# Implication of population density on biodiversity of Human-Commensal Drosophila Species in Nigeria

**R Abdulazeez** ( rashidat.int@gmail.com )
Ahmadu Bello University Zaria

**M. O. Akhadelor**
AFAKA

**Monsurat T. Gbadamosi**
International Centre for Genetic Engineering and Biotechnology, ICGEB

**A.O Iyeola-Tunji**
National Agricultural Extension Research and Laison Services, Ahmadu Bello University Zaria

**D. M Shehu**
Ahmadu Bello University Zaria

**I.S Ndams**
Ahmadu Bello University Zaria

---

**Research Article**

**Keywords:** Fruit flies, Vegetation zones, Relative abundance, Simpson Index, Sophophora

**Posted Date:** April 12th, 2022

**DOI:** https://doi.org/10.21203/rs.3.rs-1534375/v1



---

# Abstract

Environmental conditions and anthropogenic activities at various temporal and spatial scales tend to shape the patterns of biodiversity. The family Drosophilidae serves as good bio indicator model in understanding ecological indices and species diversity interactions. The potential of Drosophila to serve as an environmental indicator lies on the cosmopolitan nature of this group and the sensitivity of the flies to environmental variables. This study analyzed the biodiversity of human-commensal Drosophila inhabiting vegetable markets located within the salt water mangrove (SWM), fresh water mangrove (FWM), rain forest (RF) and Southern Guinea Savanna (SGS) vegetation regions of Nigeria. Collections were made from sixteen (l6) vegetable markets using fermented banana as bait. A total of 1,077 fruit flies, composed of four different species of Drosophila belonging to the subgenera Sophophora, Zaprionus and an unidentified species were collected. *Drosophila melanogaster* of the subgenus Sophophora was predominant (82.5%) in all the sampled vegetation zones while the unidentified fruit fly species was the least (0.7%). The Simpson Diversity Index was lowest (0.13) for Southern Guinea Savanna indicating a higher diversity of fruit flies in the zone. The ecological index of temperature was significantly negatively correlated (-0.965) with Drosophila species diversity while human population was significantly positively correlated (0.832) with biodiversity. The results suggest *D. melanogaster* as the predominant human-commensal species irrespective of environmental factors and significant impacts of temperature and human population on the biodiversity of human-commensal Drosophila in Nigeria.


# Introduction

The family Drosophilidae has about 4,000 species with a species-rich genus; Drosophila (commonly referred to as fruit flies or vinegar flies) having over 1,600 described species (O'Grady & DeSalle, 2018). Drosophila are good models in answering several biological questions in the fields of evolution, ecology, population biology, genetics, due to their high sensitivity to slight environmental changes, significant roles on nutrient recycling in the ecosystem, cosmopolitan distribution, easy handling, small size, short generation time, high fecundity, clear morphology and small number of chromosomes which was fully sequenced in year 2000 (Adams et al., 2000; Guruprasad & Padmaja, 2016). The family displays several feeding habits and lifestyle such as free living, pest, parasitism and predation, which have evolved via adaptations to ecological and environmental drivers (Máca & Otranto, 2014). For instance, *Drosophila suzukii*, an invasive species, is a global economic pest of small fruits and cherries, which can cause significant economic damage while *D. melanogaster, D. simulans, D. yakuba*, although considered as nuisance are free living (Lee et al., 2019). Some species of *Drosophila* are in a commensal relationship with humans, which is seen as a preadaptation to limit competition in food resources and to favor their spread worldwide via fruit transportation (David, 1979). Studying the ecology of Drosophila species along with its population structure is said to provide valuable information on the evolutionary process of the species (Bizzo and Sene, 1982; Srinath and Shivanna, 2014).

