Environtropica, December 2023, Vol. 18, 055 - 065 ISSN 1597-815X

A Survey of Odonata Fauna of Obafemi Awolowo University Along Sites of Varying Degrees of Human Impacts

✉**AMUSAN Babatunde Omokunle[1] ADELEKE Sikiru Oladimeji[2] and ABUBAKAR Abubakar Muhammad[2]**

[1]Department of Zoology, Obafemi Awolowo University, Ile-Ife, Nigeria.

[2]Department of Biology, Adeyemi Federal University of Education, Ondo, Nigeria

✉Corresponding author's email: tundeamusan5@yahoo.com. Tel: +234(0)803 392 3439

Accepted on December 15, 2023

Abstract

Odonata are good indicators of habitat quality as the highest abundance and diversity are found in habitats with environmental heterogeneity. Odonate fauna was studied in five sites on Obafemi Awolowo University, Ile-Ife with the aim of determining the species composition and diversity of the Odonates. Odonata specimens were collected fortnightly from January to August, 2023 with the aid of aerial nets. A total of 238 individuals of Odonates representing 31 species distributed in 6 families were recorded in this study. Libellulidae was the most abundant and diverse family as it accounted for the highest number of species and 63% of the entire collection. *Palpopleura lucia* was the most abundant species and it was recorded in all the sampled sites. The highest abundance of Odonate specimens was recorded in Parks and Garden, a site with heterogeneous microhabitats. Odonata collection in this study was dominated by generalists and pollution tolerant species. This suggests a considerable level of habitat fragmentation brought about by uncontrolled anthropogenic disturbances within the University. It is therefore important that management and conservative practices are put in place to mitigate further degradation of the environment.

Key words: Odonata, fauna, diversity, distribution, species richness.

Introduction

The Order Odonata is composed of insects popularly known as dragonflies and damselflies. Approximately 6,370 species belonging to three sub-orders; Anisoptera, Anisozygoptera and Zygoptera have been described so far, with representatives in tropical, sub-tropical and temperate regions of the world (Paulson *et al*., 2022). Insects in this group have been identified as ecologically important as they occupy both land and water which makes them better suited for use in the assessment of short and long term changes in the environment (Cerini *et al*., 2021). Their importance in biomonitoring also stem from their wide range of sensitivity to environmental degradation. Some species have the ability to tolerate a broad range of conditions in their environment while others are highly sensitive to changes in environmental quality (Adu *et al*., 2022). Odonata are known to be specifically sensitive to structural habitat quality as stages of development occupy two different habitats during their life cycle. Adults reside in the terrestrial environment while the immature ones are predominantly aquatic.

The highest abundance of species are usually found in environments that offer a wide range of micro-habitats, hence species richness and diversity of this group of insects have been widely used in biomonitoring of environmental quality. Odonata species are widespread and also represent one of the historically most studied groups of insect. As such, there is a good knowledge of the ecological requirements of a large number of species, their distribution and seasonality (Seidu *et al*., 2018). Another reason for their wide use as bioindicator of environmental quality is because they are easy to study and their occurrence and abundance are highly dependent on the ecological status of the environment (Clausnitzer *et al*., 2012). Odonates generally love to roost in the sun especially around hydro-ecosystems. Some species spend the largest part of their time in open spaces and such species are known to have broad niches (Dijkstra, 2007). They also have high propensity to survive in partially degraded habitats and are capable of rapidly colonizing new or restored habitats. However, some species spend just brief moments in open places while larger parts of their time are spent in shaded places. Such species have narrow niches and they are endangered as a result of unregulated anthropogenic activities (Vincy *et al*., 2016). As such, the absence of these species in forested areas within their expected biogeographical region could be an indication that anthropogenic activities within the areas are too harsh for them to tolerate.

Dispersal capabilities of Odonata species correspond to their respective ecological requirements. Stenotopic species are known to be poorly dispersed while the ubiquitous species have the ability to pioneer temporary habitats. Ubiquitous species thrive well in disturbed habitats or temporary wetlands while pristine streams, seepage and swamp forest harbour variety of more vulnerable but often localized species (Kalkman *et al*., 2020). Environmental factors such as light intensity, temperature, water flow, type of substratum and canopy cover are important factors that determine species assemblage of Odonata. Other equally critical factors include; competition between species, food, zoogeography, vulnerability to drought and flood.

The rapid and continuous rise of human activities on the various ecosystems has brought about the need to assess the diversity and distribution of species. This is necessary to provide basis for planning of conservation protocols for these species (Bastos *et al*., 2019). The lack of information on the faunistic occurrence of important species could be an impediment in the assessment of the conservation status of such species. As such, the importance of such information in the assessment of biodiversity and environmental quality cannot be over emphasized. Therefore, this study aims to present a checklist of species of adults of Odonata present in and around Obafemi Awolowo University campus and to provide information on their distribution and habitat preferences. This information will be useful in determining the appropriate management and conservation practices to be put in place to prevent loss of biodiversity and degradation of the environment (Fattorini *et al*., 2016).

