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A preliminary study on the abundance and species composition of mosquitoes breeding in discarded automobile tyres in Minna, Niger State, Nigeria

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Abstract
Water filled discarded automobile tyres usually provide avenues for the breeding of mosquito vectors. Mosquitoes transmit human and animal diseases such as Malaria, yellow fever, dengue hemorrhagic fever, encephalitis, fowl pox and Rift valley fever. This study was conducted to determine the species composition and relative abundance of mosquitoes breeding in discarded automobile tyres within Minna town, Niger, State, Nigeria. Mosquito larvae were isolated via standard systematic sampling technique using a soup ladle dipper and examined using standard techniques. Water samples were collected from 250 abandoned vehicle tyres containing stagnant water in nine (9) localities. The water from 95 (38.0%) of the sampled tyres were found to contain larvae of mosquitoes. Two (2) genera and six species of mosquito were identified from a total of 804 mosquito larvae isolated. These include, 722 (89.8%) *Aedes aegypti* Linnaeus; 8 (1.0%) *Culex pipiens molestus* Forsk; 7 (0.9%) *Culex pipiens pipiens* Linnaeus; 43 (5.4%) *Culex quinquefasciatus* Say; 9 (1.1%) *Culex simpsoni* Theobald and 15 (1.9%) *Culex tigripes* Grandpre. *Aedes aegypti* was the only species encountered breeding in tyres from all the nine localities and its container breeding indices ranged from 9.7% to 56.5% indicative of very high probability of transmission of epidemic yellow fever and other diseases spread by *Aedes* mosquito in the area. The abundance of each of the six mosquito species breeding in the area did not differ significantly ($P>0.05$). However, the abundance of larval *Aedes aegypti* amongst the nine locations differ significantly ($P<0.05$). Efforts to reduce the cases of Mosquito-borne diseases in the area should include proper environmental sanitation and public health awareness campaigns.

Keywords: Mosquitoes, automobile tyres, stagnant water, breeding, vector, Minna

Introduction
Mosquitoes belong to the members of the family Culicidae and order Diptera. According to Harbach [1], mosquitoes are very large and ubiquitous group of insects comprising of about 3500 known species, distributed in 44 genera. Many species of mosquitoes bred well in all available aquatic habitats including used and discarded materials that could hold water for some days. Some mosquito species bite humans routinely and act as vectors of a number of infectious diseases affecting millions of people annually [2, 3]. They are therefore of great public health significance.

Mosquitoes are regarded as public enemies because of their biting annoyance, noise nuisance, cause of sleeplessness and disease transmission. They transmit human diseases such as malaria, yellow fever, chikungunya, lymphatic filariasis, dengue haemorrhagic fever and encephalitis [4, 5]. Malaria is vectored by female *Anopheles* mosquito and is the deadliest disease in Nigeria. According to a recent estimate by the World Health Organization (WHO), there were 219 million cases of Malaria and 435,000 deaths due to malaria in the year 2017 [6]. Mosquitoes also transmit animal diseases like the fowl pox of poultry, myxomatosis of rabbits, Rift-valley fever of sheep, encephalitis of horses and birds, and heart worm diseases of dogs [7].

Mosquitoes are very widespread, occurring in all regions of the world, except for Antarctica [8]. In humid and tropical regions of the world, they are active for the entire year, but in temperate regions, they hibernate to overwinter. Many species of mosquito breed in both natural and artificial containers such as gutters, pools, leaf axils, coconut shells, tree holes, discarded tyres, bamboo stumps and other dumped materials that could contain water [9, 10].

Such materials are mostly filled by rain water showers or floods.

Scrap or abandoned automobile and truck tyres often support large population of mosquito species and could serve as potential breeding grounds for mosquitoes. For instance, in the United States, evidence of mosquitoes breeding in used and abandoned automobile tyres have been established since in the early 1980s [11]. An earlier study by Lesser [12] suggests that *Aedes albopictus* "the Asian tiger mosquito", was accidentally transported from Japan to the western hemisphere in the mid 1980's in shipments of used tyres and since then, it has become established in about half of the states of the US.

In tropical Africa, larvae of *Anopheles* mosquitoes (vectors of malaria fever) are commonly found in clear, sunlit pools of water in small depressions such as foot or hoof prints, the edges of bore holes and burrow pits, roadside puddles formed by tyre tracks, irrigation ditches and other man-made shallow water bodies [13-15]. Environmental alterations due to deforestation, swamp reclamation mainly for agriculture, excavation of sand and building stones, brick making and vegetation clearance may lead to an increase in larval habitats of malaria vectors, such as *An. gambiae* [16, 17].