Variations in biodiversity of Drosophila in relation to several environmental factors in different parts of the world especially India have been studied (Fohseca de Medieros and Klaczko (2004); Mateus et al.,

(2006); Guruprasad et al. (2010); Shrinath and Shivanna (2014); Koushik and Khrisna (2013); Rhode et a. (2014); Pavkovic-Lucic and Kekic (2014). However, there is dearth of documented records on the biodiversity of the Drosophilidae family in Nigeria. The country located within the Sub-Saharan Africa and is a considered to have two biomes: the tropical and subtropical savannah grassland and tropical moist forest biomes characterized with low temperature variation and very high species diversity (Wilson and Primack, 2019). The country is also known for its high human population density and a major importer and exporter of fruits in Africa. This study therefore provided the first report on the species composition and diversity of human commensal Drosophilid species in relation to vegetation types and human population in Nigeria.

# Materials And Methods

The assessment of species abundance and biodiversity was carried out in four vegetation zones of Nigeria (Fig. 1). The mangrove swamp is characterized by hot and wet climates throughout the year, with a total annual rainfall of above 2500mm and an average annual temperature of about 26°C. Its vegetation is a hydromorphic forest type characterized by an entangled dense growth of stems and aerial roots behind the stretch of coconut palms overlooking the Atlantic Ocean. The most prominent plant species is the *Rhizophora.* Human population inhabiting the urban settlement of this zone according to the 2018 population census is about 858,400 (FME, 2019). The second vegetation zone, which is the fresh water swamp, occur further inland beyond the reach of tidal waters. The area is colonized by bush thickets and by tall grasses in the cultivated areas and mean annual temperature of 26 ˚C. The human population is about 3,504,616. The most common species of this vegetation type is the raffia palm which dominates the swamps (FME, 2019). The climate of the rain forest, a vegetation zone which comes after the fresh water swamp, is also hot and wet throughout the year, with a mean annual rainfall of about 2000mm and mean annual temperature of 27 ˚C. The rain forest is dense and made of up of many broad-leaved trees that are mostly evergreen and stratified into three layers based on the heights and nature of the trees. The most common species of this vegetation are the Mahogany and Iroko. This vegetation zones inhabits a higher human population (5,011,000) compared to the other zones. The last of the sampled zone is the Southern Guinea Savanna with total annual rainfall of about 1140–1520mm. It has hot and wet seasons with an average annual temperature of 33 ˚C, which alternates with dry, cool season and an average annual temperature of around 21 ˚C. The vegetation is characterized by trees with short, large and broad leaves and tall grasses of about 3m high. The estimated human population of this zone is about 1,642,000. The false balsam Copaiba, *Terminalia glaucescens*, *Afzelia africana* are the common species found in the Southern Guinea Savanna (FME, 2019).

Fruit flies were collected using the standard banana bait in four vegetable markets located in each vegetation zone. Due to the insecurity issues in Nigeria, and people's reaction towards sample collection from and around them, baits were set for only two hours in the markets. The collections were done in the mornings of every other day from 22nd September to 19th October, 2018. Captured fruit flies were preserved in 70% ethanol and transported to the laboratory. Taxonomic classification was done using the identification keys by (Markow & O'Grady, 2006) and confirmed from literatures and TaxoDros. The

Simpson, Shannon-wiener and Berger- Parker indices to assess the relative abundance and diversity of Drosophila species were estimated using PAST Version 2.80 (Guruprasad & Padmaja, 2016; Mateus, Buschini, & Sene, 2006; Raj amd Krishna, 2015).

# Results

The study revealed the pattern of the distribution of different species of Drosophila and their relative abundance in four vegetation zones of Nigeria. The Mangrove swamp had the highest number of caught flies (343) while the least (136) was recorded for Southern Guinea Savanna. A total number of 1,077 fruit flies were caught during this study out of which, 889 (82.5%) *Drosophila melanogaster* and 41 (3.8%) *Drosophila yakuba* belonging to the subgenera Sophophora, 140 (13.0%) *Zaprionus tuberculatus* belonging to the subgenera Zaprionus and 7 (0.7%) unidentified fruit flies were encountered (Fig. 2).

Flies collected from rain forest had the highest Simpson and Shannon-Weiner indices (0.44 and 0.83 respectively) while Southern Guinea savanna had the least (0.13 and 0.31 respectively). The least evenness was recorded in Southern Guinea Savanna (0.3138) while rainforest had the highest evenness (0.8141). Berger Parker index valued highest in Southern Guinea savanna (0.93) and lowest in rain forest (0.72) (Table 1).