Methodology

Study Area

This study was carried out within Obafemi Awolowo University, Ile-Ife, Nigeria. For the purpose of this study, five (5) sampling sites were selected for the collection of Odonata as shown in Figure 1 and described as follows:

Parks and Garden (P&G)

The vegetation type in this area is the lowland rainforest which is characterized by tall trees with dense canopies**.** There is a mix of ornamental plants, shrubs and grasslands. Natural forest

is notable around a section of the garden. Some notable trees in the garden include *Adonsonia digitata* (Baobab), *Albizia lebbeck* (Siris) and *Cassia fistula* (Cassia). Other notable fruit trees within the garden include Mango and Guava trees. A section of the garden. A stream which flows all year round is also present in this site. The riparian vegetation is dominated by Banana plantations (*Musa* sp). The area covers about 10 ha, while the canopy cover is about 60%. The average elevation for this area is 291m amsl. Parks and Garden lies between N07^{0} 31.477' E004^{0}31.861' – N07^{0}31.234' E004^{0}31.947'.

Zoological Garden (ZG)

The Zoological Garden is located in the tropical rainforest belt of Nigeria. This sampling site comprises matured woodland and wild plants characterized by relatively tall trees with epiphytes, buttress roots and open under-storey. The trees are mixed between the evergreen and deciduous species and notable amongst them are*; Bambusa vulgaris* (Bamboo) *Cassia fistula* (Cassia), *Azadirachta indica* (Neem) and *Elaeis guineensis* (Oil Palm). Access to the main forest is restricted from human interference. However, a large area of this garden is heavily impacted by human activities due to visits by tourists. Canopy cover is about 70%. The area covers about 30 ha. The average elevation for this area is 214m amsl. Zoological Garden covers N07^{0}31.317' E004^{0}31.511' – N07^{0}31.539' E004^{0}31.571'.

Teaching and Research Farm (T&RF)

The vegetation type in this sampling location is heterogeneous as it is a mix between primary and secondary forest. The teaching and research farm is an extensively cultivated expanse of land. The farming practices on the farm include cultivation of food and cash crops as well as animal husbandry with abundance of grassland to support the animals. A section of the natural forest is still intact but a great expanse of the land is being cultivated. Notable trees found in the farm include; *Elaeis guineensis* (Oil palm), *Cocos nucifera* (Coconut) *Adonsonia digitata* (Baobab), *Albizia lebbeck* (Siris). Crops grown in the farm include Maize, Cassava, Yam, Citrus, Cashew and Cocoa. Two large ponds supply water for the needs of the farm. The ponds are also used for fishing and research activities. The farm area measures about 250 ha while canopy cover is about 50%. The average elevation for this area is 298m amsl. Teaching and Research Farm lies between N07^{0}32.304' E004^{0}32.047' – N07^{0}32.996' E004^{0}33.042'.

Religious Ground (RG)

The natural forest in the site has been greatly destroyed due to construction activities. Athough, patches of the natural forest, with less dense vegetation still exist at the edges of the religious ground Secondary re-growth forest and shrubs are commonly found around this area while ornamental plants such as Sunflower (*Helianthus annus*) and Roselle (*Hibiscus Sabdariffa)* are widely grown within close proximity to the buildings. A stream with intermittent flow runs through the forested area of the sampling station. Anthropogenic activities are pronounced around this area due to worship and related activities. The canopy cover is about 60%. The Religious ground sits on a total of about 11 ha. The average elevation for this area is 274 m amsl. Religious Ground lies between N07^{0}30.762' E004^{0}31.362' – N07^{0}30.570' E004^{0}30.870'.

Central Market (CM)

This site used to be a natural forest characterized by tall trees with dense canopies. However, the forest has been destroyed due to construction and commercial activities. A section of the forest in this area is still largely inaccessible and the tall trees can still be found there. The vegetation of this area comprises Evergreen and Decidous trees, Human- planted vegetation such as plantations. This area also shows a wide range of microhabitats comprising of open land, natural forest with wild tall trees, shrubs and plants. Anthropogenic activities in this

location are pronounced due to heavy movement of human and vehicles. The area covers about 37 ha while canopy cover is about 60%. The average elevation for this area is 324 m amsl. Central Market covers N07^{0}31.046' E004^{0}30.881' – N07^{0}31.087' E004^{0}30.671'.

