# MOSQUITO FAUNA OF A TROPICAL MUSEUM AND ZOOLOGICAL GARDEN COMPLEX

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**ABSTRACT**

***The mosquito fauna of Museum and Zoological Garden Complex (JZC), a major tourist attraction in Jos Metropolis of Nigeria, was studied. The choice of the complex was out of public health curiosity. A total of 627 mosquitoes comprising 4 genera, Aedes, Culex, Coquilletidia and Eretmapodites, and 9 species were caught in two different study trips. Five species, namely, Aedes aegypti, A. africanus, A. vittatus, Culex quinquefasciatus and Eretmapodites chrysogaster, caught by human bait method are known variously to be involved in the transmission of yellow fever and other viral diseases. Culex quinquefasciatus had the highest frequency followed by Aedes aegypti. Simpson's dominance and Shannon-Wiener diversity indices of 0.4942 and 0.4550 were respectively recorded for the whole mosquitoes sampled by the human bait method. C. quinqefasciatus was the most frequent species with diversity values of 0.4444 (Simpson's) and 0.1174 (Shannon-Wiener), followed by A. aegypti with 0.0455 (Simpson's) and 0.1431 (Shannon-Wiener). Ecological statistics demonstrated a highly significant difference in diversity between samples in March, during the dry season, and June in the rainy season (P < 0.001). The presence of man-biting mosquitoes in JZC constitutes apparent public health danger and calls for regular surveillance and control operations on such disease vectors in the complex.***

**Keywords:** Mosquitoes, Zoo Complex, Public Health, *Aedes, Culex, Eretmapodites, Coquilletidia*

## INTRODUCTION

Mosquitoes are of remarkable importance in the transmission and dissemination of both human and animal diseases. Amongst the veterinary and medically important arthropods, mosquitoes rank first in the spread of such diseases as yellow fever, encephalitis, dengue fever, malaria, filariasis as well as other viral and bacterial diseases (Chandler and Read, 1961; Gillet, 1972; Gordon and Lavoipiere, 1979; Service, 1980). Jos Museum and Zoo Complex (JMZ) with a simulated natural ecological setting for the animals is one of the major tourist attractions in the town and therefore provides good site for the study of the ecology and distribution of insect disease vector species.

The study of species diversity in an ecological community takes account of the total number of species encountered in the sample, expressed as richness, and how the species abundances are distributed among the species, expressed as evenness (Fisher *et al*., 1943). Another measure, Shannon-Wiener Index of Diversity, which combines species richness and evenness as a single value is expressed as $H = (N \log N - \sum fi \log fi)/N$, where $fi$ is the abundance and $N$ the total number of individuals in the species (Ogbeibu, 2005). A greater number of species, as well as a more even distribution among species will therefore increase species diversity as measured by Shannon-Wiener Index (Lloyd and Ghelardi, 1964). The probability of picking two organisms at random that are different species, known as Simpson's Dominance Index, is expressed as $C = \sum (Pi)^2$ or $\sum (ni/N)^2$, where $ni$ = number of individuals of the $ith$ species, $N$ is the total number of individuals for all species and $Pi$ being the proportional abundance of $ith$ species i.e., $Pi = ni/N$ (Krebs, 1972). Simpson's dominance indices is weighted towards the abundance of the commonest species and gives relatively little weight to the rare species, and ranges in value from 0 (low diversity) to a maximum of $(1–1/S)$, where $S$ is the number of species (Fisher, 1943). The formula $\sum (ni/N)^2$ refers to a finite population where all of the members have been counted. Since ecologists work with infinite populations where it is impossible to count all members, an unbiased estimator of Simpson's Index, which is expressed as $D = \sum ni(ni–1)/N(N-1)$, where $ni$ is the total number of individuals in the $ith$ species, and $N$ is the total number of individuals, has been developed for sampling from infinite natural population (Ogbeibu, 2005).

