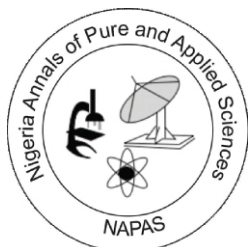


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DYNAMICS IN THE DIVERSITY AND ABUNDANCE OF ODONATA AT THE UNIVERSITY OF IBADAN, OYO STATE, SOUTHWESTERN NIGERIA

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Abstract

Odonata are sensitive indicators of habitat quality, making them ideal for evaluating both terrestrial and aquatic environments over short and long periods. The abundance and diversity of Odonata at the University of Ibadan, Oyo State, Nigeria, was investigated at Awolowo Hall, Fish Pond, and the Botanical Gardens. Adult dragonflies were collected using sweep net. A total of 479 individuals from 22 species (19 dragonflies and 3 damselflies) and 3 families (Coenagrionidae, Gomphidae, and Libellulidae) were collected from the survey. The family Libellulidae (76%) was the highest in terms of percentage composition and number of species (18), with *Trithemis arteriosa* being the dominant species, followed by Coenagrionidae (23.8%), which had 3 species, and the dominant species was *Ceriagrion glabrum*. The Museum of Natural History had more Odonata species (48) than the number encountered in the survey (22). Of these 22 species, twelve (12) were generalists and were not represented in the Museum collection. The absence of some Museum Odonata species, especially those from the families Calopterygidae, Chlorocyphidae, and Aeshnidae in the recent survey, may indicate severe alteration in the environment, resulting from a combination of habitat disruption and other anthropogenic factors. All species recorded in the survey and those in the Museum are categorized as Least Concern in the IUCN Red List of Threatened Species.

Keywords: Odonata, Museum, species diversity, University of Ibadan, habitat changes.

INTRODUCTION

Studies on Nigerian Odonata dates back to 1899 when Yngve Sjöstedt published a list of 41 odonate species from Mount Cameroon and the Nigerian border (Vick, 2003). This was followed by the expedition of two scholars, Pinhey and Coffin-Grey, who collected Odonata specimens from Cameroon and parts of Southeastern Nigeria in 1958. They discovered the species richness of Odonata at the Cameroon-Nigeria border, noting that the area was an Odonata hotspot. Gambles (1980) also worked primarily on Odonata in the middle belt of Nigeria (e.g., Jos-, and Zaria environments) and parts of the core north (Vick, 2003). Subsequent studies focused on species found in other parts of Nigeria, such as the Southwestern part (Adetunji and Parr, 1974). Some specimens collected during the studies are deposited in insect collections and Museums of various institutions, including the University of Ibadan and Ahmadu Bello University, Zaria, Nigeria.

Since then, many environmental changes have altered the odonates' diversity and primary habitats of the species. Habitat alteration resulting from anthropogenic activities remains one of the main causes of the depletion of biodiversity (Valiente-Banuet *et al.*, 2014). Arthropods respond quickly to these changes, and as a result, they are useful for measuring habitats biodiversity (Alarape *et al.*, 2015). Since Odonata (Dragonflies and damselflies) are amphibious, the sensitivity of their aquatic nymphs and terrestrial adults to environmental vicissitudes makes them a veritable tool for assessing the quality of the environment (Samways *et al.*, 2010; Pinto *et al.*, 2012; Adu *et al.*, 2015b; Dutra and De Marco, 2015; Vanacker *et al.*, 2018). The abundance of odonate species has also been used to study anthropogenic impact in different locations in Nigeria (Adu and Ogbogu, 2013; Adu *et al.*, 2015a; Adu *et al.*, 2015b, Kemabonta *et al.*, 2016; Zakka *et al.*, 2017).

This study was carried out in the University of Ibadan focusing on the inventory of odonate fauna of the University community and in comparison,

with earlier curated specimens in the Insect Reference Collection and Identification Services Centre (University's Insect Museum). This enables: 1) the determination of possible changes in Odonata diversity of the campus, 2) assistance in the proper preservation of the curated and new specimens, and 3) provides an opportunity to identify likely 'cosmetic' changes in the new specimens (of species) due to anthropogenic activities over time and climate change. This will help in inferring the impact of changes in the habitat on odonate species in the study area over the past three decades.

