# Diversity and distribution of *Aedes* mosquitoes in Nigeria

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**Abstract:** *Aedes* mosquitoes are vectors of yellow fever, Zika, dengue, chikungunya, West Nile diseases among others. These mosquitoes bite both humans and animals alike during the day, particularly in the mornings and evenings. This study sought to understand their diversity, distribution and abundance in Nigeria. Ovitrapping, larval surveys and human landing collections were used to sample for vectors in 14 states of the country and the Federal Capital Territory (FCT). This cuts across the 6 geopolitical zones of the Federation. A total of 8,659 *Aedes* mosquitoes, consisting of nine (9) different species were collected. *Aedes albopictus* 3,651(42%) constituted majority of the collections, while *Aedes circumluteolus* 40 (0.5%) was the least collected. All nine species collected in the surveillance were present in Enugu State, while Kaduna State, with the least diversity, had only one species. The study revealed the overwhelming presence of domestic, peri domestic and canopy breeders of the genus, *Aedes,* in the Country. These include those that transmit some of the most dreaded diseases across the globe. Hence, there is need to continuously update available data on these mosquitoes. This should be the basis for effective vector control and the eventual elimination of *Aedes*-related diseases in Nigeria.

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## 1. Introduction

*Aedes* mosquitoes are usually black, with characteristic white or silver markings on their bodies. They were formerly found in tropical and sub-tropical areas, but have now spread to all continents excluding Antarctica (Bonizzoni et al., 2013). This spread was aided hugely by man-made activities, including the sale of used tyres. Unlike most other mosquitoes, they are active and bite both humans and animals only during the daytime. Their peak biting periods are early mornings and evenings, before dusk.

*Aedes* species normally breed in transient water collections. These include collections in tree cavities, leaf axils, bamboo stumps, rock pools and artificial containers (including tin cans, coconut shells, water storage containers, discarded vehicle tyres, broken earthen and ceramic wares). These breeding habits keep them in close proximity with man, facilitating also disease transmission. They lay their eggs just above the water level. As a result, water waves/ripples or increases in water volume lead to hatching of viable eggs.

Members of the *Aedes* genus are known vectors for numerous viral infections. The two most prominent species are *Aedes aegypti* and *Aedes albopictus* which transmit Zika virus and other viruses that cause dengue fever, yellow fever, West Nile fever, Chikungunya, and Eastern equine encephalitis, among other less notable diseases. Some studies conducted in Nigeria revealed that the major *Aedes* mosquito species include: *Ae. aegypti, Ae. albopictus, Ae. africanus, Ae. luteocephalus, Ae. simpsoni* complex, *Ae. vittatus* (Service, 1974; Adeleke, 2008; Aigbodion and Uyi, 2013 and Chukwuekezie et al., 2016). They are important vectors of Yellow fever, Dengue fever, Chikungunya, West Nile and Zika viral diseases, as well as many other arboviruses. Some can also transmit filarial worms.

There has been re-emergence of yellow fever in the Country, since the last case in Kano State, in the year 2000. Between July and December, 2017, there were 341 suspected cases of yellow fever reported from 16 states (Abia, Anambra, Borno, Edo, Enugu, Kano, Katsina, Kogi, Kwara, Kebbi, Lagos, Nasarawa, Niger, Oyo, Plateau, and Zamfara states). Of these, 6 states (Kano, Kebbi, Kogi, Kwara, Nasarawa and Zamfara) reported confirmed cases of the disease (WHO, 2017). This is a confirmation that at present, there is circulation of the virus in the vectors in several parts of the country.

There is need for continuous collection and collation of data on *Aedes* species, which will be

indispensable in formulating effective control strategies. The present study therefore sought to determine the diversity and distribution of *Aedes* mosquitoes in Nigeria.

## 2. Materials and Methods

*Aedes* mosquitoes were studied for eight years, from the year 2007 to the year 2014 in 14 states and the FCT, spanning the six geo-political zones of Nigeria.