The major aim of this study was to sample the mosquito species in Jos museum and zoological garden complex (JZC) and determine if there was any significant difference in species diversity and dominance between adult mosquitoes sampled during parts of the dry and rainy seasons of the year. This surveillance involved the collection, analysis, consolidation and evaluation of data, and its prompt dissemination which represented an overall intelligence or disease-accounting system designed to permit disease control authorities to be alerted early to the presence of disease problems and the effects of the disease on the population they serve (WHO, 1975).

## MATERIALS AND METHODS

**Study Area:** The study was carried out in a tropical museum and zoological garden complex located in Jos, Plateau State, Nigeria. Jos is a cosmopolitan town and the capital of Plateau State of Nigeria. It houses many Federal and State Government ministries and parastatals. It is also a University Town. The neighbouring towns of Bukuru, Kuru and Vom have important federal establishments such as the National Institute for Policy and Strategic Studies, Nigerian Veterinary Research Institute, Nigerian Institute for Trypanosomiasis Research, Federal School of Laboratory Technology, National Root Crop Research Institute, Plateau State Polytechnic etc. These towns and this establishment are short distances from Jos metropolis, thus contributing to the teaming population. Jos is situated on a rocky plateau, about 1,300km above sea level with many rocky outcrops and patchy woodland bushes. It has huge mineral deposits, especially tin ore. Thus in addition, Jos attracts many mineral miners, as well as a large population of traders from different parts of Nigeria. Apart from a few hotels, the Museum and Zoological Garden Complex is the major tourist centre in the Jos metropolis. The Museum houses the famous Nok cultural materials as well as those of Gwosh, Nupe, Gwari, Igbo, Yoruba and Hausa tribes of Nigeria. Within the museum section, are decorative aquaria with water fountains and clay pots. Some of these have gone out of use, but still retained water throughout the year, thus providing good breeding places for mosquitoes.

The climate is neither too cold nor too hot, and thus attracts many foreigners from other parts of the world. It has two major seasons, the dry season between November and March, and the rainy season between April and October. The early dry season is characterized by cold harmattan period between November and February. Mean annual rainfall is 140 cm. The mean monthly temperatures vary between 20º C in the month of August and 25º C in the month of April. The relative humidity varies between 40% in January and 80% in July. Jos has a few streams and rivers flowing across the city. In the dry season, some of the streams dry up leaving breeding pools for mosquitoes and other aquatic organisms. Sometimes the rivers and steams flow sluggish and are heavily polluted with human and animals wastes such that snail intermediate hosts of helminths are common phenomena.

The Zoological section is located beyond a primary forest with giant trees that provide shade for the animals. Rock outcrops and forest patches in the Zoo provide the animals with natural ecological settings. Animals in the Zoo included members of the chimpanzee families, wild cats, jackal, drills, monkeys and baboons as well as lions, antelopes and duikers. Others include the rocky pythons, tortoises and turtles, crocodiles, various wild birds including eagles, owls, kites, peacocks and doves. The Zoological garden is traversed by a seasonal river that dries up almost entirely in the dry season, leaving small water pools and puddles for the breeding of mosquitoes. In addition, this river is usually heavily polluted by organic materials of plants, human and animal origin.

**Ethical Considerations:** The study was carried out by the staff of national arbovirus and vectors; research Centre, Enugu, under the auspices of the Federal Ministry of Health as a regular surveillance measure against Arboviruses. Formal letter of intent was written to the Curator of the museum who gave written consent before the work commenced. All the mosquito scouts were employed based on their personal consent. They were given adequate training and necessary health education. Also, each participant was given yellow fever vaccination at least ten days prior his involvement in the study. All health conditions of the mosquito scouts were taken care of by the Federal Government.

