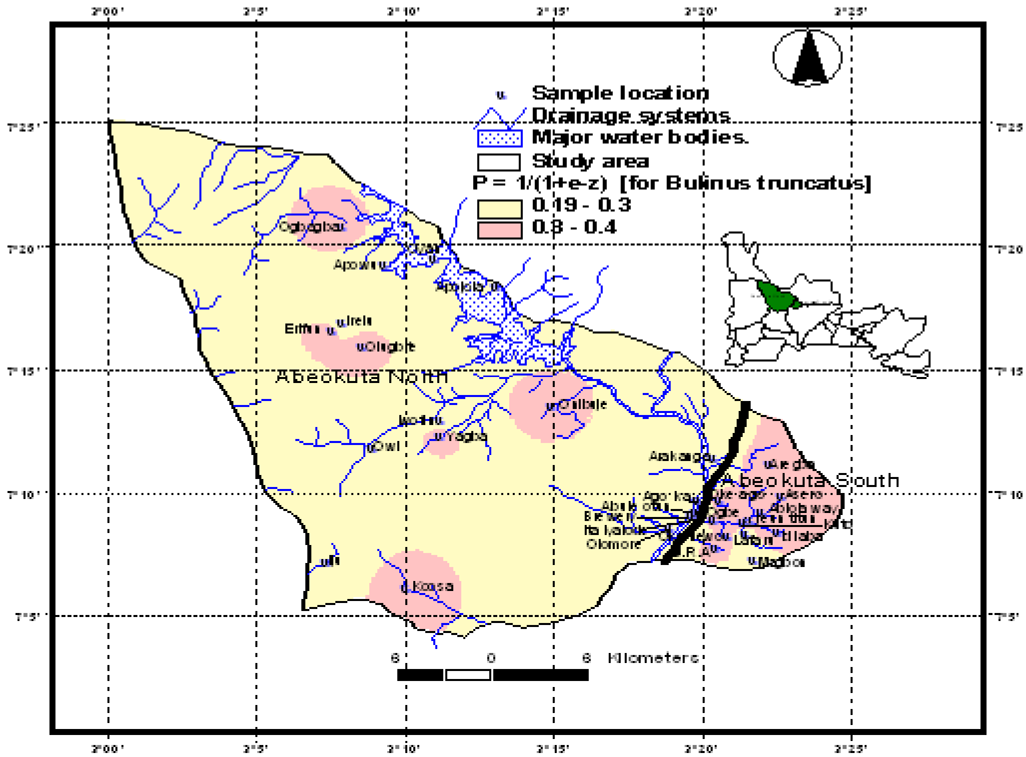

Figure 6: Probability distribution of infected *B. truncatus* in Abeokuta area (Z = -2.530+ (1.068 **B. truncatus*).

map shows that the probability of finding infected *B. truncatus* is between 0.3-0.4 (30-40%) in selected areas. These areas cover about 90% of Abeokuta South LGA, whereas, in Abeokuta North LGA, infected snails are confined to define endemic *foci* (Figure 6). However, the probability of finding infected snails in Abeokuta LGA for most areas is low (0.19-0.3).

Discussion

Urinary schistosomiasis is endemic in Abeokuta area (Mafiana and Beyioku, 1998; Ogbe and Olojo, 1989; Ogbe and Ogunsekan, 1990; Ofoezie *et al* 1991; Mafiana and Adesanya, 1994; Mafiana and Beyioku, 1998; Mafiana *et al* 2003). Studies on *Bulinus* snail vector is limited (Ofoezie, 1999). Few studies exist using GIS and spatial statistics to define the extent of the distribution of the *Bulinus sp* (Malone *et al* 1997; Opisa *et al* 2011). The observation of infected *B. truncatus* snails in many sites surveyed indicated that active contamination of surface water with schistosome eggs and transmission of urinary schistosomiasis is on-going. Presence of *B. forskalii* in only two of the sites with no infection indicates a small spatial distribution of this snail species and also confirmed that it is not a host of *S. heamatobium* in this area.

The binomial logistic regression analyses indicated that rainfall is the only significant environmental variable associated with the distribution of *Bulinus*. Similar observation has been reported by Malone *et al* (1997) and Seto *et al* (2002) in Egypt and China respectively. Altitude and Land Surface Temperature did not significantly affect the distribution of *B. truncatus* probably due to the lack of variations in altitude and LST of the study-area enough to affect its distribution. The model probability of 1.0 is indicative of the potential spreading of this snail in Abeokuta. With increasing population movement due to economic activities and coupled with limited access to safe water source, poor sanitation, and absence of health education and awareness, the potential and likely spread of urinary schistosomiasis into other areas of Abeokuta is clear. In fact, the whole of Abeokuta area is currently at risk of urinary schistosomiasis. There is therefore the need for proactive measures by governmental agencies at reducing the transmission through proper health education and mass drug treatment. Communities near infective water sources should be alerted of the danger of going to those water bodies identified.

Snail distribution map have been used effectively for schistosomiasis control measure in East Africa (Malone *et al* 1997). The model maps of spatial distribution of infected *B. truncatus* can be used by control programme to create intervention buffer and identify communities at risk for intervention, thereby reducing the cost of parasitological survey. Measures should be taken through health education and public enlightenment on the danger of wading in potential infective water bodies. Where transmission is ongoing, urgent measures are needed to reduce snail population, such as the use of mollusicide and environmental management.

