Research Square

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Spatial Distribution of Ascariasis, Trichuriasis and Hookworm Infections in Ogun State, Southwestern Nigeria

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Abstract

Background Ascariasis, Trichuriasis and Hookworm infections poses a considerable public health burden in Sub-Saharan Africa, and a sound understanding of their spatial distribution facilitates to better target control interventions. This study, therefore, assessed the prevalence of the trio, and mapped their spatial distribution in the 20 administrative regions of Ogun State, Nigeria. Methods Parasitological surveys were carried out in 1,499 households across 33 spatially selected communities. Fresh stool samples were collected from 1,027 consenting participants and processed using ether concentration method. Households were georeferenced using a GPS device while demographic data were obtained using a standardized form. Data were analysed using SPSS software and visualizations and plotting maps were made in ArcGIS software. Results Findings showed that 19 of the 20 regions were endemic for one or more kind of the three infections, with an aggregated prevalence of 17.2%. Ascariasis was the most spatially distributed found in 28 communities, with 140(13.6%) infected subjects, followed by Hookworm infection in 19 communities, with 47(4.6%) infected subjects and Trichuriasis in 9 communities, with 17(1.7%) infected subjects. The spatial distribution of infections ranges between 5.3 – 49.2% across the regions. The highest and lowest distribution was recorded in Yewa South and Yewa North respectively. By WHO preventive chemotherapy thresholds, 9 regions had infection status between 20.0%-49.2%, while 10 regions had infection status between 5.3%-15.8%. Conclusion This study provides information on the prevalence and spatial risk of Ascariasis, Trichuriasis and Hookworm infection that will serve as decision-support tool to help facilitate targeting of control interventions.

Background

Infections with *Ascaris lumbricoides* (Ascariasis), *Trichuris trichiura* (Trichuriasis) and hookworms (Ancyclostomiasis / Necatoriasis) are widely distributed in tropical and subtropical areas, with the greatest numbers occurring in sub-Saharan Africa, the Americas, China and East Asia [1]. Transmission of these parasites is prominent in areas with favorable climatic and environmental conditions, poor access to potable water supply, sanitation and hygiene resources [2]. Recent estimates shows that more than 5 billion people are at risk, and about 1.5 billion people are currently infected [1]. Besides, about 267 million pre-schoolers (children between age 2 and 5) and 568 million school-aged children (children between age 5 and 14) who live in areas where these parasites are intensively transmitted are at risk [3]. These children suffer the major brunt of these infections, with leading clinical manifestations such as malnutrition and iron deficiency anemia [4]. In addition, children co-infected with these parasites show impaired cognitive and physical development leading to significant reductions in educational gains via inefficient learning and other school achievements [5,6]. Nonetheless, in most endemic settings, there is an established morbidity control programme targeted at school-aged children due to their high level of contact with soils, and exposure to poor sanitation and unhygienic conditions [7,8]. The World Health Organization through this programme recommends large-scale administration of albendazole, either once a year (annually) when the baseline prevalence of infections is between 20 and 50%, or twice a year (biannually) when the prevalence is above 50% [7]. This strategy costs donor agencies and developing economies billions of dollar every year. However, in resource challenged settings where there are records of sporadic large-scale administration of anthelmintic drugs, there is need to constantly delineate endemic areas, and provide robust maps to identify hot spots. Such maps are essential to facilitate better targeting and efficient delivery of cost effective control interventions [9]. This study therefore mapped the spatial distribution of Ascariasis, Trichuriasis and Hookworm infections in Ogun State, southwestern Nigeria.

Methods

Study area

Ogun State is situated in the southwestern part of Nigeria and is made up of 20 administrative local government areas (LGAs) with Abeokuta as the capital city. The state has a landmass of 16,085 km^2, and is located within longitude 2°45¹E and 3°55¹E and latitude 7°01¹N and 7°18¹N. The State is highly urbanized, with a population estimate of about 5million inhabitants, an annual growth rate of 2.83%, and about 95% of the inhabitants are of the Yoruba tribe. The State covers a wide range of vegetation zones, from the freshwater swamp with mangrove forest in the southeast, through diverse forest communities to the woody guinea savannah in the northwestern tip of the state. The rain forest is the largest ecological zone running through the centre of the state from east to west. Annual rainfall ranges from 900mm in the northern parts, up to 1600 mm along the coast. The major occupation of the population is farming, timber logging, and trading. Primary schools exist in most communities but in some cases, two or more communities share the same school (Figure 1).

Study design and sampling procedures

This study was community-based and cross-sectional in design. It was conducted between July 2016 and November 2018. Systematic point sampling method was employed in selection of sampling sites to ensure an unbiased and fair representation of communities across the 20 administrative LGAs in the State. As an initial step in the selection process, a 15 km x 15 km sized grid was placed on the administrative map of Ogun state in Google Earth (GE) software using the GE path tool. The centre of each grid was located in Arc GIS 9.3 software, and the geographical coordinates were recorded. The closest community to the centre of each grid was identified and selected using Google Earth software. A total of 33 communities were selected across the 20 LGAs in the state as the study communities (Table 1).

Selection of households for survey

A total sampling method was employed for household selection in the communities surveyed. Prior to data collection, communities were visited and sensitized about the study procedures and were openly invited to participate in the research through community meetings and town announcers. Every member of the household is eligible for participating in the research. In each community, a house, usually at the centre of the community was designated as an area of work for processing and microscopic examination of stool samples. At least two members of the research team were available to follow consenting household members to their house for georeferencing with Garmin 20.0 GPS device.

Collection of faecal samples and parasitological diagnosis

A stool container was distributed to consenting participants in each of the georeferenced household. Participants' unique identifiers were marked on the containers and detailed instructions of how to collect a fresh morning stool sample were given. All participants were asked to provide a sufficiently large stool sample (at least 5 g). Stool samples were processed using the SAF- Ether (Sodium acetate-acetic acid formalin - ether) concentration method in the designated area of work within the community. Precisely, One gram (1g) of the faecal sample was emulsified in already prepared 10 ml of SAF in another sample bottle. The bottle was covered and agitated vigorously to suspend the stool efficiently in the solution. The stool suspension was further strained into a centrifuge tube using double gauze of about 13 mm diameter placed in a funnel. The residue was discarded while the filtrate was centrifuged at 2000 rpm for 1 minute. The supernatant was also discarded after centrifuging. 7 ml of normal saline was later added to the sediment, after which 3 ml of ether was finally added to the suspension. A stopper was placed on the tube, and the mixture was shaken vigorously before centrifuging for 5 minutes at 2000 rpm. The first three layers of the suspension observed after centrifuging was discarded, leaving the last layer of sediment. This sediment was then pipetted on a clean microscopic slide. Two slides were prepared from 1g of each stool sample by experienced laboratory technicians 2 hours post sample collection [10].