Collection, preservation and identification of adult Odonata specimens

The adult Odonata specimens were collected with the aid of aerial net in sunny days from 8.00 am to 2.00 pm for a period covering January to August, 2023. Each sampling station was visited fortnightly for the collection of Odonata samples. The collected specimens were kept in killing jar containing ethyl acetate soaked cotton swabs. The dead specimens were taken from the killing jar and placed in triangular paper envelope with their folded wings above the body. Information regarding locality, collector's name and date of collection were written on the paper envelope while other information like description of the habitats was noted in the field note. To prevent damage, the collected specimens were kept singly in each envelope. Specimens were properly pinned and the body parts were set appropriately on setting board. Dried specimens were transferred to collection boxes, properly labeled and each specimen was carefully tagged. Naphthalene balls and coopex powder were sprinkled in the insect boxes to protect the insects from being damaged by ants and other insect pests. All the specimens collected were identified to the lowest taxonomic level using standard identification guides and manuals such as; Dijkstra and Clausnitzer (2014) and Dijkstra (2017). The specimens were also cross referenced against web images of Odonata pictures on the African Dragonfly and Damselfly Database (ADDO) and the IUCN red list of Odonata (www.iucnredlist.org).

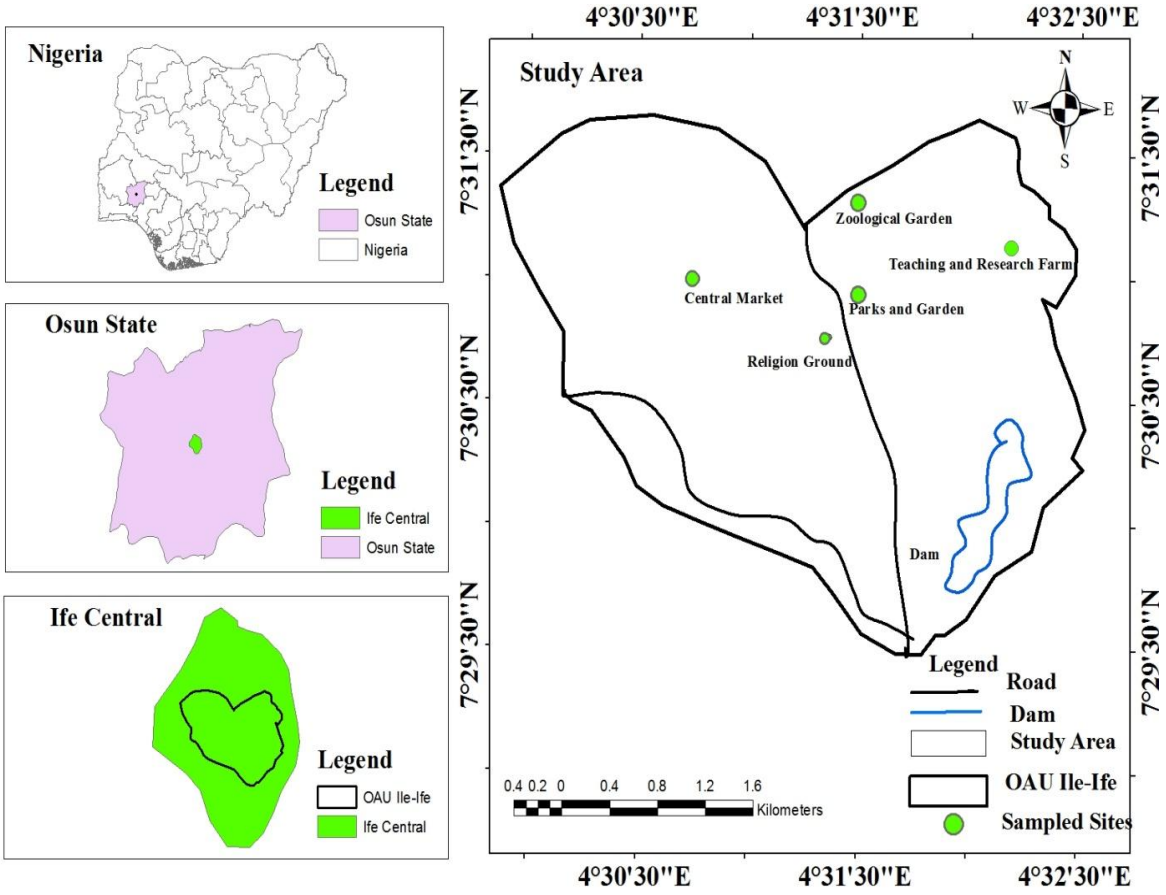

Figure 1. Map showing the location of the sampled sites on Obafemi Awolowo University, Ile-Ife, Nigeria.