**Mosquito Sampling Techniques:** Field trips were made to the Jos Museum and Zoological Garden in the months of March and June 2005. Each trip lasted four days. Adult mosquitoes were collected at the Zoological Garden between 16.30 – 20.30 hours (4.30 – 8.30pm), using Voluntary Human Bait Method. In each occasion, three mosquito scouts were deployed. The scouts sat on low stools positioned at strategic areas such as tree shades, with their hands and legs exposed to mosquito bites, by rolling up the sleeves of their shirts and trousers to their elbows or knees respectively. Thereafter, with the aid of torchlight, mosquitoes alighting to bite on the exposed parts of the body were trapped with vials. Each mosquito was kept separately in a vial carefully stoppered with cotton wool, from where it was transported to Enugu laboratory for sorting and identification. Larvae were collected with ladles from ponds and artificial-water containers, which were mainly concrete troughs, providing water for the animals. No attempt was made to estimate the larval density as this initial effort was primarily to identify the mosquito fauna of the area. Mosquito eggs were collected by using a set of 25 and 26 CDC ovitraps in March and June respectively. The traps were set randomly near animals' shades and collected two days later. The paddles were wrapped in blank white duplicating sheets of paper and sent to the laboratory of the National Arbovirus and Vector's Research Centre, Enugu, for examination. Egg-positive paddles were soaked in water for two days to hatch-out the larvae. The larvae were reared to fourth instar stage or adult for proper identification. The soaked paddles were allowed to dry under room temperature, for about five days before re-soaking to ensure that all viable mosquito eggs hatched-out. Soaking and drying were repeated three times thereafter. All mosquitoes collected were identified by disease vectors taxonomist at the National Arbovirus and Vectors' Research Centre, Enugu, where voucher specimens were preserved.

**Table 1: Species composition of mosquitoes caught with different trapping methods in Jos Museum and Zoo Complex**

| ***Mosquito genera and species*** | **Number sampled with various trapping methods** | | | | |
|---|---|---|---|---|---|
| | **Ovitrap** | **Ladle** | **Human bait** | **Total** | **Percentage** |
| ***Aedes aegypti*** | 304 | 119 | 32 | 455 | 72.6 |
| ***A. africanus*** | - | - | 5 | 5 | 0.8 |
| ***A. vittatus*** | - | - | 1 | 1 | 0.15 |
| ***A. luteocephalus*** | 5 | - | - | 5 | 0.8 |
| ***Culex quinquefasciatus*** | - | 49 | 100 | 149 | 23.8 |
| ***Coquilletidia metallica*** | - | - | 4 | 4 | 0.6 |
| ***Eretmapodites quinquevittatus*** | - | - | 5 | 5 | 0.8 |
| ***E. inornatus*** | - | - | 2 | 2 | 0.3 |
| ***E. Chrysogaster*** | - | - | 1 | 1 | 0.15 |
| **Total** | 309 | 168 | 150 | 627 | 100.0 |