Human populations in the zones were positively correlated with number of caught flies (0.072) and species diversity (0.832*****) and negatively correlated with annual temperature (-0.293) as indicated by (Table 2).

Table 1
Diversity Indices of *Drosophila* collected from four vegetation zones of Nigeria

| Diversity Index | Mangrove swamp | Fresh water swamp | Rainforest | Southern Guinea Savanna |
|---|---|---|---|---|
| Simpson Index (D) | 0.2436 | 0.2968 | 0.4385 | 0.1264 |
| Shannon-Weiner Index (H) | 0.4774 | 0.5185 | 0.8141 | 0.3138 |
| Evenness (j) | 0.5373 | 0.5598 | 0.8141 | 0.3138 |
| Berger-Parker Index (1/d) | 0.8630 | 0.8225 | 0.7231 | 0.9338 |

Table 2
Correlation of Human population, temperature and species diversity with caught fruit flies in selected vegetation zones

| | **Human population** | **Annual temperature** | **Species diversity (H)** | **Caught flies** |
|---|---|---|---|---|
| Human population | 1.000 | | | |
| Annual temperature | -0.293 | 1.000 | | |
| Species diversity (H) | **0.832*** | -0.588 | 1.000 | |
| Caught flies | 0.072 | **-0.965*** | 0.356 | 1.000 |
| * = Correlation is significant at the 0.05 level | | | | |

# Discussion

Irrespective of the vegetation type, *D. melanogaster* was the most dominant. *D. melanogaster* is known to be primarily found in environments disturbed by man, in open areas, or in degraded and urbanized environments, which are characterized by a pronounced degree of environmental stress (Acurio, Rafael, & Dangles, 2010; Da Mata, McGeoch, & Tidon, 2008; Penariol & Madi-Ravazzi, 2013). This could be the reason why this species was observed to be the most dominant of the species collected. This finding is similar to that of (Guruprasad & Padmaja, 2016) who also reported the predominance of the Sophophora subgenus from different altitudes of Chamundi Hill, India and the report of (Mahato & Gupta, 2018) who recorded a high percentage of *Drosophila melanogaster* of the subgenus Sophophora and *Zaprionus indianus* of the subgenus Zaprionus at Hazaribag, India. The unknown species in this study could be a native species, which was not captured in the taxonomic keys that were used.

It was also observed that the total number of individuals collected decreased with across the vegetation type Northwards. The decrease in number collected could be as a result of the decrease in vegetation cover, which is a reflection of rain fall, temperature and anthropogenic activities. The decrease could also be as a result of recorded increase in temperature and decrease in relative humidity as one moves up North despite same time and hours of sampling. This finding further proves that temperature and amount of rainfall affects the survival and population growth of *Drosophila* species (Torres & Madi-Ravazzi, 2006) and vegetation cover also plays an important role in density of Drosophila (Raj & Krishna, 2015).

The value of Simpson diversity index (D), which measures the probability of two randomly selected individuals from a sample might belong to the same species; Shannon-Wiener index (H), which measures the value of species as a function of their frequency in the community; species Evenness (j), which mathematically quantifies how equal the community is; Berger-Parker index (1/d), which shows the relative abundance were calculated. Lower values of the Simpson index indicate higher diversity, and value of 1 indicates no diversity while for Shannon Wiener index, Evenness and Berger Parker index,

higher values indicate higher frequency, evenness and relative abundance respectively. The lower value of Simpson index observed in Southern Guinea savanna indicates that this vegetation zone is more diverse in Drosophila species composition, which could be due to the higher the diversity of flowering plant composition in this zone. This finding is similar to the report of Raj and Krishna (2015), who reported a higher diversity of *Drosophila* species along the lake region of the Karapuzha dam, India. The authors attributed it to the rich vegetation diversity near the lake.

The populations of humans inhabiting the zones had relationships with the number of caught flies, species diversity and annual temperature. The significant positive correlation between the human population and species diversity indicated that higher the higher the number of humans inhabiting an area, the higher will be the diversity of human commensal fruit flies in that area. Annual temperature however, had a negative relationship with all other parameter. This suggests that the higher the temperature, the lower the number of humans capable of inhabiting that area, the lower the number of fruit flies and the lower the species diversity. This goes further to prove the significant effect of temperature in the biology of the commensal fruit flies.