Estimation of parasite's prevalence and intensity

Prepared slides were examined under a compound microscope for microscopic ova or larva of the three parasites (*Ascaris spp.*, *Trichuris spp.* and Hookworms). The parasites' eggs were counted for each species, and number of eggs per species and per stool examined was recorded for each participant. Mean infection intensity estimates were computed for each examined person on a logarithmic scale for the purpose of data normalization i.e. EPG = Log (n +1), where EPG means egg per gram.

Data management, analysis and visualizations

Data obtained during the survey i.e. demographics, were first subjected to descriptive analysis in SPSS 20.0 software, and results were reported in frequencies and percentages. Prevalence and intensity estimates of helminth infections were also computed for each of the communities surveyed and reported accordingly. Significance level was set at P≤0.05. Data were imported into ArcGIS 9.3 software for visualizations and plotting maps.

Results

Sex and age distribution of study participants

A total of 1,499 respondents were subsequently enrolled after consent across the 33 communities and 20 LGAs. However, only 1,027 (68.5%) of them consented to the provision of adequate stool samples (g) for laboratory analysis for parasites' ova or larva. By demography, 899(60.0%) were females and 600(40.0%) were males. The sex ratio of females to males was 3:2. In addition, the highest number of respondents were within the age range 41-70yrs (40.6%), followed by 26-40yrs (30.3%), 5-15yrs (10.7%), 16-25yrs (10.4%) and >70yrs (7.0%) (Table 2).

Spatial distribution of *Ascaris*, *Trichuris* and Hookworm infections in Ogun State

Figure 2 shows the spatial distribution of the three parasites' in Ogun State. Of the 20 LGAs examined, 19(95.0%) were endemic for one or more of the three parasite. *Ascaris lumbricoides* are the most geographically distributed, found in 28(84.8%) out of the 33 communities and 19(95.0%) out of 20LGAs. Hookworm was present in 19(57.6%) out of 33 communities and 15(75.0%) out of 20LGAs. *Trichuris trichiura* infections were found in 9(27.3%) out of 33 communities and 7(35.0%) out of 20LGAs.

Co-distribution patterns of *Ascaris*, *Trichuris* and Hookworm infections in Ogun State

Figure 3 shows the co-distribution patterns of STH infections in the State. Mono-infection was recorded only for *Ascaris lumbricoides* in 3 LGAs; Ewekoro, Ikenne and Ijebu northeast. For double infections, co-distribution of *Ascaris* and Hookworm were the most predominant, observed in 15 LGAs except Ewekoro, Ijebu east, Ijebu northeast, Ikenne and Ijebu ode. *Ascaris and Trichuris* co-distribution was recorded in 7 LGAs; Yewa north, Yewa south, Ado-odo ota, Ijebu east, Ipokia, Obafemi owode and Ogun waterside, while *Trichuris* and *Hookworm* co-distribution was recorded in 6 LGAs; Ado-odo ota, Ipokia, Obafemi owode, Ogun waterside, Yewa north and Yewa south. However, for triple infections, the three species (*Ascaris*, *Trichuris* and Hookworm) were co-distributed in 6 LGAs; Ado-Odo, Ipokia, Obafemi-Owode, Ogun waterside, Yewa North and Yewa South (Table 3).

Aggregated prevalence of *Ascaris*, *Trichuris* and Hookworm infections in Ogun State

The aggregated prevalence of 17.2% was recorded for at least one infection of *Ascaris lumbricoides*, *Trichuris trichiura* or hookworm. The prevalence range was between 5.3 – 49.2% across the LGAs (Figure

4). Infections were highest in Yewa south, lowest in Yewa north and no infection was recorded in Ijebu-Ode. Of the 19 endemic LGAs, 9 had prevalence status ranging between 20.0%-49.2% (Abeokuta north, Abeokuta south, Ifo, Ikenne, Ipokia, Obafemi owode, Ogun waterside, Remo north and Yewa south). However, 10 LGAs had prevalence status ranging between 5.3%-15.8% which is below the WHO recommended thresholds for preventive chemotherapy (Ado-odo ota, Ewekoro, Ijebu east, Ijebu north, Ijebu north east, Imeko afon, Odeda, Odogbolu, Sagamu and Yewa north). There were significant differences in the prevalence record for any STH species across the 19 endemic LGAs (P=0.000) (Figure 5).

Specific prevalence estimates for *Ascaris*, *Trichuris* and Hookworm infections in Ogun State.

By species prevalence*, Ascaris lumbricoides* infection was the most occurring 140(13.6%), followed by Hookworm 47(4.6%) and *Trichuris trichiura* 17(1.7%) (Table 3). For *Ascaris lumbricoides* infections, a total of 140 participants were positive with an overall prevalence of 13.6%. The prevalence for *Ascaris lumbricoides* ranges between 2.6% and 37.5%, with the lowest prevalence observed in Yewa north and highest in Abeokuta south (Table 3). Spatially, *Ascaris lumbricoides* are the most predominant, found in 28(84.8%) out of the 33 communities surveyed (Figure 6). An overall prevalence of 4.6% was also recorded for hookworm infections across the 19 LGAs, with a range between 1.8% and 16.7%, the lowest prevalence was observed in Yewa north and the highest in Obafemi owode LGA (Table 3). No hookworm infection was recorded in 5 of the 20 LGAs i.e. Ewekoro, Ijebu east, Ijebu north east, Ikenne and Ijebu ode. Spatially, Hookworm was the second most occurring infection following *Ascaris* and it was observed in 19 (57.6%) of 33 communities surveyed (Figure 7). There were significant differences in the prevalence record for Hookworm infections across the endemic 15LGAs (P=0.000). For *Trichuris trichiura*, an overall prevalence of 1.7% was recorded across the 19 LGAs, with a range between 0.9 % and 23.1 %, the lowest prevalence was observed in Yewa north and the highest in Ipokia (Table 3). Only 7 out of the 20 LGAs were positive for *Trichuris trichiura* infections i.e. Ado-Odo Ota, Ijebu-East, Ipokia, Obafemi-Owode, Ogun waterside, Yewa North and Yewa South. *Trichuris trichiura* infections was found in 9(27.3%) out of 33 communities surveyed (Figure 8). There were significant differences in the prevalence record for *Trichuris trichiura* infections across the endemic 7 LGAs (P=0.000).