MATERIALS AND METHOD

Sampling location

Collection of Odonata adults was carried out within the campus of the University of Ibadan (UI), Ibadan, Oyo State, southwest of Nigeria with coordinates of approximately 7°22'39.22" N, 3°54'21.28" E (Figure 1). UI is located in the rainforest belt of Nigeria with annual rainfall of approximately 1220mm in the wet season which spans from April to October. The dry season occurs between November and March. (Alarape *et al.*, 2015). The three sites surveyed within the campus were Awolowo Hall (7.4375, 3.8919), Fish Pond (7.4414, 3.8997), and Botanical Garden (7.4578, 3.8933). These sites were selected based on the consideration of the extent of anthropogenic activities. Awolowo Hall area is known for intense human activities while the Fish Pond and Botanical Gardens areas record minimal impact.

The authors visited the Museum of Insect Collection located at the Department of Agric Biology to carefully examine the odonate-type materials in insect boxes. Well-preserved type materials among the lot were selected for review.

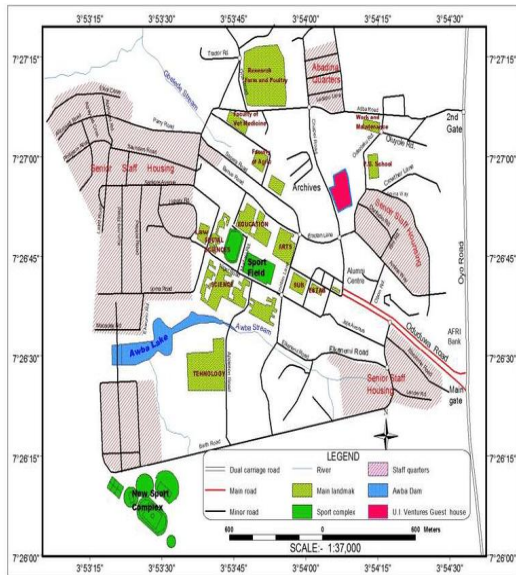


Figure 1: Map of the University of Ibadan, Nigeria. *Collection and identification of odonates*

The sampling methodology was consistent with Kipping *et al.* (2018). For ease of accurate identification, only adult specimens were sampled under favorable weather conditions between the hours of 7:00 am and 3:00 pm, using a sweep net. Adult specimens collected were kept in triangular envelopes labeled with pencils for subsequent processing and preservation in the laboratory. Males and females caught in tandem were placed together inside one envelope.

In the laboratory, specimens were immersed with the triangular envelopes in acetone for at least 12 hours to achieve the best stage of preservation and quality. They were then air-dried for 30 min. and placed in envelopes (7.5 × 12.5 cm) with cards on which vital information on the specimens was written. The preserved specimens were stored in insect boxes for subsequent identification. Identification of species was to the lowest taxonomic level using taxonomic keys in Samways (2008), Dijkstra and Clausnitzer (2014), and African Dragonflies and Damselflies (ADDO) Online (Dijkstra, 2016). The revision of the Museum (curated) specimens was done using the same identification manuals.

Data analysis

Diversity indices of Shannon Wiener (H'), Simpson's Dominance (C), Margalef (d), and Equitability (Evenness index), in Palaeontological Statistics Software (PAST) and Microsoft Excel were used to determine the diversity and distribution of odonate species within the sampling sites.

RESULTS

The odonate species sampled in the University of Ibadan (UI) are presented in **Table 1**. A total of 479 individuals from 22 species in 3 families (Coenagrionidae, Gomphidae, and Libellulidae) were sampled. The highest number of individuals were collected from Fish Pond (203) while Awolowo Hall and Botanical Garden had (140) and (136) numbers of individuals respectively. The Family with the highest number of individuals was Libellulidae (364) representing 18 species. This was 76% of the total number of odonates collected, followed by Coenagrionidae (114, 23.8%) in 3 species, and Gomphidae (1, 0.2%) in one species in that order (**Figure 1**). The 22 species were in 15 genera with *Orthetrum* having the highest number (4) of species. Two other genera (*Brachythemis* and *Palpopleura*) have the same number (3) of species, while the remaining 13 genera were represented by a single species each.