In recent years, Nigeria has witnessed an unprecedented upsurge in the ownership of cars and other automobiles by individuals. Most of the vehicles in the country were purchased as fairly used and thus, their tyres had to be replaced within short period of usage. In addition, several used tyres were also imported into the country and these have created waste tyre disposal problems especially in urban settlements within the country. Many of the used tyres are carelessly disposed in the environment where they collect rainwater and form effective breeding habitats for mosquitoes. It is common to see heap of old discarded tyres on road sides where they serve as sign posts for tyre mechanics. Data on the abundance and distribution of mosquito species associated with waste tyres in both urban and rural communities in Nigeria is very scanty. To the best of our knowledge, the present study is the first of its kind in the study area. It is therefore expected that information from the present research will open up on the potential epidemiological significance of the discarded tyres in the area on the spread of mosquito-borne diseases and the need to adopt control measures against them.

Materials and Methods

The study area

The study was conducted in Minna, the capital town of Niger state, Nigeria. According to GPS coordinates, Minna town is located approximately on latitude 9°35᾽ North and longitude 6°32᾽ East at an altitude of 299m above sea level. Minna town lies within the southern Guinea savannah vegetation belt of Nigeria and occupies a land area of about 490 ha. According to 2018 estimates, the town has a population of 291, 905 inhabitants [18].

Sampling locations: A total of nine (9) places were used for sample survey during the course of this research namely; Chanchaga (9^0 32'29.92"N, 6^0 34'51.79"E), Police barrack (9^0 36᾽29.72"N, $6^0$33'10.09"E), Railway Quarters (9^0 36'15.83"N, 6^0 32'14.18"E), Morris (9^0 17'.83"N, 6^0 33"15.18"E), Sauka kahuta (9^0 35'01.33"N, 6^0 32' 57.74"), Odoye Quarters (9^0 36'59.59"N, 6^0 31'58.65"E), Kpakungu (9^0 35'51.84"N, 6^0 32'00.15"E), Tunga Low cost Quarters (9^0 36'36.35"N, 6^0 32'32.35"E) and Barikin Saleh (9^0 34'60.62"N, 6^0 35'30.33"E).

Sample collection: A systematic sampling technique was adopted to obtain representatives of mosquito breeding in tyres. Every discarded automobile tyre sighted containing water in the study sampling sites was inspected for mosquito larvae. Larval stages of mosquitoes were collected with a small soup ladle dipper measuring 9cm in diameter and holding 138ml of water [19]. With the aid of the soup ladle dipper, ten dips were made in each tyre and the water collected was poured into a white plastic container. Observations were made into the water to confirm breeding and the water containing mosquito larvae was concentrated and poured into labelled plastic bottles. The bottles containing the mosquito larval stages were taken to laboratory. In the laboratory, each bottle was emptied into a white container and a Pasteur dropping pipette was used to isolate the mosquito larvae into labelled specimen bottles. Ethyl alcohol (70%) was used to preserve the mosquito larvae for subsequent identification. Larval stages that were not up to the fourth larval instar were cultured on a diet of Baker's yeast. At fourth larval instar, they were also isolated and preserved in 70% alcohol.

Identification of mosquitoes

The alcohol preserved mosquito larvae were identified to species after a careful observation under a dissecting microscope and using the pictorial keys of Hopkins [20] as a guide. The number of larvae that belonged to each identified mosquito species were recorded accordingly. Comparative identification on each sample was done at the museum of the Department of Zoology, Ahmadu Bello University, Zaria, Nigeria, by an independent entomologist.

Statistical analyses

The data obtained from the research was carefully organized, coded and recorded accordingly. It was then entered in an SPSS version 21.0 for windows, for further analysis. Analysis of variance (ANOVA) was used to test for significant difference in the abundance of mosquitoes' species breeding in discarded automobile tyres amongst the nine localities within Minna metropolis. The relationship between the physicochemical parameters of the breeding media and the abundance of mosquito species was determined using correlation analysis.

Results

A total of 804 mosquito larvae were isolated from the discarded tyres sampled for this study over the period of the survey. The larvae were distributed into two genera (*Aedes* and *Culex*) and six species which include; 722 (89.8%) *Aedes aegypti* Linnaeus; 7 (0.9%) *Culex pipiens pipiens* Linnaeus; 8 (1.0%) *Culex pipiens molestus* Linnaeus; 15 (1.9%) *Culex tigripes* Grandpre; 9 (1.1%) *Culex simpsoni* Theobald and 43 (5.4%) *Culex quinquefasciatus* Say (Table 1).