**Table 2: Mosquitoes sampled from eggs using CDC ovitraps in Jos Museum and Zoo Complex**

| **S/No.** | **Number of traps per animal house per time** | **Associated animal housing** | **Mosquitoes sampled** | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | **March** | | **June** | | **Total** | |
| | | | **Species** | **No.** | **Species** | **No.** | **No.** | **%** |
| **1** | 1 | Civet Cat | *A. aegypti* | 2 | *A. aegypti* | 10 | 12 | 3.9 |
| **2** | 1 | Black Kite | *A. aegypti* | 9 | *A. aegypti* | 20 | 29 | 9.4 |
| **3** | 1 | Barn Owls | - | 0 | *A. aegypti* | 50 | 50 | 16.2 |
| **4** | 1 | Serval and Crackal | - | 0 | *A. aegypti* | 60 | 60 | 19.4 |
| **5** | 1 | Peacocks and Duikers | - | 0 | - | 0 | 0 | 0.0 |
| **6** | 1 | Rock python | - | 0 | *A. aegypti* | 14 | 14 | 4.5 |
| **7** | 1 | Mona monkeys | *A. luteocephalus* | 4 | *A. aegypti* | 16 | 20 | 6.5 |
| **8** | 1 | Porcupine | - | 0 | - | 0 | 0 | 0.0 |
| **9** | 1 | Hornbill bird | - | 0 | *A. aegypti* | 6 | 6 | 1.9 |
| **10** | 1 | Black-faced monkeys | - | 0 | *A. aegypti* | 30 | 30 | 9.7 |
| **11** | 1 | Drill | - | 0 | *A. aegypti* | 14 | 14 | 4.5 |
| **12 – 15** | 4 | Lion | - | 0 | *A. aegypti* | 13 | 13 | 4.2 |
| **16** | 1 | Horse | - | 0 | *A. aegypti* | 1 | 1 | 0.3 |
| **17 – 18** | 2 | Chimpanzee | - | 0 | *A. aegypti* | 30 | 30 | 9.7 |
| **19** | 1 | Baboon | - | 0 | - | 0 | 0 | 0.0 |
| **20** | 1 | Mangabey | - | 0 | *A. aegypti* | 6 | 6 | 1.9 |
| **21** | 1 | Crocodile | *A. luteocephalus* | 1 | - | 0 | 1 | 0.3 |
| **22** | 1 | Tortoise *and* Baboon | - | 0 | - | 0 | 0 | 0.0 |
| **23** | 1 | Spotted hyaena | - | 0 | - | 0 | 0 | 0.0 |
| **24** | 1 | Stripped hyaena | - | 0 | *A. aegypti* | 3 | 3 | 1.0 |
| **25** | 1 | Doves | - | 0 | *A. aegypti* | 20 | 20 | 6.5 |
| **26** | 1 | Bateleus | - | 0 | - | 0 | 0 | 0.0 |
| **Total** | | | | 16 | | 293 | 309 | 99.9 |

**Ecological Statistics:** Data on mosquito composition were analyzed quantitatively to determine the total abundance, percentage abundance of each species identified during the study period, as well as determining Shannon-Wiener diversity index (H) and Simpson's dominance index (C) for the area. Shannon-Wiener index (H) was used in calculating *t'* (Ogbeibu, 2005), to test for significant differences in diversity and dominance of mosquito species.

## RESULTS

A total of 627 mosquitoes (Table 1), comprising 9 species from 4 genera; *Aedes, Culex, Coquilletidia and Eretmapodites* were caught during the sampling period. Also, 309 mosquitoes, consisting of 304 *A. aegypti* and 5 *A. luteocephalus* were collected as eggs; 168 mosquitoes, comprising 119 *A. aegypti* and 49 *C. quinquefasciatus* were collected as larvae; whereas 150 mosquitoes made up of 8 species namely: *A. aegypti, A. africanus, A. vittatus, C. quinquefasciatus, C. metallica, E. quinquevittatus, E. inornatus* and *E. chrysogaster* were collected as adults. On the whole, *A. aegypti* had the highest dominances of 455 mosquitoes, representing 72.6% of the total mosquito population. This was followed by *C. quinquefasciatus,* 100 mosquitoes, 23.8% of the total catch, with also the highest catch from human bait collections.

As illustrated in Table 2, CDC ovitraps were set close to animal sheds or cages to trap engorged female mosquitoes seeking oviposition sites after feeding on these animals. Mainly *A. aegypti* was collected from traps associated with reptiles, birds and mammals. This was an indication that *A. aegypti* virtually feeds on all animals. Amongst the sheds housing the rock python (*Python sabae*), crocodiles (*Crocodylus niloticus*) and tortoise (*Geochelone pardalis*), it was only from the tortoise shed that there was no collection. Amongst the aviary housing black kites (*Falco peregrinus*), barn owls (*Tyto alba*), peacocks, hornbills (*Upupa epops*), doves and eagles, only the eagles' aviary did not yield egg-positive paddles.