Aggregated and specific mean intensity estimates for *Ascaris*, *Trichuris* and Hookworm infections in Ogun State.

Table 4 shows the intensity estimates for *Ascaris*, *Trichuris* and hookworm infections in Ogun state. The aggregated geometric mean intensity of infections was 0.14 0.01 with mean intensity ranging from 0.03 0.01 to 0.43 0.06 across the LGAs. The aggregated intensity shows that worm loads were highest in Obafemi owode and lowest in Imeko-afon. By species intensities*, Ascaris lumbricoides* infection intensities was the highest 0.11 0.01, followed by Hookworm 0.03 0.01 and *Trichuris trichiura* 0.01 0.00.

Ascaris mean intensities range between 0.01 0.01 and 0.32 0.05, with the lowest in Imeko afon and highest in Ifo and Yewa south. For Hookworm infection, intensities range between 0.01 0.00 and 0.13 0.04, with the lowest in Ijebu north, Yewa north, Yewa south, Ogun waterside, Imeko afon and highest in Obafemi-owode. *Trichuris* mean intensities range between 0.01 0.01 and 0.10 0.05 with the highest load in Ipokia and the lowest in Ogun waterside, Ijebu east and Yewa north.

Prevalence of *Ascaris*, *Trichuris* and Hookworm infections infection by sex and age characteristics

Table 5 shows the prevalence of infection by sex and age distribution of study participants. Majority of those infected were females 122(18.8%), although there were no significant differences in prevalence estimates across sex ($P > 0.05$). By age category, majority of those infected were adults and with age above 26 years, however there were no significant differences in prevalence of infection across age category ($P > 0.05$).

Discussion

In Nigeria, research findings on the geospatial distribution of *Ascaris*, *Trichuris* and Hookworm infections are scarce, but emerging [11,12,13]. This study therefore adds to the wealth of existing data on spatial distribution of these infections in Ogun State, Nigeria. The overall prevalence recorded in this study (17.2%) is in line with the predictions of 13.8% and <20% prevalence reported by Oluwole *et al*. [11] and Yaro *et al.* [13] respectively. The prevalence estimate also corroborates with existing reports on the decreasing trend of soil transmitted helminth (STH) infections due to chemotheraphy programmes in SSA countries [14,15]. However, aggregated estimates such as this may unnecessarily mask the spatial patterns of disease distribution in any endemic setting, hence misleading intervention programmes. For instance, almost half of the LGAs surveyed had prevalence estimates within the WHO threshold for preventive chemotheraphy programmes (>20%), which is in dissonance with the overall prevalence reported. This therefore reflects the dynamics of STH morbidity in the state and reiterates the need to intensify public health efforts in delineating localized hotspots and intervening appropriately to curtail the menace.

The preponderance nature of *Ascaris lumbricoides* infections in this study corroborates with findings from recent epidemiological surveys [12,16]. *Ascaris lumbricoides* infections were observed in 19 of the 20 LGAs studied, with increased prevalence in the western part of the state. The spatial patterns observed here is similar with those reported by Oluwole *et al*. [12], where moderate prevalence (<20%) of *Ascaris lumbricoides* infections were spread across the entire state, and high prevalence necessitating treatment (20-50%) were restricted to the central and southern region of the state. A major reason for such similarity in patterns maybe due to the commonality in ecological factors supporting the transmission of STH parasites in the state. However, none of the LGAs studied has prevalence rate above 50% as compared to the findings of Oluwole *et al.* [12]. This may be attributed to the difference in study population in both studies. Over 40% of the respondents in this study were adults within the age range 41-70years, as compared to 100% school-aged children population in the report of Oluwole *et al.* [12]. The school-aged children are known to be the most vulnerable to STH infections, and infections tend to be higher among this group than any other subset in the community due to their risky behaviours that predisposes them to infection. Nevertheless, the findings from this study give a more complete population-based picture of current infection patterns that may exist in endemic communities, as infections may also cluster in households (adults) rather than school unit (children) only [17,18,19,20].

Trichuris trichiura has a restricted distribution in Ogun State. In fact, the prevalence of this parasite has been consistently reported to be low and non-existent in many parts of the country [2,11,12,13,16]. As such the low aggregated prevalence of 1.7% reported in this study is expected, and the geo-spatial restrictions of *Trichuris trichiura* ova to the southern part of the state may have been due to favourable environmental conditions, most importantly temperature as other parasites like *Ascaris lumbricoides* and hookworm can withstand extreme temperatures which has contributed to their preponderance nature [11]. In addition, there are commonalities in the spatial distribution of *Trichuris* observed in this study with that reported by Oluwole *et al.* [12].

Hookworm infections is the second most common infection recorded in this study, with peak prevalence's observed among the adult respondents. This observation is in line with already established fact that prevalence and intensities of hookworm infections are restricted to adult populations [23]. However, the prevalence recorded in this study (4.6%) is lower than those reported by Mogaji *et al.* [2]; Oluwole *et al.* [12] and Fafunwa *et al.* [21] where prevalence estimate within the range 7.1 - 26.2% was observed. Nevertheless, the prevalence is higher than the 4.13% reported by Sam-wobo *et al.* [16]. The disparities observed across these studies maybe due to differences in study area/population, seasonality, soil parameters, environmental variables and socioeconomic status. In addition, walking barefooted which is a major risk factor in the percutaneous transmission of hookworm parasites is a common feature of school-aged children. However, this group of children only constitutes 10% of the respondents in this study. This might be a reason for the very low prevalence recorded for hookworm infections in this study.

Conclusion

This study has shown the geospatial distribution of Ascaris, Trichuris and hookworm infections in Ogun State, Nigeria. These results and maps are useful and can serve as decision support tools for targeting, planning and delivery of intervention programmes aimed at controlling STH morbidity.