Odonata was more diverse around the Fish Pond ($H' = 2.49$, $d = 4.10$, $D = 0.88$, and $J = 0.79$), followed by Awolowo Hall and Botanical Garden (**Table 2**). The

distribution of the species at the study sites was also best at the Fish Pond followed by Awolowo Hall.

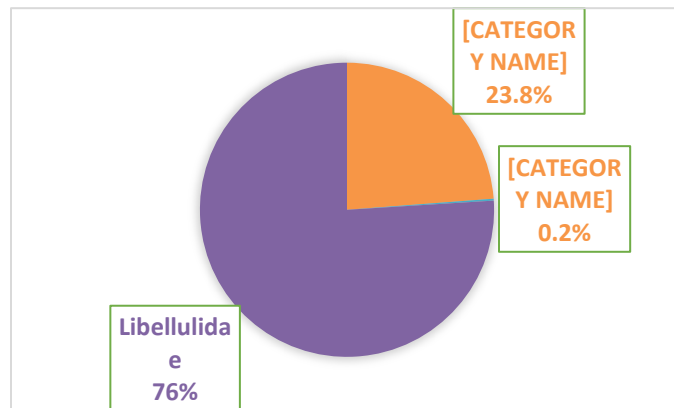


Figure 1: Percentage composition of Odonata families collected from the University of Ibadan

Table 1: List of Odonata collected from three selected locations in the University of Ibadan (UI)

Family/Species	Sites			Total
	Awolowo Hall	Fish Pond	Botanical Garden	
Coenagrionidae				
<i>Ceriagrion glabrum</i> Burmeister, 1839	27	33	3	63
<i>Ischnura senegalensis</i> Rambur, 1842	0	5	0	5
<i>Pseudagrion kersteni</i> Gerstaecker, 1869	0	12	34	46
Subtotal	27	50	37	114
Gomphidae				
<i>Ictinogomphus ferox</i> Rambur, 1842	0	1	0	1
Subtotal	0	1	0	1
Libellulidae				
<i>Brachythemis impartita</i> Karsch, 1890	0	8	0	8
<i>Brachythemis lacustris</i> Kirby, 1889	0	3	0	3
<i>Brachythemis leucosticta</i> Burmeister, 1839	0	10	1	11
<i>Bradinopyga strachani</i> Kirby, 1900	0	2	0	2
<i>Chalcostephia flavifrons</i> Kirby 1889	0	2	0	2
<i>Crocothemis erythraea</i> Brulle, 1832	0	13	0	13
<i>Hadrothemis infesta</i> Karsch 1891	0	4	0	4
<i>Neodythemis klingi</i> Karsch, 1890	1	0	0	1
<i>Nesciothemis farinosa</i> Forster, 1898	2	0	0	2
<i>Orthetrum austeni</i> Kirby, 1900	0	1	0	1
<i>Orthetrum chrysostigma</i> Burmeister, 1839	7	4	2	13

<i>Orthetrum julia</i> Kirby, 1900	27	13	12	52
<i>Orthetrum stemmale</i> Burmeister, 1839	4	2	2	8
<i>Palpopleura deceptor</i> Calvert, 1899	0	1	0	1
<i>Palpopleura lucia</i> Drury, 1773	55	45	9	109
<i>Palpopleura portia</i> Drury, 1773	9	2	4	15
<i>Pantala flavescens</i> Fabritius, 1798	0	2	0	2
<i>Trithemis arteriosa</i> Burmeister, 1839	8	40	69	117
Subtotal	113	152	99	364
Total	140	203	136	479

Table 2: Diversity indices of Odonates collected from three selected sites in the University of Ibadan, Oyo State, Nigeria.

Index	Awolowo Hall	Fish Pond	Botanical Garden
Taxa_S	9	22	9
Individuals	140	203	136
Shannon_H'	1.72	2.49	1.51
Simpson_1-D	0.76	0.88	0.68
Margalef (d)	1.82	4.10	1.82
Equitability_J (Evenness index)	0.75	0.79	0.65

Table 3: List of Odonata species in the University of Ibadan Museum.