Aedes aegypti is therefore the most dominant species breeding in the area, followed by *Culex quinquefasciatus* (the two species constituted 95.3% of the total larvae collected). The least abundant mosquito species encountered during the study was *Culex pipiens pipiens* which constitutes 0.9% of the total collections. *Aedes aegypti* was encountered in tyres from all the localities where samples were collected. *Culex quinquefasciatus* occurred in four (4) locations, *Culex tigripes*

was encountered also in four (4) locations, *Culex simpsoni* was found in three (3) locations while *Culex pipiens pipiens* and *Culex pipiens molestus* were encountered in one location each. Mosquito larvae were most abundant in Barikin Saleh area where the highest number of larvae (201), were obtained. The least number of larvae (21) were however collected at the Railway sampling location (Table 1). Statistical analysis however, showed that the abundance of each of the six mosquito species breeding in the area did not differ significantly ($P>0.05$).

In terms of larval diversity, Sauka kahuta area recorded the highest diversity of four species of mosquito breeding in tyres. Three species of mosquito occurred in tyres sampled at Railway quarters, Morris, Kpakungu, and Tunga lowcost locations respectively. Similarly, two species each, occurred in Chanchaga and Odoye quarters while only one specie was encountered in Barikin Saleh area (Table 1).

Table 1: Mosquito larval distribution and diversity collected in discarded automobile tyres in parts of Minna, Niger state, Nigeria.

Localities	Mosquito (larval) species isolated; Number (%)						Total
	Aedes aegypti	***Culex pipiens pipiens***	***Culex pipiens molestus***	***Culex tigripes***	***Culex simpsoni***	***Culex quinquefasciatus***	
Chanchaga	46 (80.70)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	11 (19.3)	57
Police Barrack	35 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	35
Railway	13 (61.9)	0 (0.0)	0 (0.0)	3 (14.3)	5 (23.8)	0 (0.0)	21
Morris	74 (94.9)	0 (0.0)	0 (0.0)	1 (1.1)	3 (3.80)	0 (0.0)	78
Sauka kahuta	81 (91.0)	0 (0.0)	0 (0.0)	1 (1.1)	1 (1.10)	6 (6.7)	89
Odoye	98 (91.6)	0 (0.0)	0 (0.0)	10 (9.3)	0 (0.0)	0 (0.0)	108
Kpakungu	116 (77.9)	0 (0.0)	8 (5.4)	0 (0.0)	0 (0.0)	25 (16.8)	149
Tunga low cost	58 (87.9)	7 (10.6)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.1)	66
Barikin Saleh	201 (100.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0:0)	0 (0.0)	201
Total	722 (89.8)	7 (0.9)	8 (1.0)	15 (1.9)	9 (1.1)	43 (5.3)	804 (100.0)

Two breeding patterns of single and double species of mosquito breeding per tyre were encountered during the study. Five mosquito species bred as sole species per tyre in 85 (89.5%) of the 95 positive tyres encountered. Amongst the breeding patterns observed, *Aedes aegypti* bred as sole species in 76 (80.0%) tyres. *Culex tigripes* was isolated as sole breeder in 5 (5.3%) tyres while *Culex quinquefasciatus* bred as sole specie in 3 (3.2%) tyres. Moreover, *Culex pipiens molestus* and *Culex simpsoni* were found to be sole breeders in 1 (1.3%) positive tyre each. Four combinations of two species of mosquito were encountered in same tyre habitats in 10 (10.5%) tyres. Amongst the combinations of the two species breeding per tyre, *Aedes aegypti* and *Culex simpsoni* predominated in 5 (5.3%) tyres. Similarly, two tyres each were found to contain a combination of *A. aegypti + C. tirgripes* and *A. aegypti + C. quinquefasciatus* respectively (Table 2).

Table 2: Mosquito breeding pattern in discarded automobile tyres in Minna metropolis

Mosquito species isolated and pattern of occurrence	Number (%) of tyres occured (N=95)
a. Single species occurrence	
Aedes aegypti	76 (80.0)
Culex pipiens molestus	1 (1.3)
Culex tigripes	5 (5.3)
Culex quinquefasciatus	3 (3.2)
Culex simpsoni	1 (1.1)
Sub-total	85 (89.5)
b. **Double species occurrence**	
Aedes aegypti + Culex simpsoni	5 (5.3)
Aedes aegypti + Culex tigripes	2 (2.1)
Aedes aegypti + Culex quinquefasciatus	2 (2.1)
Culex pipiens pipiens + Culex quinquefasciatus	1 (1.1)
Sub-total	10 (10.5)

In this research, *Aedes aegypti* mosquito account for the highest number of species encountered and was the only species isolated from all the nine sampling locations considered for this research. The larval breeding indices of *Aedes aegypti* in discarded automobile tyres in the study area was therefore examined and is shown on Table 3. *Aedes aegypti* bred in 81 out of the 250 (32.4%) tyres in parts of Minna. The least of the container indices was recorded in Railway qarters to be 9.7% whereas the highest index occurred in Odoye quarters as 56.5%. All the *Aedes aegypti* breeding indices obtained for all the localities were within the critical ranges that could support the transmission of yellow fever, which is one of the arbovirus diseases transmitted majorly by *Aedes aegypti* species of mosquito. However, the abundance of larval *Aedes aegypti* amongst the nine locations differ significantly ($P<0.05$). Similarly, statistical analysis indicated that larval *Aedes aegypti* is significantly more abundant compared to other species of mosquitoes isolated in the study locations ($P<0.05$).