# Conclusion

The importance of the Drosophilidae family and the need for a more comprehensive and systematic investigations into the diversity of the fruit flies in Nigeria cannot be overemphasized. The selected ecological zones favored populations of *D. melanogaster* with Southern Guinea savanna having more species diversity compared to other zones. There are ample scopes for further biodiversity investigations and taxonomic classification of the species of fruit flies in Nigeria.

# Declarations


### Acknowledgements

We appreciate the efforts of Mr. N. Aliyu, Department of Computer Science, Ahmadu Bello University Zaria, for assisting in sampling and analysis of the data. We are grateful to Mr. S. Muhammad, Department of Zoology, A.B.U. Zaria for assisting in the sexing and counting of the fruit flies. We are thankful to Dr. D. Obbard, University of Edinburgh and Dr. Y.D. Momodu, University of Calgary, for their comments on the manuscript.


### Authors Contributions

RA, AOI, DMS and ISN conceived and designed the experiment. RA and M.O.A conducted field work and positioning. RA and MG interpreted the data and wrote the manuscript; other authors provided editorial advice.


### Funding

No funding was received for conducting this research

### Conflict of Interest

The authors declare no conflict of interest

# References


1. Acurio A, Rafael V, Dangles O (2010) Biological invasions in the Amazonian tropical rain forest: the case of Drosophilidae (Insecta, Diptera) in Ecuador, South America. Biotropica 42(6):717–723
2. Adams MD, Celniker SE, Holt RA, Evans CA, Gocayne JD, Amanatides PG, Venter C, J (2000) The genome sequence of Drosophila melanogaster. Science 287(5461):2185–2195. https://doi.org/10.1126/science.287.5461.2185
3. Da Mata RA, McGeoch M, Tidon R (2008) Drosophilid assemblages as a bioindicator system of human disturbance in the Brazilian Savanna. Biodivers Conserv 17(12):2899–2916. https://doi.org/10.1007/s10531-008-9403-7
4. David JR (1979) Attractive behavior toward human constructions helps to explain the domestic and cosmopolitan status of some Drosophilids. Experientia 35(11):1436–1438
5. Guruprasad BR, Padmaja C (2016) Drosophila–A model organism for assessment of biodiversity. J Entomol Zool Stud 4:88–90
6. Lee JC, Wang X, Daane KM, Hoelmer KA, Isaacs R, Sial AA, Walton VM (2019) Biological control of spotted-wing drosophila (Diptera: Drosophilidae)—current and pending tactics. J Integr Pest Manage 10(1):13
7. Máca J, Otranto D (2014) Drosophilidae feeding on animals and the inherent mystery of their parasitism. Parasites & Vectors 7(1):1–8
8. Mahato SP, Gupta KK (2018) *Species diversity status of family Drosophilidae at Hazaribag, Jharkhand, India*
9. Markow TA, O'Grady PM (2006) Phylogenetic relationships of Drosophilidae. Markow, TA, O'Grady, PM Drosophila: A Guide to Species Identification and Use. Academic Press, London, pp 3–64
10. Mateus RP, Buschini MLT, Sene FM (2006) The Drosophila community in xerophytic vegetations of the upper Parana-Paraguay river basin. Brazilian J Biology 66(2B):719–729
11. O'Grady PM, DeSalle R (2018) Phylogeny of the genus Drosophila. Genetics 209(1):1–25
12. Penariol LV, Madi-Ravazzi L (2013) Edge-interior differences in the species richness and abundance of drosophilids in a semideciduous forest fragment. SpringerPlus 2(1):1–7. https://doi.org/10.1186/2193-1801-2-114
13. Torres FR, Madi-Ravazzi L (2006) Seasonal variation in natural populations of Drosophila spp. (Diptera) in two woodlands in the State of São Paulo, Brazil. Iheringia Série Zoologia 96(4):437–444