S/N	FAMILY	SPECIES	SAMPLED	MUSEUM
1.	Aeshnidae	<i>Anax imperator</i> Leach, 1815	-	+
2.		<i>Anax tristis</i> Hagen, 1867	-	+
3.		<i>Gynacantha cylindrata</i> Karsch, 1891	-	+
4.		<i>Gynacantha sextans</i> McLachlan, 1896	-	+
5.	Calopterygidae	<i>Phaon iridipennis</i> Burmister, 1839	-	+
6.	Chlorocyphidae	<i>Chlorocypha curta</i> Hagen in Selys, 1853	-	+
7.		<i>Chlorocypha glauca</i> Selys, 1879	-	+
8.		<i>Chlorocypha rubida</i> Hagen in Selys, 1853	-	+
9.	Coenagrionidae	<i>Agriocnemis maclachlani</i> Selys, 1877	-	+
10.		<i>Ceriagrion glabrum</i> Burmeister, 1839*	+	+
11.		<i>Ceriagrion corallinum</i> Campion, 1914	-	+
12.		<i>Ceriagrion moorei</i> Longfield, 1952	-	+
13.		<i>Ischnura senegalensis</i> Rambur, 1842	+	-
15.		<i>Pseudagrion glaucescens</i> Selys, 1876	-	+
16.		<i>Pseudagrion kersteni</i> Gerstaecker, 1869*	+	+
17.		<i>Pseudagrion melanicterum</i> Selys, 1876	-	+
18.		<i>Pseudagrion whellani</i> Pinhey, 1956	-	+

19.	Gomphidae	<i>Ictinogomphus ferox</i> Rambur, 1842	+	-
20.	Libellulidae	<i>Neodythemis klingi</i> Karsch, 1890	-	+
23.		<i>Brachythemis impartita</i> Karsch, 1890	+	-
24.		<i>Brachythemis lacustris</i> Kirby, 1889	+	-
25.		<i>Brachythemis leucosticta</i> Burmeister, 1839	+	-
26.		<i>Bradinopyga strachani</i> Kirby, 1900*	+	+
27.		<i>Chalcostephia flavifrons</i> Kirby, 1889*	+	+
28.		<i>Crocothemis erythraea</i> Brulle, 1832*	+	+
29.		<i>Crocothemis sanguinolenta</i> Burmeister, 1839	-	+
30.		<i>Cyanothemis simpsoni</i> Ris, 1915	-	+
31.		<i>Hadrothemis infesta</i> Karsch 1891	+	-
32.		<i>Hemistigma albipunctum</i> Rambur, 1842	-	+
33.		<i>Neodythemis klingi</i> Karsch, 1890	+	-
34.		<i>Nesciothemis farinosa</i> Forster, 1898*	+	+
35.		<i>Orthetrum austeni</i> Kirby, 1900	+	-
36.		<i>Orthetrum abbotti</i> Calvert, 1862	-	+
37.		<i>Orthetrum brachiale</i> Beauvois, 1817	-	+
38.		<i>Orthetrum chrysostigma</i> Burmeister, 1839	+	-
39.		<i>Orthetrum guineense</i> Ris, 1910	-	+
40.		<i>Orthetrum falsum</i> Longfield, 1955	-	+
41.		<i>Orthetrum julia</i> Kirby, 1900*	+	+
42.		<i>Orthetrum stemmale</i> Burmeister, 1839*	+	+
43.		<i>Palpopleura deceptor</i> Calvert, 1899	+	-
44.		<i>Palpopleura lucia</i> Drury, 1773	+	+
45.		<i>Palpopleura portia</i> Drury, 1773	+	-
46.		<i>Pantala flavescens</i> Fabricius, 1798	+	+
47.		<i>Parazyxomma flavicans</i> Martin, 1908	-	+
48.		<i>Trithemis arteriosa</i> Burmeister, 1839	+	-
49.		<i>Rhyothemis notata</i> Fabricius, 1787	-	+
50.		<i>Rhyothemis semihyalina</i> Desjardins, 1835	-	+
51.		<i>Tetrathemis camerunensis</i> Sjostedt, 1900	-	+
52.		<i>Tholymis tillarga</i> Fabricius, 1798	-	+
53.		<i>Trithemis annulata</i> Beauvois, 1807	-	+
54.		<i>Trithemis arteriosa</i> Burmeister, 1839	-	+
55.		<i>Trithemis dichroa</i> Karsch, 1893	-	+
56.		<i>Trithemis grouti</i> Pinhey, 1961	-	+
57.		<i>Trithemis kalula</i> Kirby, 1900	-	+
58.		<i>Urothemis assignata</i> Selys, 1872	-	+
59.		<i>Urothemis edwardsii</i> Selys in Lucas, 1849	-	+
60.		<i>Zyxomma atlanticum</i> Selys, 1889	-	+
61.	Platycnemididae	<i>Allocnemis nigripes</i> Selys, 1886	-	+
62.		<i>Elatoneura nigra</i> Kimmins, 1938	-	+