Results

Libellulidae was the most abundant and diverse family as it accounted for 14 species which represents 63% of the entire collection. The least represented family is the Protoneuridae which occurred with a single species and only one (1) specimen. Other families; Ceonagrionidae, Chlorocyphidae, Aeshnidae and Gomphidae occurred with 62, 12, 9 and five specimens respectively (Fig. 2). A total of 238 specimens of Odonata distributed in six (6) families (Gomphidae, Ceonagrionidae, Chlorocyphidae, Aeshnidae, Protoneuridae and Libellulidae) and represented by 31 species were recorded in this study (Table 1). The dominant genera include; *Palpopleura, Orthetrum, Chlorocypha and Pseudagrion*. The most abundant species is *Palpopleura lucia* which was represented by 25 specimens and 10% of the entire Odonata collection while the least represented species are *Pseudagrion sjestedti,Chlorocypha glauca, Chlorocypha cancellata, Chlorocypha Platycypha auripes, Elattoneura incerta* and *Sympetrum fronscolombii* which all occurred with one specimen each. Other species that were relatively abundant include; *Trithemis aconita* (21), *Orthetrum cancellumtun (*20*), Orthetrum Julia* (18), *Pseudagrion serrlatum (*15*)* and *Orthetrum africanum (*14*).* The sampling station that accounted for the highest abundance and diversity of Odonates is the Parks and Garden (P&G) while the least collection was recorded in the Central Market (CM). The second highest abundance was recorded in the Zoological Garden (ZG) while Teaching and Research Farm and Religious Ground followed with 42 and 25 specimens respectively (Fig. 3). The diversity indices of Odonata adults collected in this study are indicated in Table 2. Parks & Garden (P&G) had the highest number of species (23) and individuals (88) as well as the highest values for species richness as revealed by Shanon-weiner index (2.421). This site also had the highest value for Evenness (E = 0.7445) and Simpson (1-D = 0.891). Central Market (CM) accounted for the least number of species (13) and individuals (22). Shannon Wiener diversity (2.011) index revealed that the site is the poorest in terms of species diversity. CM also had the least value for Evenness (E = 0.4333) and Simpson (1-D = 0.813).

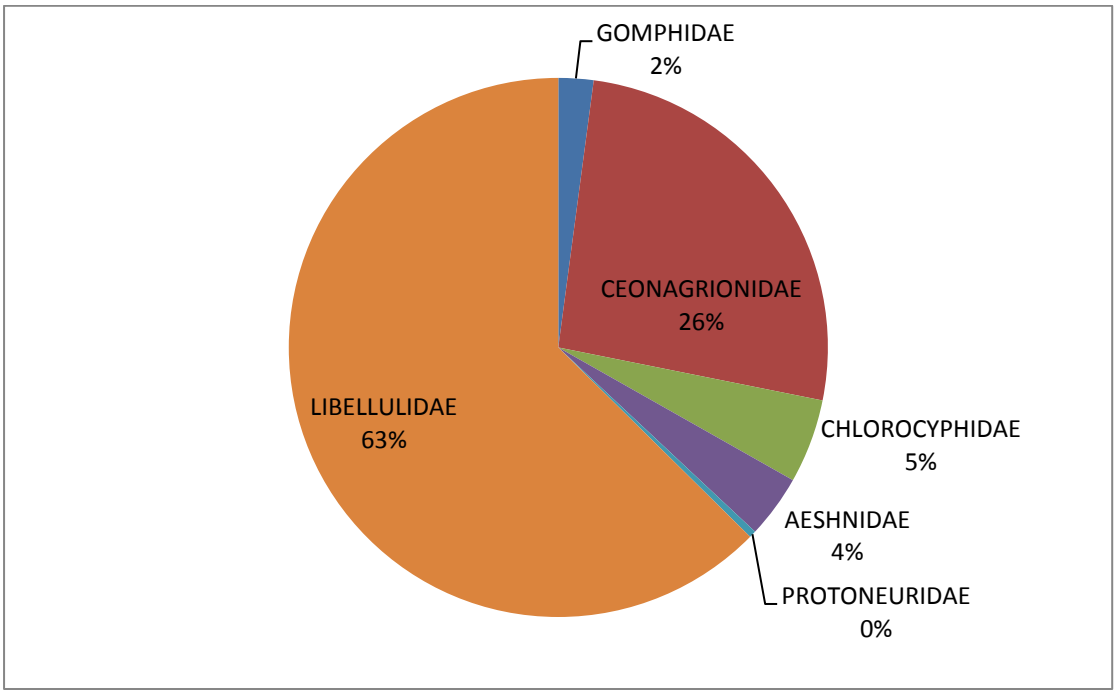

Figure 2. Relative abundance (%) of Odonates (Family) in Obafemi Awolowo University, Ile-Ife, Nigeria

Table 1. Taxonomic composition and distribution of Odonates in Obafemi Awolowo University, Ile-Ife, Nigeria.