**Table 3: Mosquitoes sampled from larvae, using ladles in Jos Museum and Zoo Complex**

| Mosquito species | Breeding place | *Number sampled* | | |
|---|---|---|---|---|
| | | March | June | Total |
| ***Aedes aegypti*** | Artificial containers and concrete scoops | 0 | 119 | 119 |
| ***Culex quinquefasciatus*** | Polluted river pools and ponds | 10 | 36 | 49 |
| **Total** | | 10 | 158 | 168 |

**Table 4: Mosquitoes sampled as adults using voluntary human bait method in Jos Museum and Zoo Complex**

| Mosquito species | Number sampled | | | |
|---|---|---|---|---|
| | March | June | Total | Percentage |
| ***Aedes aegypti*** | 0 | 32 | 32 | 21.3 |
| ***A. africanus*** | 1 | 4 | 5 | 3.3 |
| ***A. vittatus*** | 46 | 1 | 1 | 0.7 |
| ***Culex quinquefasciatus*** | 0 | 54 | 100 | 66.7 |
| ***Coquilletidia metallica*** | 0 | 4 | 4 | 2.7 |
| ***Eretmapodites quinquevittatus*** | 0 | 5 | 5 | 3.3 |
| ***E. inornatus*** | 0 | 2 | 2 | 1.3 |
| ***E. chrysogaster*** | 0 | 1 | 1 | 0.7 |
| **Total** | 47 | 103 | 150 | 100.0 |

Among the sheds housing civet cats (*Viverra civetta*), serval (*Leptailurus serval*) and crackal (*Caracal caracal*), mona monkeys, black-faced monkeys (*Cercopothecus ascanius*), lions (*Panthera leo*), horses (*Equus caballus*), chimpanzee (*Pan troglodytes*), baboons (*Papio cynocephalus*), mongabey (*Cercocebus attarimus*), hyaenas (C*rocuta crocuta* and *Hyaena hyaena*) and porcupines, no mosquitoes were trapped near the porcupine and baboon sheds. The groups of animals, servals and crackals, barn owls, chimpanzees and black-faced monkeys appeared to have attracted the mosquitoes most, with 60, 50, 30 and 30 mosquitoes respectively. Doves seemed to attract the *A. aegypti* mosquitoes. Few eggs of *A. luteocephalus* were caught from some animals units.

Eight (32%) of the 25 ovitraps set in March were positive and yielded 16 mosquito larvae. This gave an average of 2 eggs per egg-positive paddle and also represented 5.2% of the total eggs trapped during the study. In June, 18 (69.2%) of the 26 ovitraps set were positive with eggs and yielded 293 larvae, giving an average of 16 eggs per-positive paddle and this represented 94.8% of the total mosquitoes caught as eggs.

From Table 3, a total of 168 mosquito larvae, comprising 49 *C. quinquefasciatus* and 119 *A. aegypti* were collected with ladle. All the *Aedes* larvae were collected in June in artificial containers only, whereas, *Culex* larvae were collected in March and June from polluted river pools and ponds, a fact indicating the affinity of *Culex* to polluted water for oviposition.

A total of 151 adult mosquitoes were collected through human bait method. In the dry period of March, 1 *A. africanus* and 46 *C. quinquefasciatus* were collected giving a total of 47 mosquitoes (Table 4). One hundred and three (103) adult mosquitoes, comprising *C. quinquefasciatus* (54), *A. aegypti* (32), *Eretmapodites* spp. (8), *A. africanus* (4), *C. metallica* (4), and *A. vittatus* (1) were caught in June.

In March and June, 36 man-hours were spent in each occasion for collecting the mosquitoes. This translated to 1.3 and 2.9 mosquitoes per man-hour respectively. For *C. quinquefasciatus* and *A. aegypti* it was 1.6 and 0.9 respectively. Computations for diversity and dominance indices for adult mosquitoes sampled at Jos Zoo Complex are shown in Table 5. Simpson's diversity values of 0.9584 and 0.3773 and Shannon-wiener diversity values of 0.0448 and 0.5499 were recorded for the adult mosquitoes during the months of March in the dry season, and June during the wet season, respectively. A Simpson's and Shannon-Wiener values of 0.4942 and 0.4550 were recorded for the whole adult mosquitoes sampled with human bait method (Table 5). *C. quinquefasciatus* was the most frequent species with diversity values of 0.4444 (Simpson's) and 0.1174 (Shannon-Wiener). This was followed by *A. aegypti* with 0.0455 (Simpson's) and 0.1431 (Shannon-Wiener). Ecological statistics demonstrated a highly significant difference in diversity between samples in March and June ($P<0.001$).