### 2.1 Mosquito Collection Techniques

#### 2.1.1 Ovitrapping

Ovitraps were used to collect eggs of *Aedes* mosquitoes. Each ovitrap consisted of a plastic cup (dark colour preferable) one-third filled with clear water, lined internally with a strip of white cloth (ribbon) measuring 3cm in width and a length equal to the internal perimeter of the cup. Care was taken to ensure that part of the ribbon was above the water line. The cups were positioned in shaded and cool places where children and/or animals around the homes will not disturb them. In an attempt to lay their eggs just above the water line/level, the mosquitoes oviposit on the ribbon (s). After 48 hours, the ribbons were removed from the cups and air-dried at room temperature. Eggs on each ribbon was counted and recorded accordingly. They were then preserved in well labelled containers for transportation, counting, storage, flooding/soaking, eventual hatching and rearing to adult stage.

#### 2.1.2 Larval Sampling/Survey

Larvae were sampled from various man-made water collections such as cans, coconut shells, water storage containers, discarded vehicle tyres, broken earthen and ceramic wares among others. Ladles, pipettes, bowls and buckets were utilized for this activity. The collections were introduced into well labelled plastic containers with lids. They were eventually taken to the insectary for rearing to the adult stage.

#### 2.1.3 Human Landing Collection

Adult *Aedes* mosquitoes were collected using human baits between 4:30pm and 8pm during the study periods. Collections were recorded at intervals of 15 minutes to gather more information on the vector biting activities. To collect mosquitoes, the lower legs of the collectors were exposed such that when they perched to take a blood meal the mosquitoes were collected using test tubes. The opening of the tube was plugged with cotton wool to prevent escape of the mosquito.

Table 1. Collections from different states and the Federal Capital Territory (FCT)

| S/N | State | Year | Species | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *Ae.aegypti* | *Ae.albopictus* | *Ae.africanus* | *Ae.leutocephalus* | *Ae.cumminsi* | *Ae.taylori* | *Ae.vittatus* | *Ae.simpsoni* | *Ae.circumluteolus* |
| 1 | Abia | 2009 | 45 | 53 | 107 | 47 | 0 | 0 | 0 | 0 | 0 |
| | | 2012 | 3 | 20 | 34 | 4 | 0 | 0 | 0 | 0 | 0 |
| 2 | Delta | 2007 | 5 | 21 | 247 | 59 | 0 | 0 | 0 | 0 | 0 |
| | | 2011 | 8 | 18 | 29 | 15 | 0 | 0 | 0 | 0 | 0 |
| | | 2012 | 30 | 54 | 255 | 69 | 0 | 0 | 0 | 0 | 0 |
| | | 2013 | 46 | 45 | 33 | 86 | 0 | 0 | 0 | 0 | 0 |
| 3 | Enugu | 2008 | 15 | 12 | 1 | 3 | 1 | 1 | 2 | 0 | 0 |
| | | 2011 | 27 | 42 | 15 | 12 | 0 | 1 | 2 | 2 | 0 |
| | | 2012 | 160 | 189 | 31 | 52 | 1 | 0 | 15 | 8 | 1 |
| | | 2013 | 101 | 550 | 2 | 4 | 1 | 0 | 0 | 3 | 0 |
| | | 2014 | 805 | 2012 | 0 | 1 | 9 | 0 | 0 | 225 | 0 |
| 4 | Imo | 2012 | 7 | 27 | 17 | 11 | 0 | 0 | 0 | 0 | 0 |
| | | 2014 | 287 | 146 | 103 | 58 | 0 | 0 | 0 | 0 | 0 |
| 5 | Anambra | 2008 | 1 | 17 | 50 | 117 | 2 | 0 | 0 | 7 | 10 |
| | | 2012 | 136 | 38 | 5 | 8 | 4 | 0 | 2 | 1 | 0 |
| | | 2014 | 171 | 204 | 12 | 0 | 0 | 0 | 1 | 34 | 0 |
| 6 | Akwa Ibom | 2011 | 4 | 22 | 20 | 36 | 0 | 0 | 7 | 0 | 0 |
| 7 | Ondo | 2010 | 6 | 23 | 7 | 0 | 0 | 0 | 0 | 2 | 4 |
| 8 | Ebonyi | 2010 | 17 | 35 | 31 | 82 | 4 | 0 | 7 | 0 | 6 |
| | | 2012 | 1 | 6 | 13 | 72 | 0 | 1 | 0 | 0 | 0 |
| 9 | Ogun | 2011 | 11 | 41 | 0 | 2 | 0 | 0 | 3 | 0 | 0 |
| 10 | Cross River | 2010 | 1 | 5 | 47 | 53 | 0 | 1 | 0 | 0 | 12 |
| 11 | Benue | 2007 | 84 | 55 | 49 | 492 | 29 | 39 | 4 | 0 | 4 |
| | | 2010 | 29 | 7 | 1 | 61 | 0 | 5 | 3 | 0 | 0 |
| 12 | Taraba | 2010 | 29 | 9 | 0 | 25 | 0 | 2 | 3 | 0 | 3 |
| 13 | Kebbi | 2011 | 2 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 14 | FCT | 2011 | 21 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 15 | Kaduna | 2010 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | **TOTAL** | | **2055** | **3651** | **1109** | **1370** | **51** | **50** | **51** | **282** | **40** |
| | | **Grand Total** | | | | | | | | | **8659** |