SPECIES	FAMILY	ZG	P&G	T&RF	RG	CM	TOTAL
Crenigomphus renei Fraser, 1936	GOMPHIDAE	2	0	0	2	1	5
Ceriagrion suave Ris, 1921	CEONAGRIONIDAE	1	6	1	1	0	9
Ceriagrion glabrum (Burmeister, 1839)		2	4	2	0	0	8
Pseudagrion serrlatum (Gerstacker 1846)		2	4	0	2	0	8
*Pseudagrion kersteni (*Karsch, 1894)		3	5	7	0	0	15
Pseudagrion sjestedti Forster, 1906		0	0	1	0	0	1
Pseudagrion sublacteum (Karsch, 1893)		4	2	4	0	0	10
Ischnura senegalensis (Rambur, 1842)		5	1	2	0	3	11
Chlorocypha cancellata (Selys, 1879)	CHLOROCYPHIDAE	0	1	2	1	0	4
Chlorocypha curta (Hagen in Selys, 1853)		0	1	0	0	2	3
Chlorocypha glauca (Selys, 1879)		0	0	0	1	0	1
Chlorocypha victoriae (Forster, 1914)		0	0	0	2	0	2
Chlorocypha cancellata (Selys, 1879)		1	0	0	0	0	1
Platycypha auripes (Forster, 1906)		0	0	0	1	0	1
Heliaeshna sembe Pinhey, 1962	AESHNIDAE	2	1	1	0	0	4
Gynacantha bispina Karsch, 1891		1	2	1	0	1	5
Elattoneura incerta Pinhey, 1962	PROTONEURIDAE	0	0	0	1	0	1
Brachythemis lacustris (Kirby, 1889)	LIBELLULIDAE	2	2	1	0	0	5
Lokia erythromelas (Ris, 1910)		0	1	0	1	0	2
Crocothemis erythrae (Brulle, 1832)		0	1	0	0	1	2
Hadrothemis infesta (Karsch, 1891)		3	1	0	1	1	6
Orthetrum africanum (Selys, 1887)		3	6	0	3	2	14
Orthetrum cancellumtun (Linnaeus,1758)		3	9	3	1	4	20
Orthetrum Julia Kirby, 1900		3	5	6	2	2	18
Orthetrum monardi Schmidt, 1951		2	7	1	0	0	10
Palpopleura lucia (Drury, 1773)		6	11	4	3	1	25
Palpopleura Portia (Drury, 1773)		3	5	2	1	0	11
Palpopleura albifrons Legrand, 1979		2	3	0	1	2	8
Sympetrum fronscolombii (Selys,1840)		0	0	0	1	0	1
Trithemis aconita Lieftinck, 1969		9	7	4	0	1	21
Trithemis aenea Pinhey, 1961		2	3	0	0	1	6
TOTAL	**6**	**61**	**88**	**42**	**25**	**22**	**238**

ZG- Zoological Garden; P&G – Park & Garden; T&RF – Teaching and Research Farm; RG – Religious Ground; CM – Central Market.

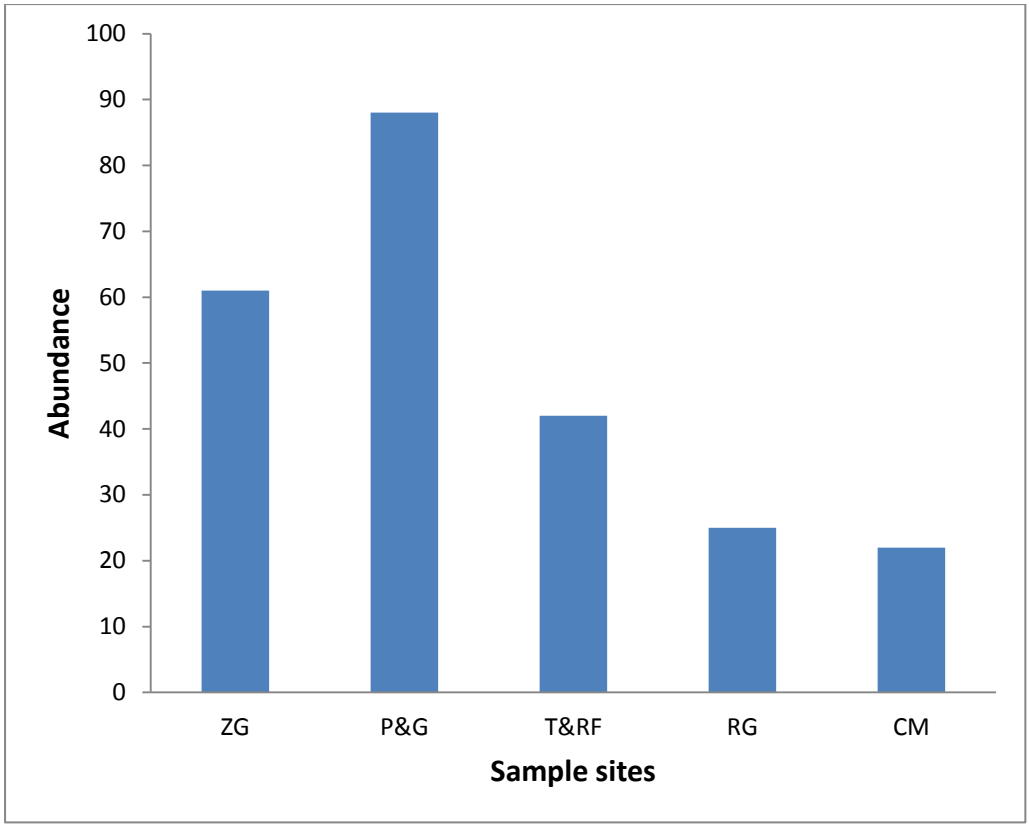

Figure 3. Abundance of Odonates across the sample sites in Obafemi Awolowo University, Ile-Ife, Nigeria.