## DISCUSSION

The choice of Jos Museum and Zoological Garden Complex (JMZ) for this study was out of public health curiosity. Apart from the fact that the complex serves as a good holiday resort for visitors, the human and animal populations provided a regular blood-meal source for the mosquitoes. Such constant interaction between animal and human populations on one side and mosquito population on the other had the potential for diseases transmission to visitors and staff of the Zoological Garden and Museum. Also the attempt to fashion the Zoological Garden as close as possible to natural conditions does not only make it ecologically habitable for the animals but also for these disease vector species.

Historically, epidemics of yellow fever had been recorded in 1952 and 1953 in Okwoga district of Jos was postulated to be as a result of northward

**Table 5: Computations for species diversity and dominance indices for adult mosquitoes sampled in March and June in Jos Zoo Complex (JZC) Nigeria**

| Jos Zoo Complex | fi | fi *log* fi | fi log² fi | Pi | (Pi)² *or* (ni/N)² | ni (ni-1)/N (N-1) | Pi log Pi | Pi In Pi | Pi(In Pi)² | ***Shannon-Wiener diversity index*** ***H = (N log N − Σ fi log fi) /N*** ***or* − ( Pi log Pi)** | ***Simpson's dominance index*** ***C = Σ (ni/ N)²*** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **March and June** | | | | | | | | | | | |
| 1 ***Aedes aegypti*** | 32 | 48.1648 | 72.4952 | 0.2133 | 0.0455 | 0.0444 | -0.1431 | -0.3296 | 0.5092 | 0.1431 | 0.0455 |
| 2 ***A. africanus*** | 5 | 3.4948 | 2.4428 | 0.0333 | 0.0011 | 0.0009 | -0.0492 | -0.1133 | 0.3854 | 0.0492 | 0.0011 |
| 3 ***A. vittatus*** | 1 | 0.0000 | 0.0000 | 0.0067 | 0.0001 | 0.0000 | -0.0146 | -0.0335 | 0.1679 | 0.0146 | 0.0001 |
| 4 ***Culex quinquefasciatus*** | 100 | 200.00 | 400.00 | 0.6667 | 0.4444 | 0.4429 | -0.1174 | -0.2693 | 0.1089 | 0.1174 | 0.4444 |
| 5 ***Coquilletidia metallica*** | 4 | 2.4082 | 1.4499 | 0.0267 | 0.0007 | 0.0005 | -0.0420 | -0.0967 | 0.3505 | 0.0420 | 0.0007 |
| 6 ***E. quinquevittatus*** | 5 | 3.4948 | 2.4428 | 0.0333 | 0.0011 | 0.0009 | -0.0492 | -0.1133 | 0.3854 | 0.0492 | 0.0011 |
| 7 ***E. inornatus*** | 2 | 0.6021 | 0.1812 | 0.0133 | 0.0002 | 0.0001 | -0.0249 | -0.0575 | 0.2482 | 0.0249 | 0.0002 |
| 8 ***E. chrysogaster*** | 1 | 0.0000 | 0.0000 | 0.0067 | 0.0011 | 0.0000 | -0.0146 | -0.0335 | 0.1679 | 0.0146 | 0.0011 |
| **Σ** | 150 | 258.1647 | 479.0119 | 1.0000 | 0.4942 | 0.4897 | -0.4550 | -1.0467 | 2.3234 | 0.4550 | 0.4942 |
| **March** | | | | | | | | | | | |
| 1 ***A. africanus*** | 1 | 0.0000 | 0.0000 | 0.0213 | 0.0005 | 0.0000 | - 0.0356 | -0.0819 | 0.3155 | 0.0356 | 0.0005 |
| 2 ***A. vittatus*** | 46 | 76.4868 | 127.1791 | 0.9787 | 0.9579 | 0.9574 | -0.0092 | -0.0211 | 0.0005 | 0.0092 | 0.9579 |
| **Σ** | 47 | 76.4868 | 127.1791 | 1.0000 | 0.9584 | 0.9574 | -0.0448 | -0.103 | 0.316 | 0.0448 | 0.9584 |
| **June** | | | | | | | | | | | |
| 1 ***Aedes aegypti*** | 32 | 48.1648 | 72.4952 | 0.3110 | 0.0965 | 0.0944 | -0.1577 | -0.3632 | 0.4245 | 0.1577 | 0.0965 |
| 2 ***A. africanus*** | 4 | 2.4082 | 1.4499 | 0.0390 | 0.0015 | 0.0012 | -0.0547 | -0.1261 | 0.4096 | 0.0547 | 0.0015 |
| 3 ***A. vittatus*** | 1 | 0.0000 | 0.0000 | 0.0100 | 0.0001 | 0.0000 | -0.0195 | -0.0450 | 0.2084 | 0.0195 | 0.0001 |
| 4 ***Culex quinquefasciatus*** | 54 | 93.5493 | 162.0642 | 0.5240 | 0.2749 | 0.2624 | -0.1470 | -0.3385 | 0.2186 | 0.1470 | 0.2749 |
| 5 ***Coquilletidia metallica*** | 4 | 2.4082 | 1.4499 | 0.0380 | 0.0015 | 0.0012 | -0.0546 | -0.1254 | 0.4084 | 0.0546 | 0.0015 |
| 6 ***E. quinquevittatus*** | 5 | 3.4948 | 2.4428 | 0.0490 | 0.0024 | 0.0020 | -0.0637 | -0.1468 | 0.4442 | 0.0637 | 0.0024 |
| 7 ***E. inornatus*** | 2 | 0.6020 | 0.1812 | 0.0190 | 0.0003 | 0.0002 | -0.0332 | -0.0765 | 0.3015 | 0.0332 | 0.0003 |
| 8 ***E. chrysogaster*** | 1 | 0.0000 | 0.0000 | 0.0100 | 0.0001 | 0.0000 | -0.0195 | -0.0450 | 0.2084 | 0.0195 | 0.0001 |
| **Σ** | 103 | 150.6273 | 240.0832 | 1.0000 | 0.3773 | 0.3614 | -0.5499 | -1.2665 | 2.6236 | 0.5499 | 0.3773 |