63.	<i>Mesocnemis singularis</i> Karsch, 1891	-	+
64.	<i>Platycnemis sikassoensis</i> Martin, 1912	-	+

*Common species recorded; **Additional species recorded; Species not recorded in the present sampling. (+) indicate presence of species; (-) indicate absence of species.

The overall odonate species in the University campus are listed in Table 3. The Museum holds 48 odonates species, which were sampled and curated between 1952 and 1971. Ten of these species were recorded in the present sampling sites while 13 additional species were collected within the campus. A species of Gomphidae (*Ictinogomphus ferox*) which was not among the Museum specimens was collected at the Fish Pond. Also, the three species of *Brachythemis* collected during this study were not among the odonates in the Museum. None of the species of Aeshnidae, Calopterygidae, Chlorocyphidae, and Platycnemididae found in the Museum was sampled in this study. *Trithemis arteriosa* which was not sampled (i.e. based on the Museum odonate list) became the dominant odonate species in the present study.

DISCUSSION

The results of this study revealed that 22 species (19 dragonflies and 3 damselflies) in 3 families were recorded in the University of Ibadan, with Libellulidae being the highest in terms of number of individuals (76) and number of species (18). *Trithemis arteriosa* contributed more than any other libellulid to the number. Coenagrionidae (23.8%) with 3 species followed, with the dominant species in the family being *Ceriagrion glabrum*. Similar studies also revealed that Libellulidae and Coenagrionidae were the dominant families of Odonata in University of Lagos (Kemabonta *et al.*, 2016), Iloyin Forest, Akure (Adu *et al.*, 2015a) and Obafemi Awolowo University Ile-Ife (Adu *et al.*, 2015b). These are in tandem with the report that *T. arteriosa* and *C. glabrum* were among the most abundant dragonfly and damselfly species in Africa (Hupało and Tończyk, 2014; Dijkstra and Clausnitzer, 2014).

Fish Pond site had the highest species diversity and distribution, with 203 individuals, out of which 153 were dragonflies and 50 were damselflies. This was followed by Awolowo Hall with 140 individuals (113 dragonflies and 27 damselflies) and Botanical Garden with 136 individuals (99 dragonflies and 37 damselflies). Similar findings by Vanacker *et al.* (2018) and Rosset *et al.* (2014) revealed that fish ponds substantially sustain considerable diversity and richness of Odonata. The low species diversity in the University of Ibadan Botanical Garden differs from the findings by Adu *et al.* (2015b), which revealed high species richness and distribution in Obafemi Awolowo University Ile-Ife Biological Garden.

Dragonflies and damselflies in the Museum were more diverse than those in this study. This is expected since the university campus has experienced considerable opening up of natural habitats for the odonate fauna due to infrastructural developments. This habitat disruption and destruction are responsible for the reduced number of species when compared to the list in the Museum. However, it should be noted that the Museum specimens were collected over a long period, spanning ten years. This may explain the difference in the number of species recorded in these periods. It can be observed that most of the Museum specimens have near-ubiquitous status, and the majority of them are widespread in the Afrotropical Forest. The three families found in the Museum collection that were not included in the list of those inhabiting study sites are Aeshnidae, Calopterygidae, and Chlorocyphidae. It is believed that members of these families must have relocated to nearby forests due to

deforestation caused by infrastructure development on the campus. Since this study is limited to the University campus, forests adjacent to the campus were not surveyed. It is believed that a future survey of the adjacent forests will yield some species from these families and probably other families that are absent from the Museum list.