Digital maps on freshwater snail intermediate host distribution are lacking in Nigeria. Available maps are hand-drawn and thus cannot be easily analysed and updated for informed decision-making. Such maps are unsuitable for control programme to managers interested in snail control. This study has provided maps of the spatial distribution of *B. truncatus*, which is the intermediate host *S. heamatobium*. The predictive model map indicated that *B. truncatus* snail may be wide spread with the potential danger of urinary schistosomiasis transmission in water bodies in Abeokuta area of Ogun State.

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References

Brooker, S. 2002. Schistosomes, snails and satellites. *Acta Trop 82:* 207-214.

Brown,D.S. and Kritensen, T.K. 1993. A fish guide to fresh water snails. Danish Bilharziasis Laboratory. DK-2920 Charlottenlund. Denmark.

Ejeze, G.C., Uko, I.E. Braide, E.I. 1991. Schistosomiasis in Cross River State, Nigeria I: Prevalence and intensity of infection in Adim, Akamkpa Local Government Area. *J. Hyg. Epid, Microbiol & Immunol 35(20):* 141-147.

Ekpo, U.F. and Mafiana, C.F. 2004. Epidemiological Studies of urinary schistosomiasis in Ogun State, Nigeria: Identification of high-risk communities. *Nig. J. Parasitol. 25*: 111-119.

Ekpo, U.F., Mafiana, C.F., Adeofun, C.O., Solarin, A.R.T., Idowu, A.B. 2008. Geographical information system and predictive risk maps of urinary schistosomiasis in Ogun State, Nigeria. *BMC Infect Diseases 2008, 8:*74 doi:10.1186/1471-2334-8-74.

Mafiana, C.F. and Adesanya, O.O. 1994. Urinary schistosomiasis in Ilewo-Orile, Ogun State, Nigeria. *Nig J. Parasitol 15*: 31-34.

Mafiana, C.F. and Beyioku, Y.O. 1998. Schistosoma haematobium infection in Abeokuta, Nigeria. *Afr. J. of Med. and Medical. Sci. 27:* 5-7.

Mafiana, C.F. Ekpo U.F., Ojo, D.A. 2003. Urinary schistosomiasis in pre-school children in settlements around Oyan Reservoir in Ogun State, Nigeria: Implications for control. *Trop. Med. Int. Health 8(1):* 78-82.

Malone, J.B. Abdel-Rahman, M.S. El Bahy, M.M. Huh, O.K. Shafik, M. Bavia, M. 1997. Geographic information systems and distribution of *Schistosoma mansoni* in the Nile Delta. *Parasitol Today 13(3):* 112-119.

Malone, J.B. Yilma, J.M, McCarroll, J.C. Erko, B. Mukaratirwa, S., Zhou, X. 2001. Satellite climatology and the environmental risk of *Schistosoma mansoni* in Ethiopia and East Africa. *Acta Trop.79 (1):*59-72.

Opisa, S. Odiere, M.R. Jara, W.G.Z.O. Karanja, D.M.S., Mwinzi, P.N.M. 2011. Malacological survey and geographical distribution of vector snails for schistosomiasis within informal settlements of Kisumu City, western Kenya. *Parasite and vectors 4*:226.

Ofoezie, I.E., Imevbore A.M.A.Balogun M.O., Ogunkoya O.O., Asaolu S.O. 1991. A study of outbreak of schistosomiasis in resettlement villages near Abeokuta, Ogun State, Nigeria. *J. Helminthol. 25:* 95-102.

Ofoezie, I.E. 1999. Distribution of freshwater snails in the man-made Oyan Reservoir, Ogun State, Nigeria. *Hydrobiologia, 416*: 181-191.

Ogbe, M.G. and Olojo, A.O. 1989. A preliminary survey of urinary schistosomiasis in Abeokuta, Nigeria. *Niger J. of Basic and Appl Sci, 3:* 158-168.

Ogbe, M.G. and Ogunsekan, F.A. 1990. *Schistosoma haematobium* infections among school children in Abeokuta, Nigeria: A preliminary report. *Nig J. Parasitol, 9-11:* 60-62.

Seto, E., Xu, B., Liang, S., Gong, P., Wu, W., Davis, G., Qiu, D., Gu, X., Spear, R. 2002. The use of remote sensing for predictive modeling of schistosomiasis in China. *Photogrammetric Engineering and Remote Sensing 68(2):* 167-174.

Steinmann, P., Keiser, J., Bos, R., Tanner, M. Utzinger, J. 2006. Schistosomiasis and water resources development: systematic review, meta-analysis and estimates of people at risk. *Lancet Infect. Dis. 6 (7):* 411-425.

Kariuki, H.C, Clennon J.A, Brady, M.S., Kitron, U., Sturrock, R., Ouma, J.H., Ndzovu, S.T., Mungai, P., Hamburger, J., Pellegrini, C., Muchiri, E.M., King, C.H. 2004. Distribution patterns and cercarial shedding of *Bulinus nasutus* and other snails in the Msambweni area, Coast Province, Kenya. *Am. J. Trop. Med. Hyg. 70:*449-456.

Abe, E.M., Oluwole, A.S., Ojo, D.A., Idowu, O.A., Mafiana, C.F., Braide, E.I. and Ekpo, U.F.
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