**Key:** *fi = Abundance of species, N = total number of individuals, Pi = Proportion of individuals found in the ith species, In = the Natural (Naperian) logarithms ($log_e$), $(ni/N)^2 = (Pi)^2$*

transmission of yellow fever virus from the epidemic foci in Eastern Nigeria (Monath, 1972). The yellow fever virus exists normally in animal reservoir (monkey), in which it is maintained by several forest mosquitoes, with man acquiring the infection by frequenting forests or their neighbourhood where he becomes exposed to the bites of infected wild mosquitoes. An infected person subsequently returns to the village where the virus is transmitted to non-infected persons by domesticated species of mosquitoes.

Of the nine mosquito species collected, four were *Aedes*, three were *Eretmapodites* species, while one species each of *Culex* and *Coquilletidia* were recorded. Only *Aedes* and *Culex* were caught in the March and June surveys respectively. With the exception of *A. luteocephalus* captured as eggs only, the others were caught in adult forms by human bait method. This indicated that the mosquitoes fed on man were attracted to man. Human bait collections have been reported to be the most reliable method of detecting and monitoring the anthropophilic mosquito species (Service, 1977).

The hours of collection, 4.30 – 8.30pm is also the period of the crepuscular activities of these mosquitoes and corresponds to the peak visiting hours to the JMZ, especially between 4.00 – 6.00pm. This means that during any epidemic, considerable population of holiday makers could be bitten by infected mosquitoes and infected persons will subsequently transport the infections to their cities and villages, where others would be affected.