Table 2: Diversity indices of Odonates collected from Obafemi Awolowo University, Ile-Ife, Nigeria.

Diversity indices	ZG	P&G	T&RF	RG	CM
Taxa	21	23	16	17	13
Individuals	61	88	42	25	22
Simpson (1-D)	0.852	0.891	0.831	0.838	0.813
Shanon (H')	2.312	2.421	2.214	2.225	2.011
Margalef	4.146	4.851	3.173	3.281	2.671
Equitability	0.765	0.753	0.621	0652	0.523
Evenness (E)	0.521	0.745	0.671	0.482	0.412

ZG- Zoological Garden; P&G – Park & Garden; T&RF – Teaching and Research Farm; RG – Religious Ground; CM – Central Market.

Discussion

Most species recorded in this study have been reported in previous studies in tropical freshwater bodies in West Africa (Adu *et al*., 2022). The abundance and diversity of species recorded in this study compares favourably with studies carried out in similar landscapes by

Kemabonta *et al*. (2019) in University of Lagos, Adu *et al*. (2022) in Ipogun and Manu *et al*. (2022) in Owabi Wetland, Ghana. The occurrence of Libellulidae as the most diverse and abundant family in this study is not surprising, as they have been reported to be dominant in several other studies in Africa (Dijkistra and Lempert, 2003; Dijkistra and Clausnitzer, 2005; Adu and Ogbogu, 2013; Manu *et al*., 2022). Libellulidae is reported to be the largest Odonata family and about 1,000 species have been described so far in this family (Dijkstra and Kalkman, 2012). Most members of this family are ubiquitous and pioneers of temporary or degraded environments. Libellulids are also known to be tolerant of disturbed habitats, have preference for open places. These are factors that could have been responsible for the abundance and diversity of Libellulidae in this study.

Coenagrionidae is the next in terms of dominance in this study. This is the second largest family of Odonata and it has closely followed Libellulidae in terms of abundance and diversity in Odonata studies in Africa (Dijkstra *et al*., 2013). Kemabonta *et al*. (2016) had reported Coenagrionids as good indicators of habitat fragmentation because they are known to colonize disturbed habitats. *Pseudagrion*, which is the largest genus in this family with about 100 species accounted for the large number of species collected in this family. *Pseudagrion kersteni* was the most abundant coenagrionid in this study. This particular species has been reported as pollution tolerant species and good colonizers of degraded ecosytems (Clausnitzer, 2003). The abundance of this species in this study is similar to findings of Adu *et al*. (2022) in which *P. kersteni* was equally reported as the most abundant Coenagrionidae in Ipogun (a degraded ecosystem). The other *Pseudagrion* species (*Pseudagrion serrlatum, Pseudagrion sjestedt* and *Pseudagrion sublacetum*) recorded in this study have also been reported to be abundant and widely distributed across West and East Africa (Clausnitzer and Dijkstra, 2005). *Palpopleura lucia* was the most abundant species in this study and it was found to be abundant in parks and garden, a site that has a slow-flowing stream. This observation supports earlier assertion that *P. lucia* has preference for slow-flowing or still water habitats as such microhabitats provide appropriate breeding sites for the Odonates (Boudot *et al*., 2013; Dijkstra and Clausnitzer, 2014). *Palpopluera* sp are known as generalists and they occur in both natural and man-made habitats (Kemanbonta *et al*., 2019). They are mostly predatory species and are also strong fliers; as such they have the ability to travel over a wide range of habitats. So, they can easily be collected in various habitats. *Palpopleura sp* are very common in tropical and temperate regions of the world. The commonness and wide spread distribution of this species is the reason why it is listed as a species of Least Concern in the IUCN Red List of Threatened Species (IUCN, 2020; Seidu, *et al*., 2020).

Crenigomphus renei was the only species recorded in the Family Gomphidae and a total of 5 specimens were collected from Zoological Garden (2), Religious Ground (2) and Central Market (1). This family is known to have preference for tall trees with dense canopy and they are somewhat less tolerant of anthropogenic disturbances. However, the members of this family rarely occur in large numbers as they have been recorded in low numbers in many studies (Acquah-Lamptey *et al*., 2013; Adu *et al*., 2016; Kemabonta *et al*., 2016). Only few tall trees were present in the sites in which they were collected and this may explain their low number recorded in this study. Similarly, Adu *et al*. (2022) recorded only one species of Gomphidae in Ipogun (a degraded ecosystem) and it was attributed to habitat specificity of the species. Protoneuridae is another family represented by only one species (*Elattoneura incerta*). Suprisingly, the only specimen recorded in this family was collected at the Religious Ground. This is because members of Protoneuridae are known to seek out spots in open spaces while *Elattoneura sp* specifically occupy streams, rivers and edges of large lakes (Clausnitzer *et al*., 2017). Species of the Family Aeshnidae are predominantly crepuscular in nature and well

noted to shun the sun during the day but they usually come to light at night. This characteristic has been confirmed in a study in which some species in this Family showed strong association with dense vegetation cover along stream banks. In this study, the insects were seen using the vegetation for perching and roosting during the day. In addition to this, the members of this family are also not known to occur in large numbers (Dijkstra & Clausnitzer, 2013). These may account for the low numbers recorded in this study.