List Of Abbreviations

GE: Google Earth

GPS: Geographic Positioning System

LGAs: Local Government Areas

SAF: Sodium Acetate Acetic Acid Formaladehyde

SPSS: Statistical Package for Social Sciences

STH: Soil Transmitted Helminths

WHO: World Health Organization

Declarations

Ethical approval and consent to participate

Ethical clearance for this study (HPRS/381/183) was obtained from the Ethics review committee of Department of Planning, Research and Statistics, Ogun State Ministry of Health, Oke Imosan Abeokuta, Nigeria. For each household visited, consent forms were made available to household members after explaining the objectives of the research to them. Members willing to participate in the research and who completed written consent froms were enrolled into the study. However, for children below age sixteen, consent was provided by their parents after completing an assent form on their behalf.

Consent for publication

Not applicable

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interest

Funding

Not applicable

Authors’ contribution

MHO and EFU conceptualized the study, and prepared the protocol, while DGA, BBS and OAS improved the protocol. MHO, BS, ONS, OOO, AA, FMT participated in field surveys and data collection. BS, MHO, OOO, FMT handled laboratory analysis of stool specimens. MHO performed all statistical analysis. MHO and OAS prepared the first draft of the manuscript. All authors contributed to the development of the final manuscript and approved its submission.

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Figures

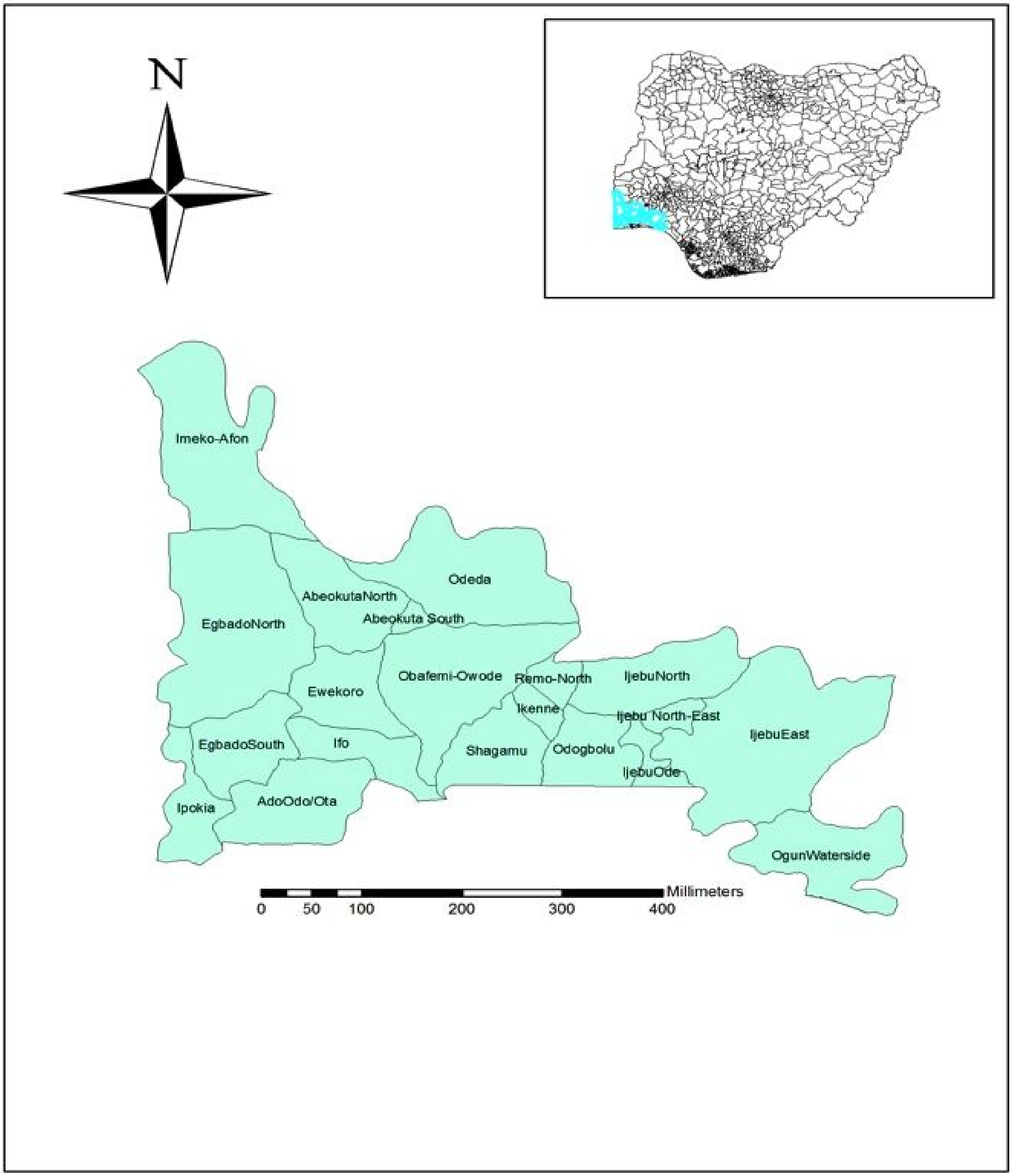

Figure 1

Map of Ogun State with Nigeria as Inset. Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