The absence of *Ictinogomphus ferox* (Gomphidae) from the Museum list, and its presence at the fish pond is evidence that there are other species, especially the ubiquitous ones which can tolerate human disturbance at the campus. *Ictinogomphus ferox* is a good flier that easily adapts to environments undergoing perturbation. It can tolerate human disturbance like many ubiquitous odonates. The Aeshnid *Anax imperator* is also a good flier like the *I. ferox* and among the members of the Family that can tolerate human disturbance. They usually inhabit uphill vegetation in the vicinity of standing water. *A. tristis* is more of a migratory aeshnid than the *Anax imperator* because of its choice of habitat which is seasonal (Dijkstra and Clausnitzer, 2014). The absence of aeshnids in this study could be their elusiveness and difficulties in the sampling of the adults. The calopterygid *Phaon iridipennis* is nearly ubiquitous (Dijkstra and Clausnitzer, 2014), with a preference for shaded streams with fragments of openings to sun baths. This species was absent at the three study sites.

Chlorocyphidae is another family that was expected to be part of the collection from the study area. Members of this family are colorful and commonly found in forest streams and rivers. *Chlorocypha curta* is moderately sensitive to human disturbance and is found in openings of shaded running waters in the forest.

The University of Ibadan Museum had more species of Odonata (48) previously collected from the study area, between 1952 and 1971 than the present study (25). Eleven of these species (*C. glabrum*, *P. kersteni*, *T. arteriosa*, *O. julia*, *P. lucia*, *O. stemmale*, *P. flavescens*, *C. flavifrons*, *C.*

erythraea, *N. farinosa* and *B. strachani*) were recorded in the present study. On the other hand, 11 additional species recorded in the present study include *I. senegalensis*, *N. klingi*, *O. chrysostigma*, *P. portia*, *O. austeni*, *B. impartita*, *B. lacustris*, *I. ferox*, *H. infesta*, *B. leucosticta*, and *P. deceptor*. Seven of these – *I. senegalensis*, *O. austeni*, *B. impartita*, *B. lacustris*, *I. ferox*, *H. infesta* and *P. deceptor* – were sampled from the fish pond site alone. Three species (*O. chrysostigma* and *P. portia*) were sampled from the three study sites while *N. klingi* was sampled from Awolowo Hall area, and *B. leucosticta* from fish pond and Botanical Garden area. Reports by Seidu *et al.* (2018) and Adu *et al.* (2015a, b) indicate that some of the common and new species such as *C. flavifrons*, *T. arteriosa*, *N. klingi*, *O. julia*, *O. stemmale*, *C. glabrum* and *P. kersteni* recorded in this present study are generalist species and are common in disturbed environments. The absence of some species in this study especially those from the families Calopterygidae, Chlorocyphidae, and Aeshnidae, which are present in the museum collection is an indication of changes in their habitats in particular and the environment in general over the years. *Gynacantha sextans* and *G. cylindrata* (Aeshnidae) prefer waters covered by forest canopy, while *Anax imperator* and *A. tristis* are found in open landscapes or open areas in the forest (Dijkstra, 2019). *Phaon iridipennis* (Calopterygidae) prefers waterbodies with gallery forest or forest openings (Dijkstra, 2019). *Chlorocypha glauca* and *C. rubida* (Chlorocyphidae) also prefer running waters covered by forest canopy (Dijkstra, 2019). These species cannot withstand human disturbance and respond quickly to environmental changes (Adu *et al.*, 2015b; IUCN, 2010). As a result, they might have been eliminated or simply emigrated in response to habitat disruption or other factors. The odonate species of the University of Ibadan Museum and those of the present study are currently in the Least Concern category in the IUCN red list of threatened species (IUCN, 2019).

CONCLUSION

The absence of other Museum Odonata species especially those from the families, Calopterygidae, Chlorocyphidae, and Aeshnidae in this study is an indication of alteration in the environment resulting from habitat disruption or other factors. Although the odonate species of the University of Ibadan Museum and those of the present study are not considered Threatened (according to the IUCN red list), they currently face the risk of population decline and outright local extinction in the wild if the current rate of deforestation on the campus in particular and Nigeria, in general, continue unabated.

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