In terms of relative abundance of the Odonata, the highest abundance and diversity of species was obtained in Parks and Garden (P&G) and was closely followed by the Zoological Garden (ZG). These two locations possess environmental heterogeneity and are relatively less impacted by human activities while the Central Market (CM) (in which the least number was recorded) was the location with the highest degree of habitat loss and anthropogenic activities. Habitat loss and fragmentation cause a decline in insect population. Odonata species are especially threatened by the destruction of both aquatic and terrestrial environments (Kalkman, *et al*., 2020). As such, the abundance of Odonates in P&G and ZG further reinforces the belief that native habitats characterized by diverseness of habitats and limited human impacts play important role in the maintenance of insect biodiversity.

Conclusion

The abundance of tolerant and less sensitive species was an indication of considerable level of habitat fragmentation, possibly due to increasing anthropogenic disturbances within the University campus. Diversity and abundance of Odonates was highest at Parks & Garden which was an area characterized by heterogeneous microhabitats and relatively lesser anthropogenic disturbances. This showed that Odonata thrive in environments that offer a wide range of micro-habitats and reduced human interference. It is therefore important that management and conservative practices are put in place to mitigate loss of biodiversity and degradation of the environment.

References

Acquah-Lamptey, D., Kyerematen, R., and Owusu, E.O. (2013). Dragonflies (Odonata: Anisoptera) as Tools for Habitat Quality Assessment and Monitoring. *Journal of Agriculture and Biodiversity Research* 2:178–182.

Adu, B. Dada, O. and Tunwase, V. (2022). An ecological study of freshwater ecosystem and its colligation to Odonates assemblages in Ipogun, Southwestern Nigeria. *Bulletin of the Natural Research Centre* 46: 86-90.

Adu, B. W. and Ogbogu, S. S. (2013). Diversity and community structure of Dragonflies and Damselflies (Insecta: Odonata) in Apomu Forest south-western Nigeria. *International Journal of Agriculture and Forestry* 3 (6): 231-239.

Adu, B.W., Kemabonta, K.A., and Ogbogu, S.S. (2016). 'Composition and Abundance of Anisoptera as Tools for Habitat Quality Assessment and Monitoring', *Journal of Agriculture and Biodiversity Research* 2: 178–182.

Bastos, R. C. Brasil, L. S. Carvalho, F. G. Calvão, L. B. Silva, J. O. .A. Juen, L. (2019). Odonata of the state of Maranhão, Brazil: Wallacean shortfall and priority areas for faunistic inventories. *Biota Neotrop*. 19, e20190734.

Boudot, J. P, Clausnitzer V., Samraoui B., Suhling F., Dijkstra K. B, Schneider W. (2013). "*Trithemis arteriosa*". IUCN red list of threatened species. International Union for Conservation of Nature, Gland.

Cerini, F., Bombi, P., Cannings, R., and Vignoli, L. (2021). Odonata metacommunity structure in northern ecosystems is driven by temperature and latitude. *Insect Conservation and Diversity* 14(5): 675–85.

Clausnitzer, V. K., Dijkstra, K.D.B and Koch, R. I. (2012). Focus on African freshwaters: Hotspots of dragonfly diversity and conservation concern, *Frontiers in Ecology and the Environment* 10 (3): 129–134.

Clausnitzer, V. (2003). "Dragonfly communities in coastal habitats of Kenya: Indication of biotope quality and the need of conservation measures," *Biodiversity and Conservation* 12 (2): 333–356.

Clausnitzer, V. and K. D. B. Dijkstra (2005). The dragonflies (Odonata) of Ethiopia, with notes on the status of endemic taxa and the description of a new species. *Entomologische Zeitschrift, Stuttgart* 115 (3):1-15.

Clausnitzer, V., Simaika, J.P., Samways, M.J., and Daniel, B.A. (2017). Dragonflies as Flagships for Sustainable Use of Water Resources in Environmental Education. *Applied Environmental Education & Communication*, 16 196–209.

Dijkstra, K.D.B**,** Clausnitzer V (2013). The dragonflies and damselflies of eastern Africa: handbook for all Odonata from Sudan to Zimbabwe. *Studies in Afrotropical Zool. Belgian Royal Museum for Central Africa* 18: 32-35.

Dijkstra, K-DB (2007). The name-bearing types of Odonata held in the Natural History Museum of Zimbabwe, with systematic note of Afrotropical taxa. Part 2: Zygoptera and description of new species. *Int J. Odonatol* 10:1–29.