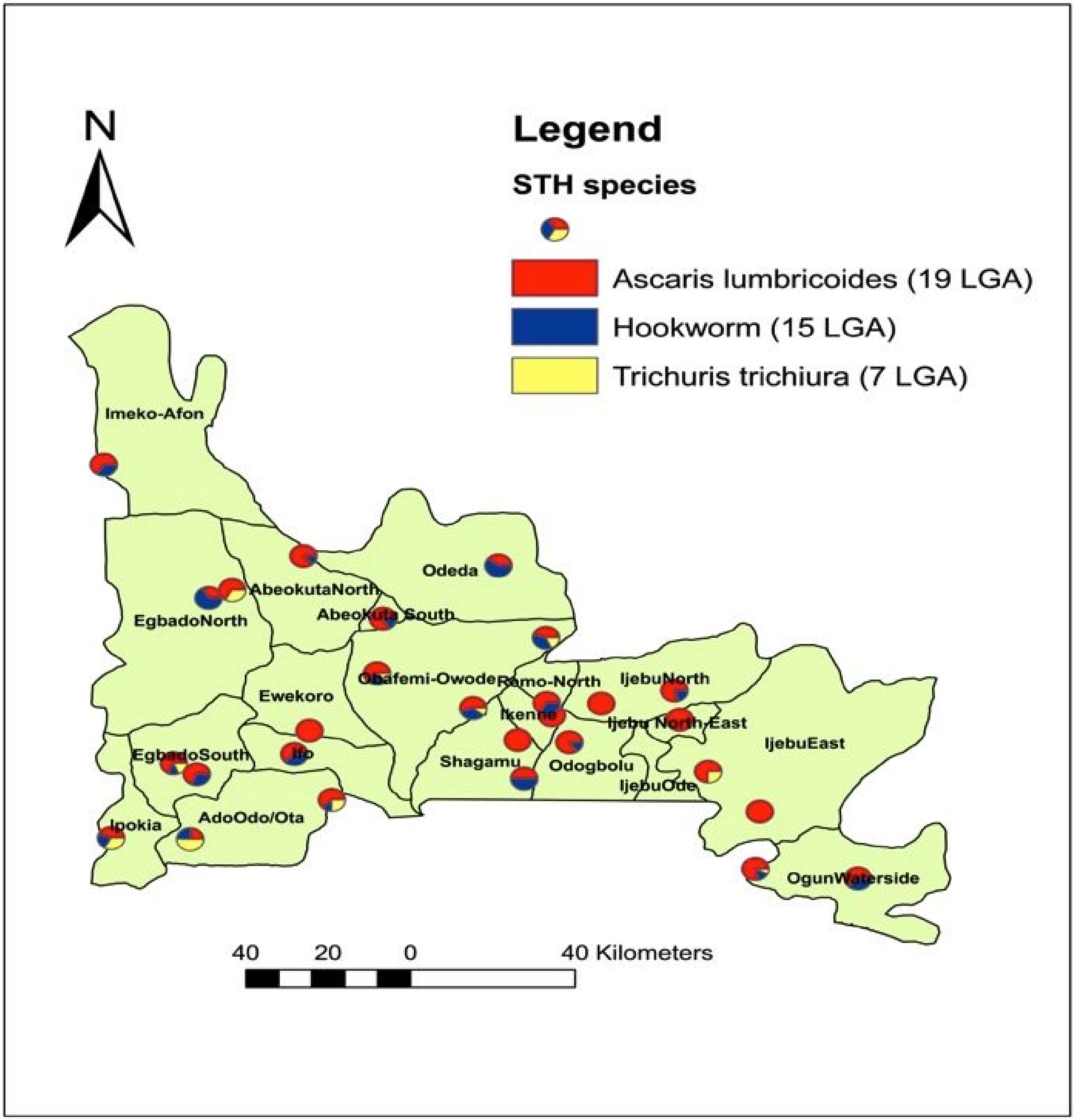

Figure 2

Spatial distribution of Ascaris, Trichuris and Hookworm infections in Ogun State Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

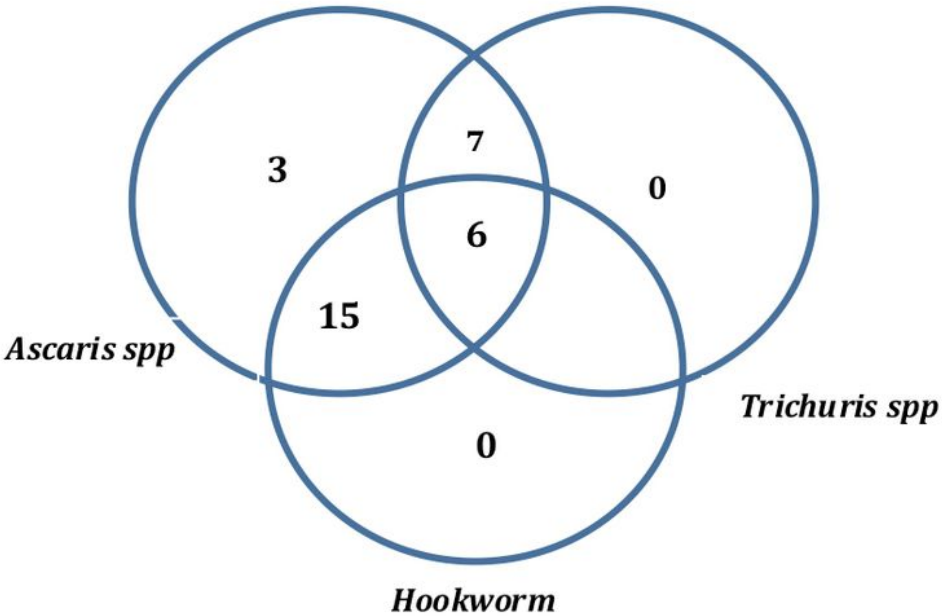

Figure 3

Venn diagram showing the co-distribution of Ascaris, Trichuris and hookworm infections in Ogun State Footnote: The numbers in the venn diagram reflects the number of affected LGAs Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