# Figures

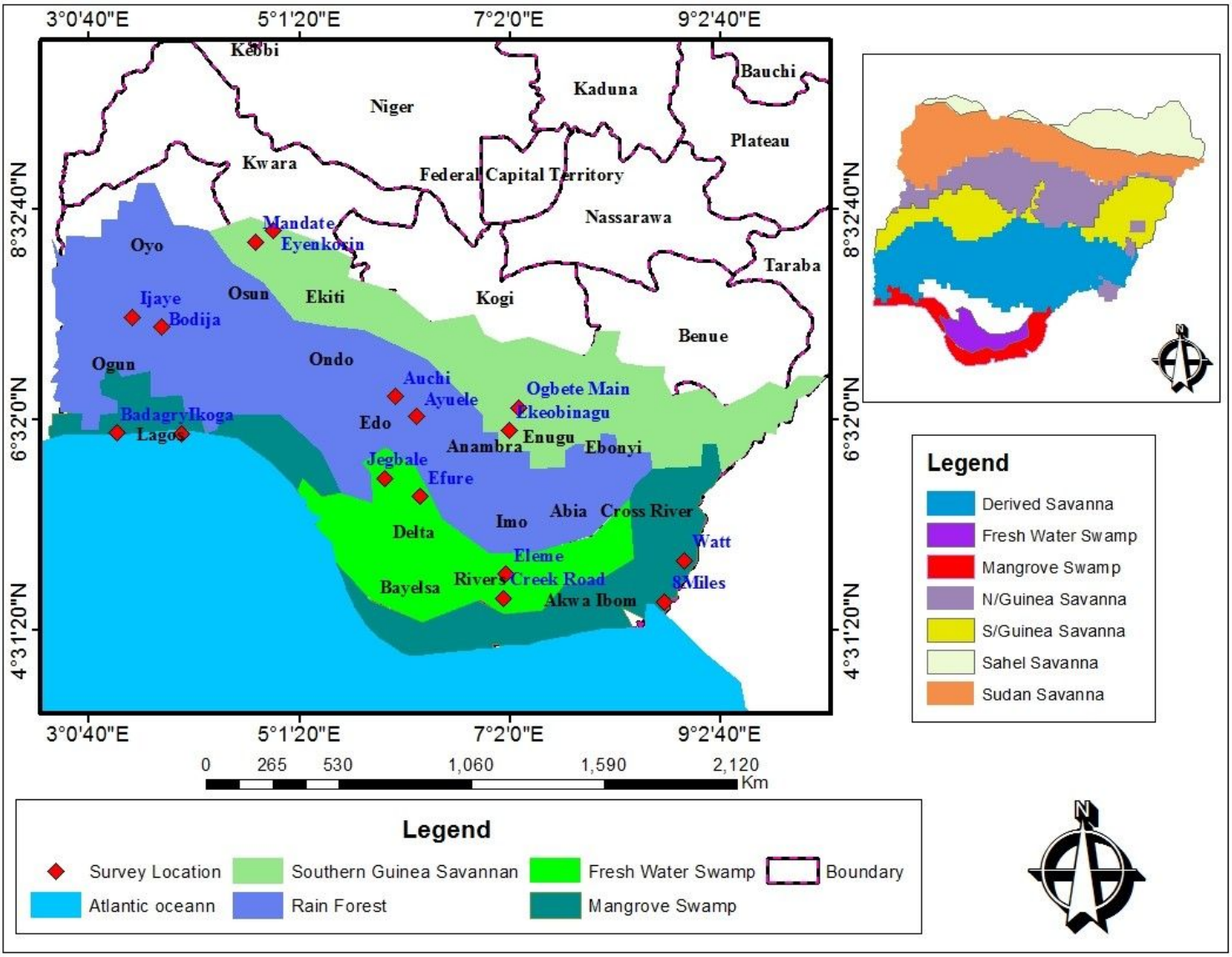


Figure 1

Map of study area

Source: Modified from Administrative map of Nigeria 2019

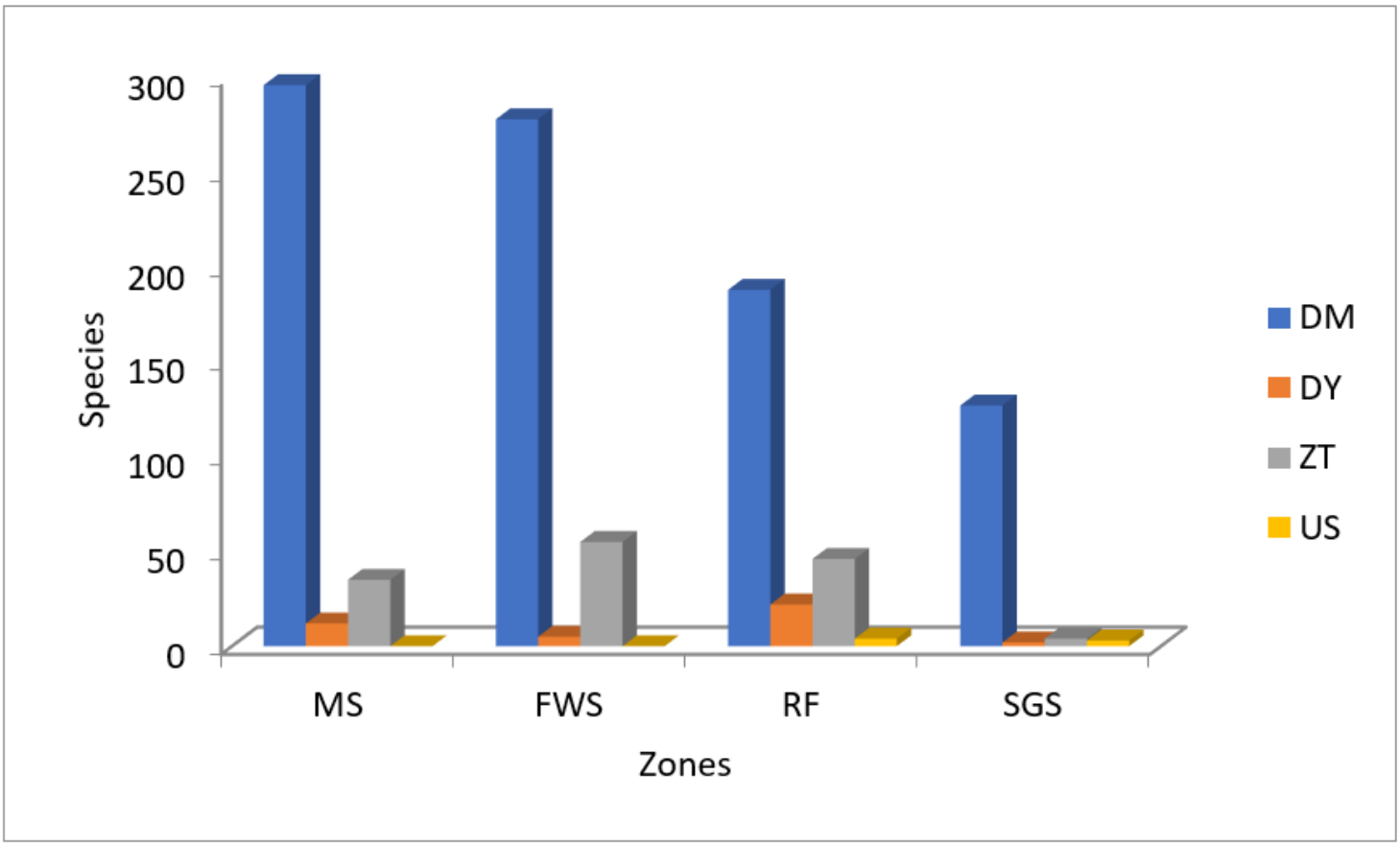


**Figure 2**

**Number of *Drosophila* species collected from four vegetation zones of Nigeria**. MS: Mangrove swamp; FWS: Fresh water swamp; RF: Rain forest; SGS: Southern Guinea savanna; DM: *Drosophila melanogaster*, DY: *Drosophila yakuba*; ZT: *Zaprionus tuberculatus*; US: Unidentified species