Dijkstra, K. B, Kalkman. V. J., (2012) Phylogeny, classification and taxonomy of European dragonflies and damselflies (Odonata): A review. *Org Divers Evol*. 12: 209-227.

Dijkstra, K. D. and Clausnitzer, V (2014). *The Dragonflies And Damselflies of Eastern Africa: Handbook for All Odonata*.

Dijkstra, K. D. B. and Clausnitzer, V. 2005. An annotated checklist of the dragonflies (Odonata) of eastern Africa, with critical lists for Ethiopia, Kenya, Malawi, Tanzania and Uganda, new records, taxonomic notes and descriptions of new species.

Dijkstra, K.-D. B., Bechly, G., Bybee, S. M., Dow, R. A., Dumont, H. J., Fleck, G., Garrison,R. W., Hämäläinen, M., Kalkman, V. J., Karube, H., May, M. L., Orr, A. G., Paulson, D. R., Rehn, A. C., Theischinger, G., Trueman, J. W. H., Van Tol, J., Von Ellenrieder, N., and Ware, J.(2013). The classification and diversity of dragonflies and damselflies (Odonata). *Zootaxa* 3703 (1): 36–45.

Dijkstra, K.D.B., and Clausnitzer, V. (2014), *The Dragonflies and Damselflies of Eastern Africa: Handbook for all Odonata from Sudan to Zimbabwe.* Studies in Afrotropical Zoology. 298pp, Royal Museum for Central Africa.

Dijkstra, K.D.B., and Lempert, J. (2003), 'Odonate Assemblages of Running Waters in the Upper Guinean Forest'*, Archiv F€ur Hydrobiologie, Stuttgart* 157: 397–412.

Dijkstra, K.D. B. (2023) African dragonflies and damselflies online. (2017). http://addo.adu.org.za. Accessed on 17th October, 2023.

Fattorini, S. Rigal, F. Cardoso, P. and Borges, P. A. V. (2016). Using species abundance distribution models and diversity indices for biogeographical analyses. *Acta Oecologica* 70: 21–28.

Kalkman, V. J., Babu, R., Bedjaniˇc, M., Conniff, K., Gyeltshen,T., Khan, M. K., Subramanian, K. A., Zia, A., and Orr, A. G. (2020). Checklist of the dragonflies and damselflies (Insecta: Odonata) of Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. *Zootaxa* 4849: 1–84.

Kemabonta, K. A, Adu B. W, Ohadiwe A. C. (2016). Impact of human disturbance on the abundance, diversity and distribution of Odonata in the University of Lagos, Akoka, Lagos, Nigeria. *Appl Trop Agric.* 21 (3):143–150.

Kemabonta, K. A, Uche-Dike, R., Adu B. W, Ogbogu, S. S. (2020). Water quality of Lakes in Lufasi Park and Omu Resort, Lagos Nigeria as indicators of Odonata diversity, distribution and abundance. *J Sci Res Dev* 19(1):152–165.

Kemabonta, K. A., Adu, B. W., Nwabueze, O. F., Ogbogu, S. S. and Ohadiwe, A. (2019). The diversity and distribution of Dragonflies and Damselflies (Odonata) in University of Lagos, Akoka, Lagos, south-western Nigeria. *The Zoologist* 17: 1-5.

Manu, M. K., Ashiagbor, G., Seidu, I. Groen, T., Gyimah, T. & Bert, T. (2022). Odonata as bioindicator for monitoring anthropogenic disturbance of Owabi wetland sanctuary, Ghana, Aquatic Insects, DOI.

Paulson, D., Schorr, M., and Deliry, C. (2022). World Odonata List. *Slater Museum of Natural History* [online]. Available at https://www2.pugetsound. edu/academics/academic-resources/slater-museum/biodiversity-resources/dragonflies/world-odonatalist2/. Accessed 10 October, 2023.

Seidu, I. Nsor, C. A. Danquah, E. and Lancaster, L. T. (2018) Odonata assemblages along an anthropogenic disturbance gradient in Ghana's eastern region, *Odonatologica* 47 (1-2): 73–100.

Seidu, I., Saphianu, B., Manu, M.K., and Kwarteng, D.A. (2020), 'Contribution to the Knowledge of Odonata Fauna of the Atewa Range Forest Reserve, Bobiri Forest Reserve, Owabi Wildlife Sanctuary and Ankasa Forest Reserve (Southern Ghana)', International Dragonfly Fund E.V., Germany, p. 6.

The IUCN Red List of Threatened Species. (2020). Available at: https://www.iucnredlist.org/ [Accessed on 25 Oct 2020].

Vincy, M., Brilliant, R. and Kumar, A. P. (2016). Checklist of Odonata species as indicators of riparian ecosystem of a tropical river, the Southern western ghats. *Journal of Entomology and Zoology Studies* 4 (2): 104–108.