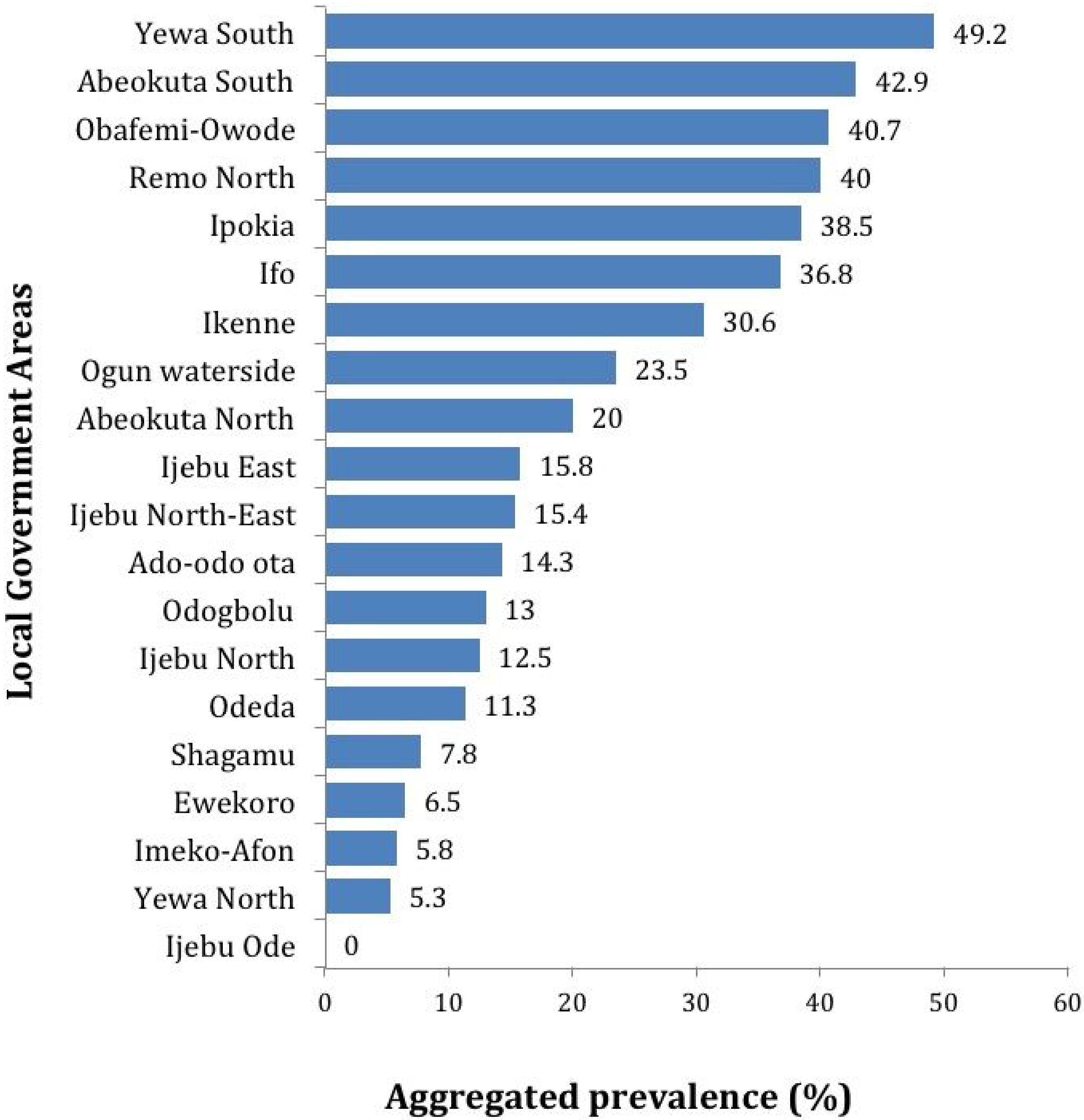

Figure 4

Aggregated prevalence of Ascaris, Trichuris and Hookworm infections in Ogun State Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

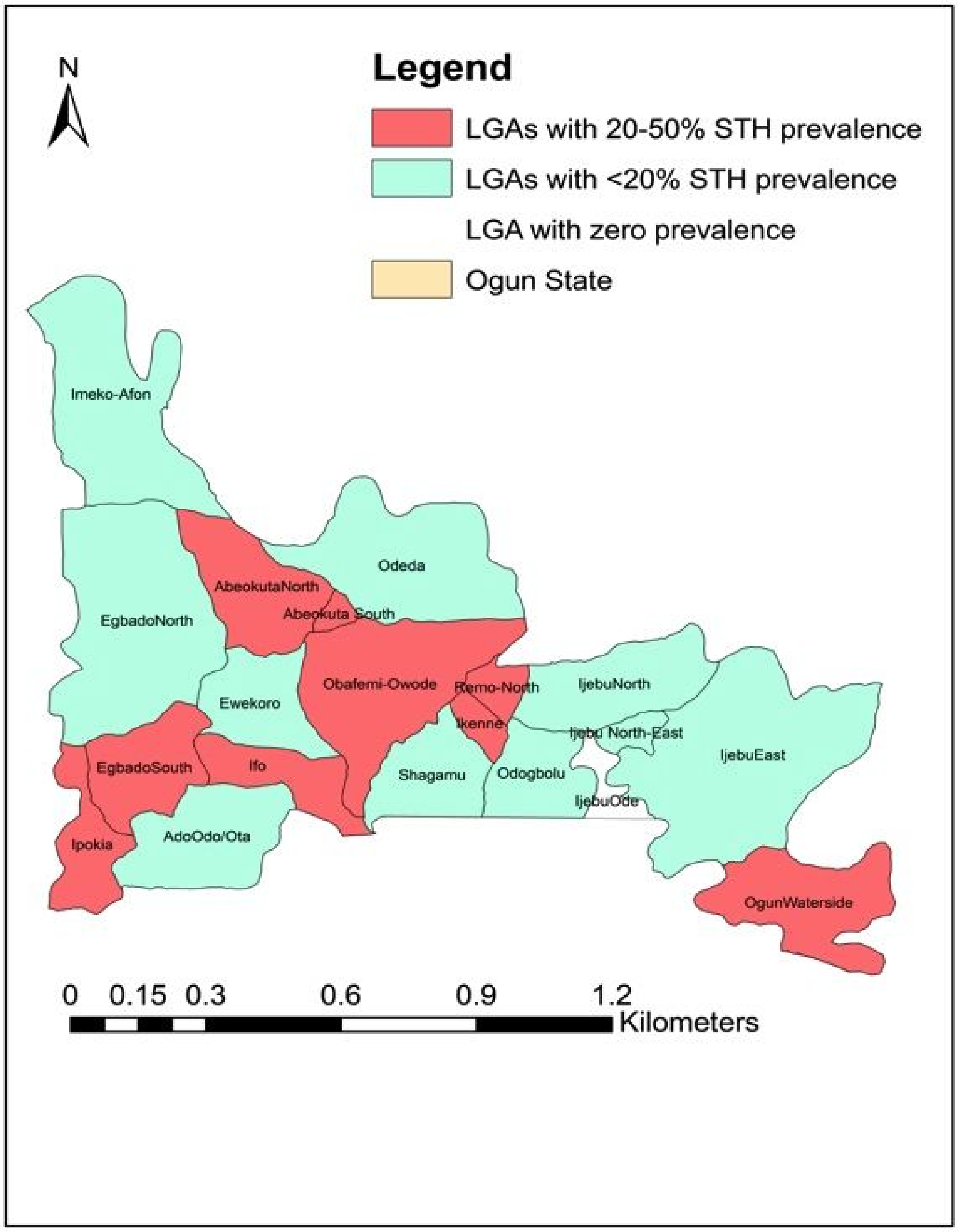

Figure 5

LGAs classification by WHO prevalence thresholds for preventive chemotherapy Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