From the result above, *Aedes aegypti* (24%) was collected in all the states sampled. *Aedes albopictus* (42%) was the most abundant of all the collections made, while *Aedes circumluteolus* (0.5%) was the least abundant species.

**2.2 Hatching of Eggs and Rearing of Mosquitoes to Adults**

The ribbons containing the eggs were placed into well labelled clean bowls. Clean/clear water devoid of *Aedes* eggs was poured into the bowl till the ribbons were submerged. The bowl was immediately covered with a net to prevent oviposition by another mosquito and possible escape of emerging adult mosquitoes. As eggs hatched, the ribbon was removed and air-dried. The larvae were then counted. The entire process was repeated 3 times to ensure all the viable eggs hatched.

The larvae were fed with animal feed. Water in the bowls was changed every other day to prevent pollution. As soon as adults emerged, they were collected by means of a mouth aspirator and introduced into a well-labelled test tube.

**2.3 Mosquito Identification**

Mosquito identification was done at the adult stage. Adult mosquitoes from ovitrapping, larval surveys and human landing collections were all identified using the keys of (Edwards, 1941; Gillet, 1972 and Huang, 1979). The mosquitoes were chilled to death in a test tube and then identified to species level using stereomicroscopes.

**3. Results**

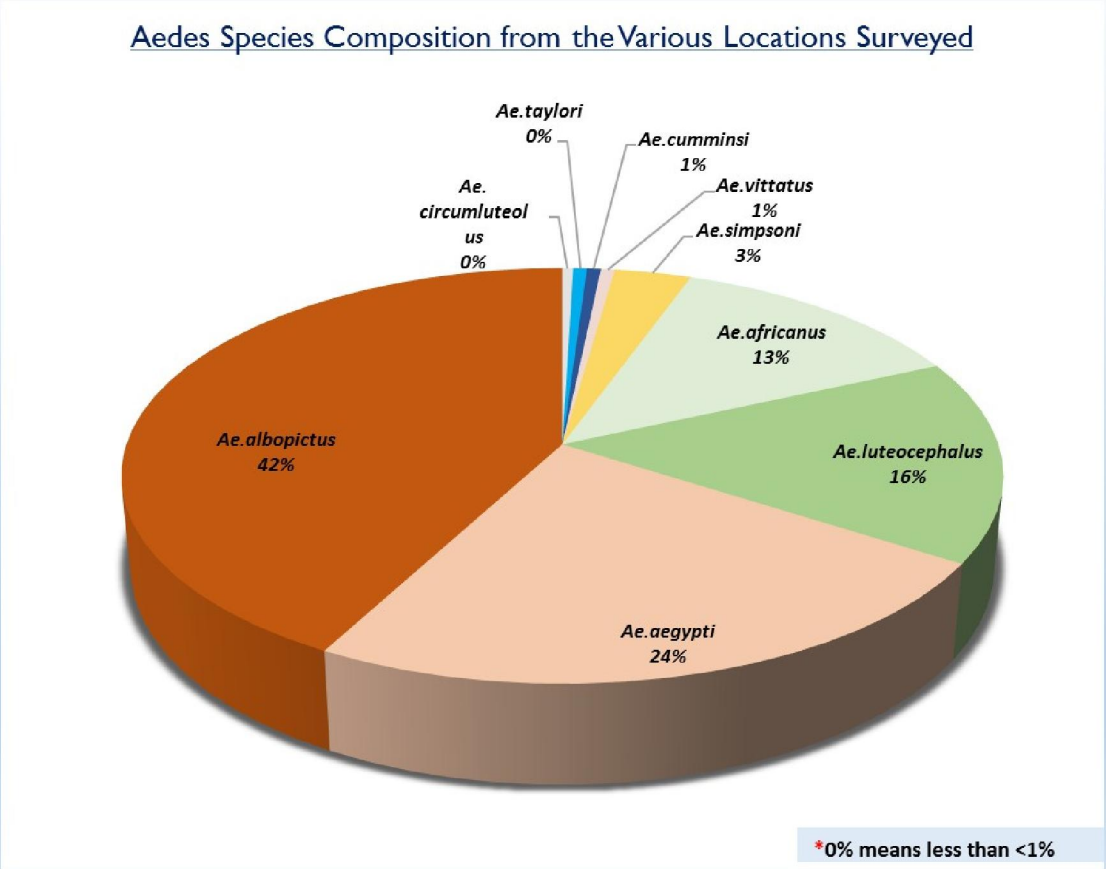


Figure 1. *Aedes* species composition from the study

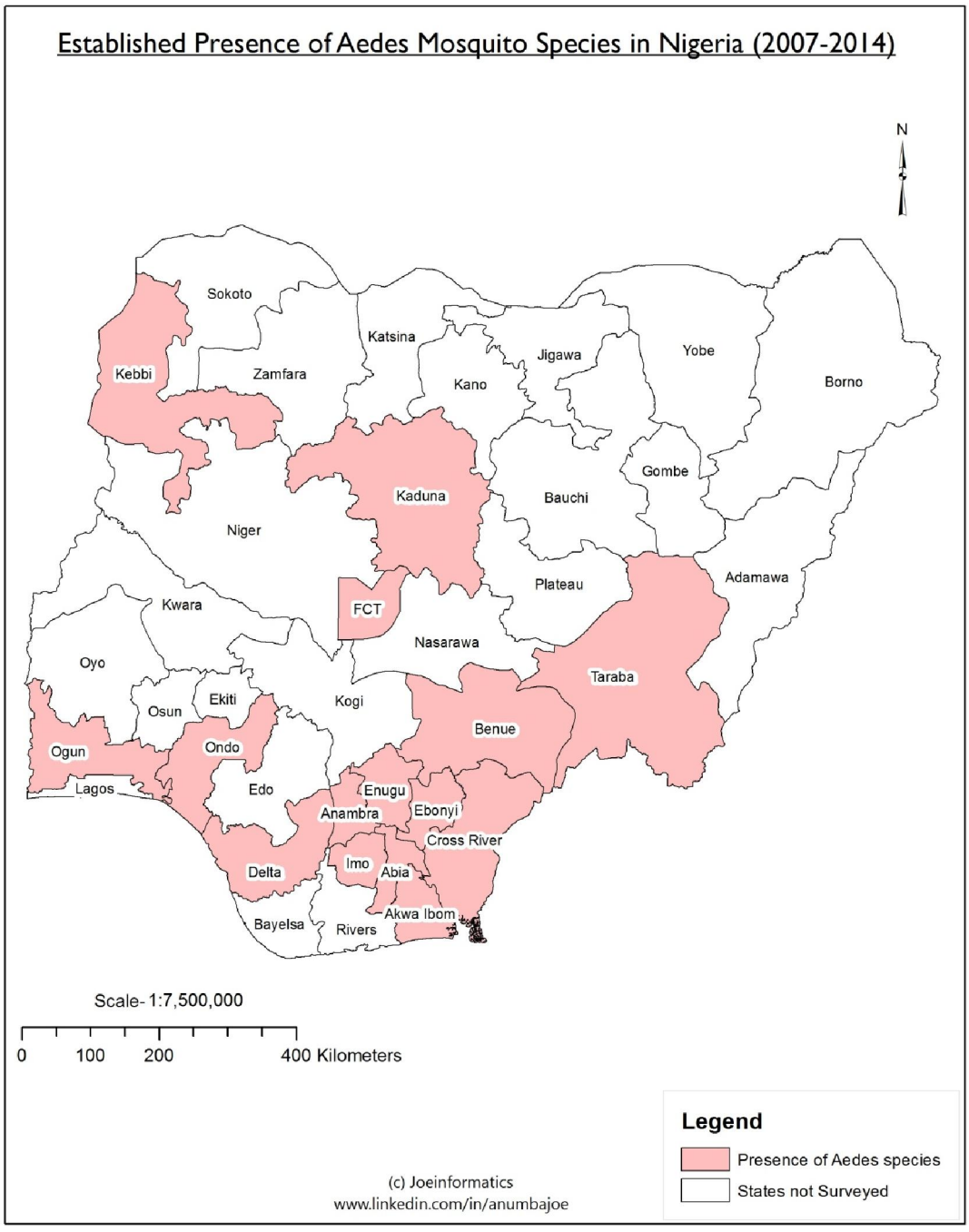


Figure 2. Map showing states from where *Aedes* species were collected

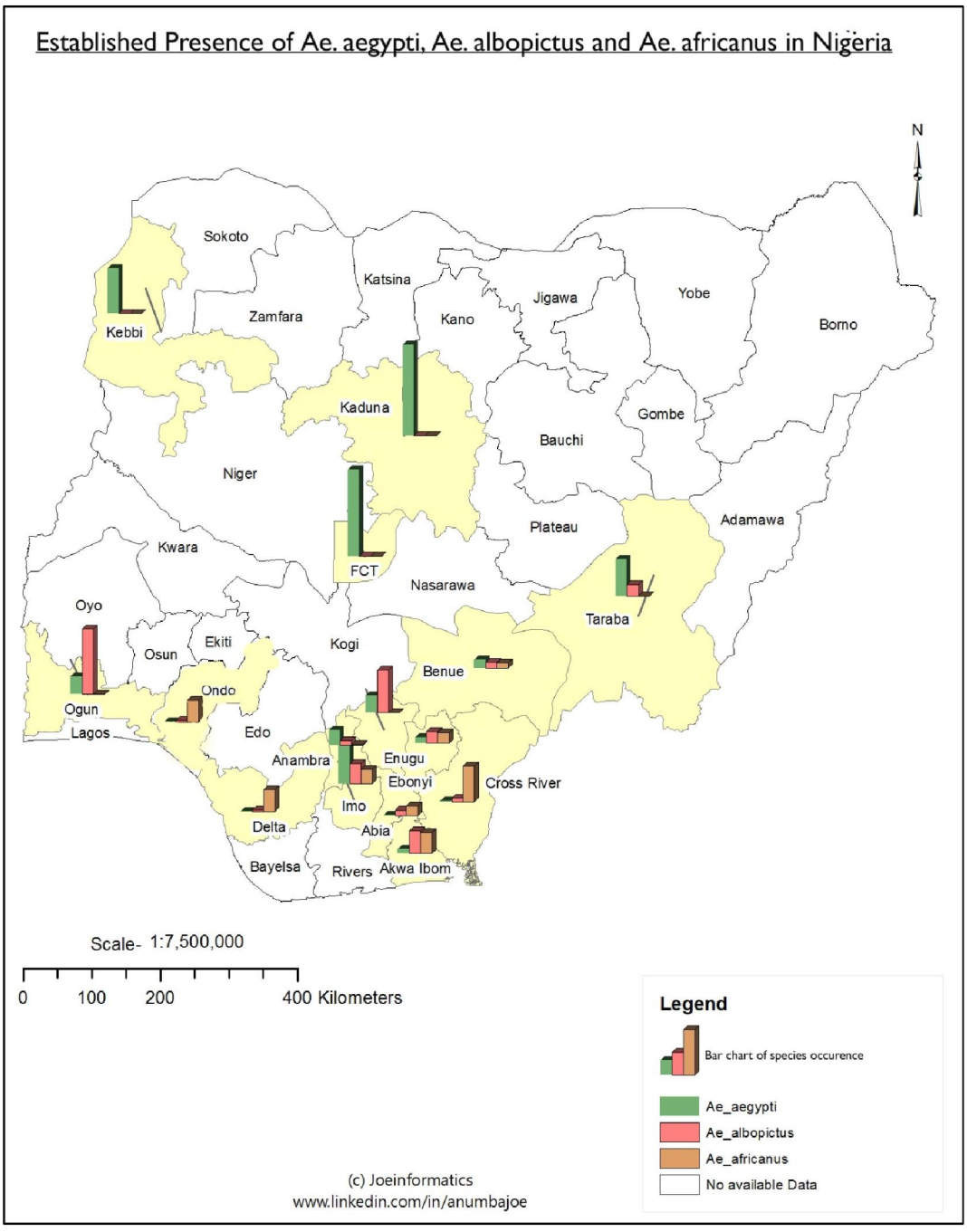


Figure 3: Established presence of *Aedes aegypti*, *Ae. albopictus* and *Ae. africanus* in the locations surveyed