Table 3: *Aedes aegypti* larval indices in discarded automobile tyres in parts of Minna, Niger State, Nigeria

Localities	Number of tyres examined	Number of tyres positive for *Aedes aegypti*	Larval Container indices (%)
Chanchaga	29	3	10.3
Police barack	22	3	13.6
Railway quarters	31	3	9.7
Morris	32	13	40.6
Sauka kahuta	23	8	34.8
Odoye quarters	23	13	56.5
Kpakungu	23	9	39.1
Barikin saleh	23	10	43.5
Tunga lowcost	44	19	43.2
Total	250	81	32.4

Discussion

This study has revealed that discarded automobile tyres served as very important breeding places of mosquito species in the study area. The ability of mosquito species to breed in the discarded tyres attributed to the collection of rainwater in the abandoned tyres when dumped in the open bushes or road sides around residential areas. The availability of discarded tyres in the environment thus offers a suitable habitat for opportunistic mosquito to breed. In this study, six species from two mosquito genera were isolated. Our finding isolate fewer species compared with a recent study conducted in Kerala India [21]. This could be due to smaller scope covered by this study and ecological differences. Larvae of mosquitoes were encountered from discarded tyres in all the localities visited during the conduct of this research. The highest larval indices were found in Barikin Saleh. This is probably this area is more of an urban slum settlement with lots of open refuse and other stagnant water locations. However, Railway quarters had the least larval indices of mosquitoes probably because the area consist of more spaced government quarters with adequate drainage system and less surface stagnant water for larger concentration mosquitoes.

Of the six species of mosquitoes encountered during the study, *Aedes aegypti was* the most dominant species over the remaining five species encountered in the discarded tyres. The occurrence of *Aedes aegypti* breeding in discarded tyres in all the localities visited showed that probably it has more preferece for breeding in tyres than other habitats. Our findings agree with the report by Simard *et al.*, [22] who maintained that *Aedes aegypti* and *Aedes albopictus* breed frequently in used tyres and other artificial sites in the Republic of Cameroon. It also concurs with the findings from a similar Nigerian study by Adebote *et al.*, [23]. The dominance of *Aedes aegypti* in the discarded tyres also probably indicate that, the species could tolerate a wide range of physico-chemical and ecological conditions, compared to other mosquito species. In this research, no specie of *Anopheles* mosquito was encountered, this could be probably attributed to the fact that water amount in the discarded tyres is small in quantity and could contain high concentration of ions and less dissolved oxygen which do not favour Anopheline larval development. Previous studies have shown that, the genus *Anopheles* favour larger volumes of water with less contration of chemical ions and much of dissolved oxygen [17, 24].

Larval indices of *Aedes aegypti* obtained for the nine localities is within the critical range associated with yellow fever transmission. WHO [25] gave the container indices range of 3-20% and above for yellow fever epidemics. Therefore, the nine localities visited in this study are prone to epidemics of yellow fever if this trend continues. Despite this finding that *Aedes aegypti* larval indices are within the critical range for yellow fever epidemics, no yellow fever outbreak has been reported in the area over the time. This could be attributed to the absence of the causative virus in humans as well as absence of the monkey reservoir hosts in the study area. Be that as it may, the potential for an outbreak of yellow fever is still high in the area whenever there is a tilt in the epidemiologic factors.

Conclusion

The results from this study revealed that discarded automobile tyres supported the breeding of six species of mosquito within Minna Metropolis, Northern Nigeria. Four of the species isolated, namely; *Aedes aegypti, Culex pipiens pipiens, Culex pipiens molestus, and Culex quinquefasciatus* are known to be potential vectors of human diseases.

The authors would like to recommend that further research on discarded automobile tyres should include aspect of chironomid larvae breeding in tyres, because in the course of this research, we came across chironomid larvae in several of the tyres. The physico-chemical quality of the water also need to be documented to properly infer why some species of mosquitoes are absent in the discarded tyres. Effort should be made to rid the environment of discarded tyres via recycling or burning, since they support the breeding of disease vectors that pose threat to public health. There is also the need for more public enlightenment on the dangers of mere throwing away of old vehicle tyres as a means of their disposal by people.

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We also declare that we have no any competing interest.

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