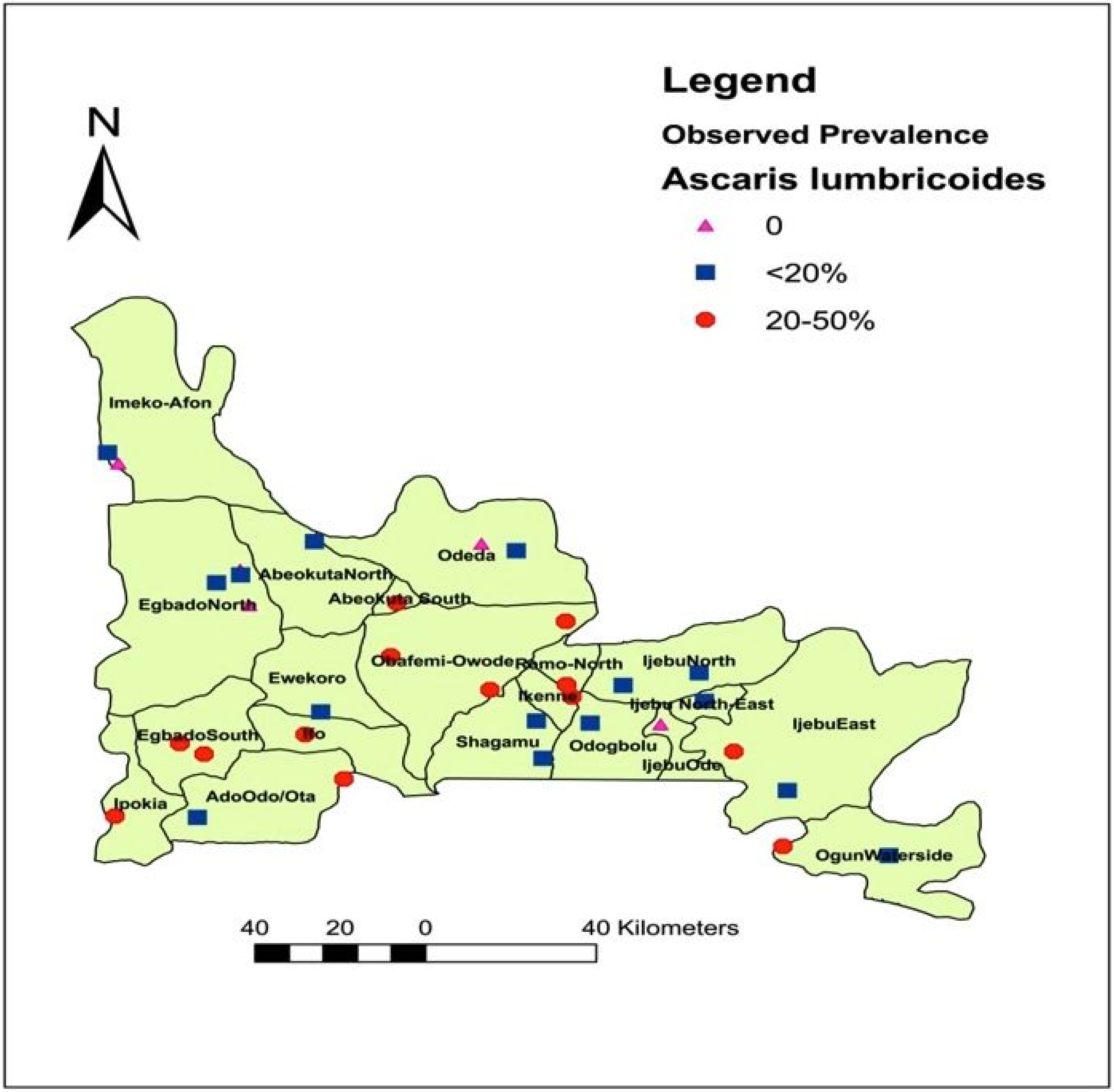

Figure 6

Spatial distribution of Ascaris lumbricoides infection in Ogun State, Nigeria Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