Of all the mosquitoes collected, the presence of *A. aegypti, A. africanus, A. vittatus, C. quinquefasciatus, E. chrysogaster* were of apparent health danger. In Nigeria, *Coquilletidia* and *Eretmapodites* species have not been known to be involved in disease transmission, although *Eretmapodites chrysogaster* and *Coquilletidia metallica* are known to be capable of transmitting yellow fever and West Nile fever viruses respectively (Gillet, 1972; Service, 1980). Although this situation has not been reported in Nigeria, close watch is required on any mosquito that feeds on or is attracted to man. *Aedes* subgroup, especially *A. aegypti, A. africanus, A. vittatus* and *A. luteocephalus* have since been known to feed on man and other animals and are involved in the transmission of many viral infections, especially *A. aegypti* which is the principal vector of viral infections such as dengue fever virus, encephalitis virus, haemorrhagic fever virus, chikungunya, Rift Valley and Uganda S. viruses (Gillet, 1972; Service, 1980). The capacity of *A. aegypti* to do this depends on its ability to feed on virtually every moving animal (Snow and Boreham, 1978). This might explain why the eggs were collected virtually from all animal sheds. *A. vittatus* and *A. africanus* are equally important vectors of yellow fever and other viral diseases. In 1941, in the Sudan, where a serious outbreak of yellow fever occurred, it was shown that *A. vittatus* was the important vector. *A. vittatus* is a rock-pool breeder and is well known to be involved in peri-urban transmission of yellow fever in Nigeria. Service (1974), in a survey of yellow fever vectors in North-West Nigeria showed that only *A. aegypti* and *A. vittatus* were the dominant vectors.

In East Africa, sylvan yellow fever virus was passed from monkey to monkey by *A. africanus* (Gillet, 1972). This species is a forest mosquito which breeds in tree holes often at high levels. The females become active soon after sunset and feed throughout the night on monkey living in the higher foliage of the forest (Gordon and Lavoipierre, 1979). These forest monkeys come to the ground to raid plantations, such as banana plantations situated on the forest fringes or clearings in the forest, in these circumstances the monkeys are exposed to day-biting mosquitoes, *A. simpsoni,* which breeds chiefly in leaf-axils of the banana plants.

In Nigeria, it was reported that the role of *A. simpsoni* was probably continued by *A. africanus* and *A. aegypti* which are found in large numbers in rural dwellings and forest fringes (AVRU 1979a; 1979b). The *A. simpsoni* found in Nigeria seems to be non-man biting variants – *A. lilii* and *A. bromeliae* (Huang and Ward, 1981). With the Zoological Garden sheltered by the primary forest trees, the monkey populations, the abounding vector population supported by the favourable ecological conditions and the ever-increasing population of visitors, is a pointer to the immediate need for constant surveillance and control of mosquitoes to make the complex safe for tourists and staff.

*Culex quinquefasciatus* also caught in the Museum Complex is a cosmopolitan mosquito. *Culex quinquefasciatus* is night-biting and serves as the most important vector of the nocturnally periodic form of the filarial worm, *Wuchereria bancrofti,* heavy infection of which leads to elephantiasis (Chandler and Read, 1961; Gillet, 1972; Gordon and Lavoipierre, 1979). Besides the capacity of mosquitoes as vectors of public health diseases, they constitute serious nuisance by their frequent and menacing bites. All-day biting mosquitoes with crepuscular peaks as *Aedes* group under heavy infestation may scare away some tourists within the Zoo - Museum Complex, whereas night-biting species including the *Culex* group will certainly affect the performance of the zoo staff on night-duties. This may result in loss of many man-hours spent in seeking medical treatment. Mosquitoes affect also the productively of the zoo animals, not only by possible transmission of some bacterial and viral diseases to them (Andrews and Pereira, 1976), but also by their bites and sucking of blood from them. This may lead to aneamia, restlessness and loss of condition amongst these animals thereby directly or indirectly affecting their general well-being and productivity.

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