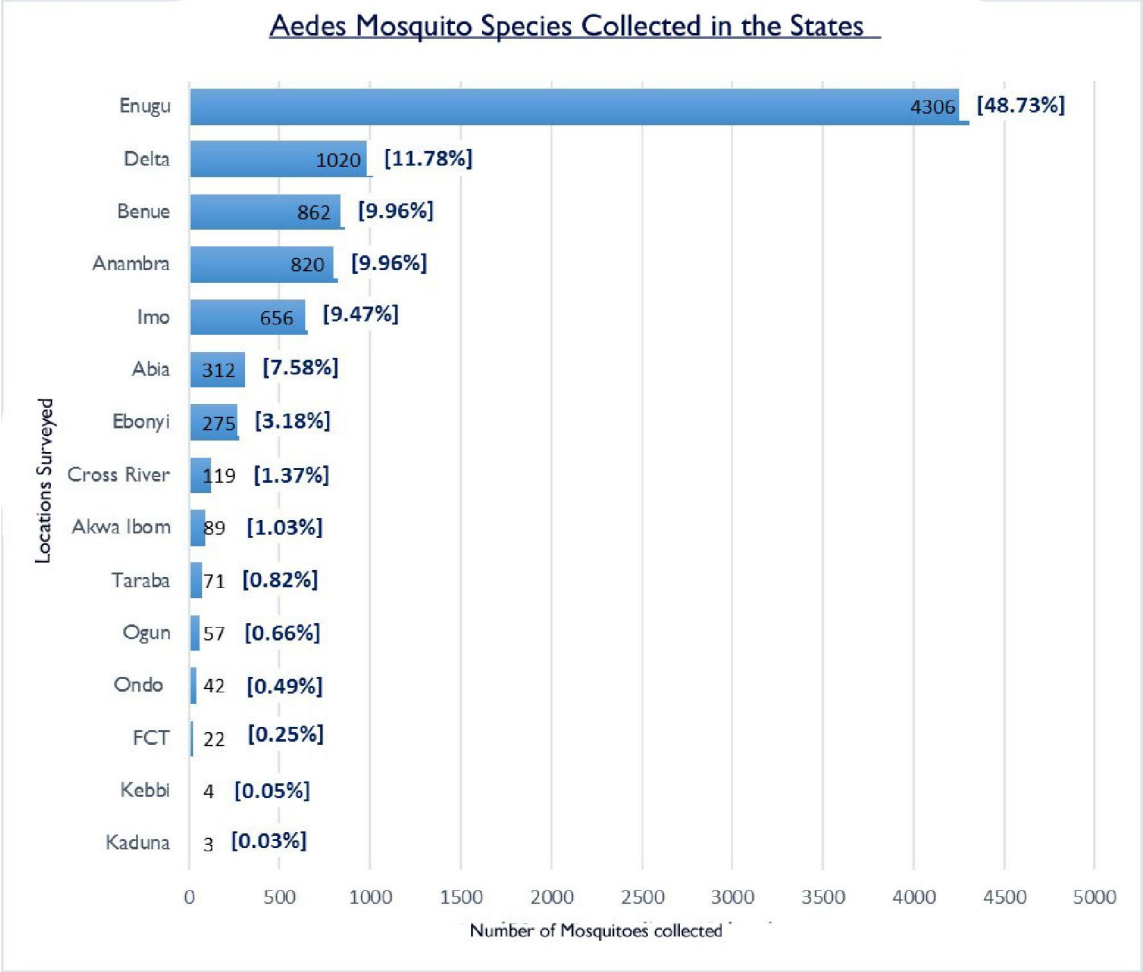


Figure 4. *Aedes* species collected per State

All the *Aedes* species (*Ae. aegypti, Ae. albopictus, Ae.africanus, Ae. luteocephalus, Ae. vitattus, Ae.cumminsi, Ae.simpsoni* complex, *Ae.circumluteolus, Ae. taylori*) were collected in Enugu, while in Kaduna State, only *Aedes aegypti* was collected. The four most abundant species collected were *Ae.aegypti, Ae.albopictus, Ae.africanus* and *Ae.luteocephalus.*