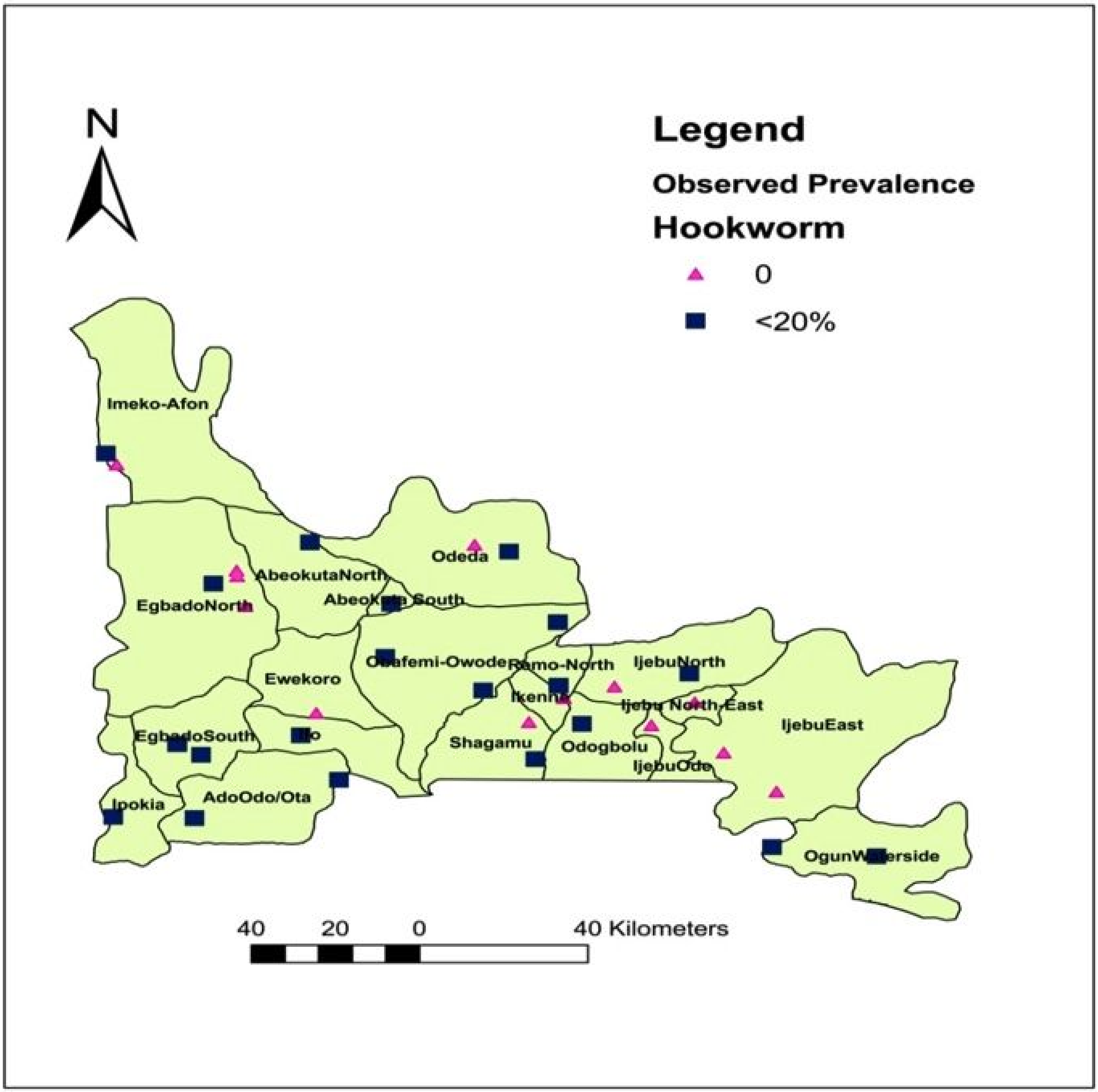

Figure 7

Spatial distribution of hookworm infections in Ogun State, Nigeria Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

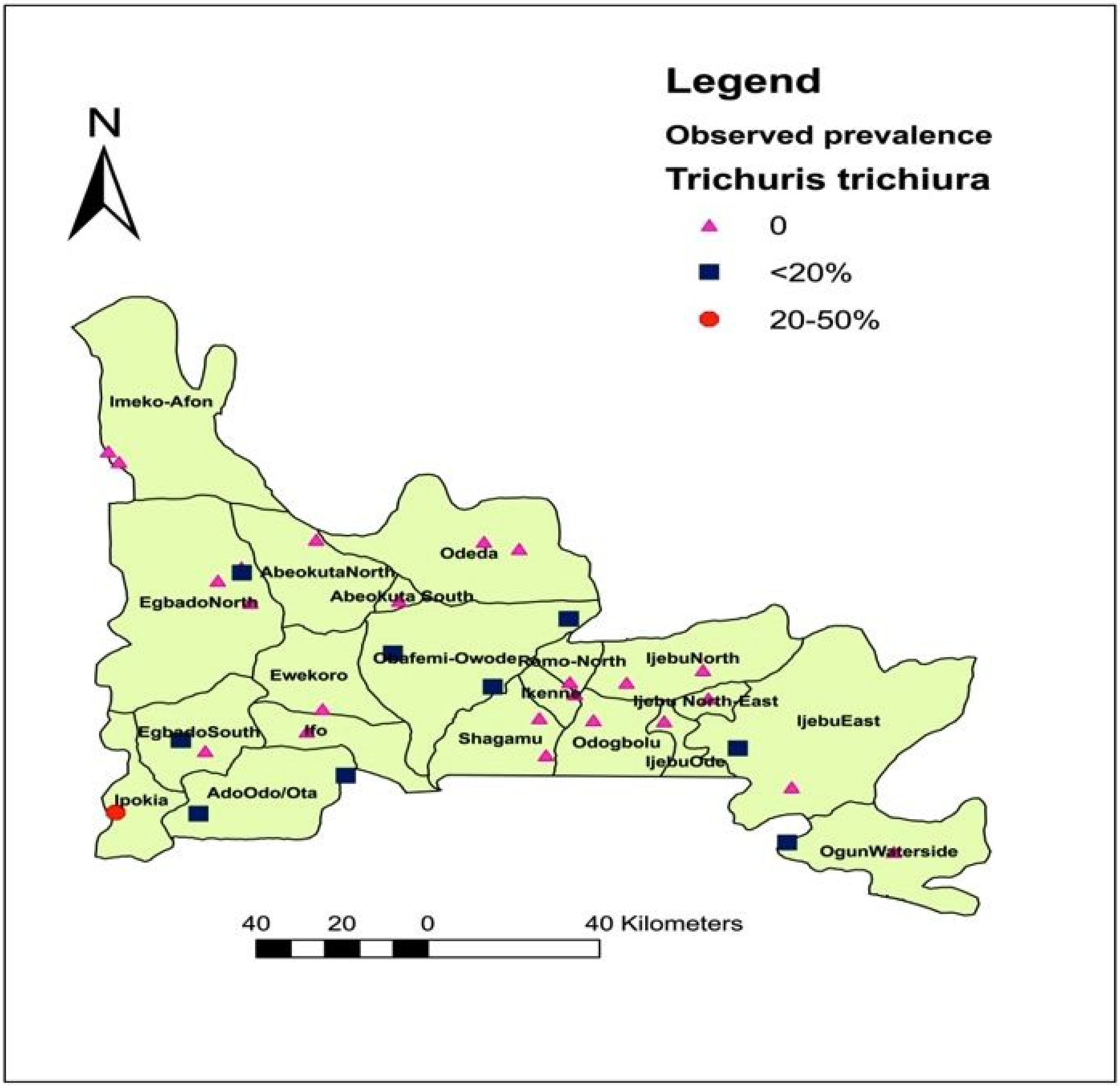

Figure 8

Spatial distribution of Trichuris trichiura infections in Ogun State, Nigeria Source: The authors using their primary data in ArcGIS software created this map. Permission: The authors give permission to re-use this map.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- MogajiSTROBEchecklistcrosssectional.pdf
- ListofTables.pdf