## 4. Discussion

Outbreak of arboviral infections such Zika, Dengue, Yellow fever, Chikungunya among others have always been associated with *Aedes* species. Though there are bits/fragments/inedequate of information on *Aedes* species and the diseases they transmit in different parts of the country, there is no concise ecological record of *Aedes* species in the country. The National Arbovirus and Vectors Research Centre (NAVRC) is saddled with the responsibility to study the ecology, bionomics, distribution and seasonal variation of disease vectors, especially arbovirus vectors. Hence, the Centre embarked on this study. From 14 states and the FCT (all from the 6 geopolitical zones), a total of 9 different species of the *Aedes* genus were collected. This is the widest coverage done by any group on *Aedes* species in the country. The findings corroborate those of (Service, 1974; Chukwuekezie et al., 2016; Nwoke and Eboh, 1988; Onyido et al, 2009; Lawal et al., 2012 and Idowu et al., 2012).

The findings showed that *Aedes aegypti* was present in all the States visited. This agrees with the findings of (Surtees, 1967), who reported that *Aedes aegypti* occurs throughout Nigeria, from the coastal swamp zone to the Northern Guinea/Sudan savannah. On its part, *Aedes albopictus* was the dominant species from the collections. This was no surprise, as it had been described as one of the most invasive species because of the way it spread globally (Bonizzoni et al., 2013). *Aedes africanus,* one of the vectors for sylvatic yellow fever, was quite prominent in some southern states (Delta, n=564; Abia, n=141 and Imo, n=120) which are in the tropical rain forest zone.

Breeding of these species were predominantly in man-made containers such as cans, tyres, earthen pots among others as observed in the study of Onyido et al., (2008). Nwoke and Nwoke (2006) observed that the habit of littering the environment with discarded containers among dwellers provides good breeding sites for these mosquitoes. A near uniform peak biting period between 7am – 9am and 5pm – 7pm) which was observed during the day, further buttresses their proclivity for diurnal biting activities.

It is worthy of note that members of the *Aedes simpsoni* complex (collected through use of human baits) were collected from Anambra, Enugu and Ondo States, suggesting that the species collected may be *Aedes bromeliae*, the widely distributed anthropophagic member of the complex in Africa (Huang, 1979). The four most abundant *Aedes* species collected were *Ae. aegypti, Ae. albopictus, Ae. africanus* and *Ae. luteocephalus. Aedes albopictus* (42%) was the most abundant, while *Ae. circumluteolus* (0.5%), was least abundant of all the collections. However, comparisons were not made with respect to the various sites and species of vectors collected. This was because there were discrepancies in: the number of visits to the various states; sampling duration; number of collectors; months and years of sampling. The findings however, give an insight into the *Aedes* fauna in various locations of the country.

Findings of this study give credence to the potential public health threats posed by *Aedes* mosquitoes in Nigeria as this becomes increasingly more important when the species have very high hunger for feeding on man, high reproductive potential and remarkable longevity (Gordon and Lavoipierre, 1976). NAVRC, Enugu, has continued with studies on these species and some are on-going. This study provides basic information on the *Aedes* species in the Country. The adult and larval abundance is a risk factor for arboviral diseases in the country. This is evident in the surge in cases of yellow fever in Nigeria. Therefore, organized and continuous surveillance will not only give Nigeria a data base of the *Aedes* species but will help in policy changes and planning a targeted vector control strategy.

**5.0 Conclusion**

*Aedes* mosquitoes are abundant and widely distributed across Nigeria. This is an enormous risk factor that demands continuous and systematic surveillance across the different geopolitical and ecozones of the country. Such sustained surveillance must be standardized for adequate comparisons within and among states. Also, there is need for inclusion of vector viral incrimination and insecticide resistance monitoring in subsequent studies. This will enhance early warnings of possibility of disease outbreaks and adequate emergency preparedness and response.

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