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DRAGONFLIES AND DAMSELFLIES (INSECTA: ODONATA) AS TOOLS FOR HABITAT QUALITY ASSESSMENT AND MONITORING

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ABSTRACT

Dragonflies and damselflies of Obafemi Awolowo University Ile-Ife, Nigeria were assessed for the purpose of determining the habitat quality of Odonata community in the campus. Adult dragonflies and damselflies were sampled at four study sites at the campus. The study sites are Opa Reservoir spillway stream: OR, Health Sciences: HS, Biological Garden: BG, and Staff Quarters: SQ. A total of 195 individuals comprising of thirty-six species in six families (Aeshnidae, Libellulidae, Calopterygidae, Chlorocyphidae, Coenagrionidae and Platycnemididae) were sampled at the campus. Similarity test on the odonate community structure at the four study sites was conducted using Soerensen's quotient. OR/BG and OR/SQ were similar, while the other paired study sites (BG/SQ, OR/HS, HS/BG and HS/SQ) were dissimilar. Diversity indices results have Shannon Wiener (H') value ranging between 2.20 - 3.05, Simpson value ranging between 0.86 - 0.95 and Margalef value ranging between 3.39 - 5.8 for the four sites. BG was the richest study site with the highest values (Shannon Wiener: 3.05, Simpson: 0.95 Margalef: 5.8 and evenness was 0.92), followed by OR (Shannon Wiener: 2.96, Simpson: 0.94 Margalef: 5.41 and evenness was 0.81). The forest environments of Obafemi Awolowo University appeared been depleted yet possessed the habitat quality that sustained some species of Odonata. Nevertheless BG and OR have proven to possess the best community structure for the existence of Odonata fauna in the campus

Keywords: Dragonflies, damselflies, human disturbance, forest, community structure

INTRODUCTION

Odonata (Dragonflies and Damselflies) are aquatic insects that are commonly seen around us especially in areas where there are inland water bodies (natural or artificial). This insect order is highly diverse with about 6,500 species (Dijkstra, 2007). Both the naiads and adults of this insect order are carnivores, feeding on other insects (or animals) that are smaller or of the same size with them. They are used as bio-indicators for monitoring habitat degradation both on terrestrial and aquatic ecosystem because of their sensitivity to anthropogenic activities (Clausnitzer, 2003; Darwall, *et al.*, 2005 and Samways, 2008). Dragonflies and Damselflies have a range of preference for different biotope, from

permanent shaded sites to temporary pools (Corbet, 2004). The choices of different biotope by different species are used as a means of determining the extent to which landscapes have been affected (Samways, 2008).

Obafemi Awolowo University, Ile-Ife (lat. 07° 29' - 07° 31' N; long 004° 30' - 004° 34' E) is an ancient town in Osun State, south-western Nigeria. It is in lowland rain forest area. Derived savannah is found in some areas of the town, presumably as a result of human activities such as farming and construction works. These human activities were extended to the University campus. The temperature variation of Ile-Ife is relatively minimal. There are two major seasons in the ancient town.

They are dry and wet seasons. Heavy rains characterize the wet season, while the dry season exhibits dryness, a period referred to as harmattan. There are two peaks of rainfall (June and October) and is characterised by double peaks, of 1005mm in June and a little over 1800mm in October (Ogbogu, 2007). The dry season is controlled by tropical continental wind and is between November and February. The tropical maritime blow controls the rainy season and it prevails between March and October. The sun shines throughout the year and the average temperature is between 29.4°C and 31.26°C.

This research was carried out at the fragments of forest scattered within the campus community. The forests are characterized by heterogeneous vegetation. It is believed that heterogeneity of a forest is one of the cues for habitat preferential by Odonata species. According to Watanabe *et al.* (2004), heterogeneous forest appears to support a rich diversity of Odonata. Although, the forest in the campus is becoming depleted as a result of construction works and farming activities going on, however, some species of dragonflies and damselflies are still seen around. Yet the actual ecological status of the forest environments is not known. It is hypothesised that apart from eurytopic species present in the forest there is possibility of some stenotopic species locked up in some part of the forest which can as well act as bio indicator in monitoring the forest. This study was therefore aimed at using species of Odonata present in the forest as a tool to determine the habitat quality of the forest and use the assemblage to assess and monitor the habitat.

MATERIALS AND METHODS

Study sites

The vegetation of Obafemi Awolowo University, Ile-Ife (lat. 07° 29' -07° 31' N;

long. 04° 30' -04° 34'E ; Fig. 1), is heterogeneous and typical of tropical rainforest region of Africa. Recent information on the patterns of annual rainfall and temperature is provided in Ogbogu (2007). Four study sites were identified in the campus where samplings were carried out. The study sites included the forest around the Opa Reservoir spillway stream (OR), the forest behind of the Health Sciences buildings (HS), the Biological Gardens (BG) and the forested area of Staff Quarters (SQ) (Fig.1). The sites were selected taking cognizance of the water bodies and forests in the campus.

Study site at Opa Reservoir (OR): The stream below Opa Reservoir spillway starts from the auxiliary spillway of the Opa Reservoir and runs southwards of the campus. The lower reaches of the stream are shaded, with trees and shrubs of dense canopy, which renders the stream course quite humid most times of the year. The upper reaches are open, with virtually no tree but with partly submerged grass and other weeds at the banks.

The study site at the Health Sciences building is bordered by a small but undisturbed forest, with a small marshy land and runnel dries up during the dry season. The forest at the back of the building extends towards the reservoir to the south of the campus.

The third site is the Biological Gardens. The forests here have received some conservation attention and research ever since the university was established in the early 1960s. Vegetation is characterized by tall trees with emergent vegetation below the canopy. The fourth study site is the Staff Quarters. This site is at northern part of the of the campus. It is more open than other sites. The vegetation of this site is characterised by shrubs with few trees. It is more disturbed than the rest of the sites because of human activities such as subsistence crop farming and infrastructural development.

Sampling procedure and identification

Collection of adult dragonflies and damselflies was carried out with a sweep net with 150cm long handle and orifice 25 cm in diameter. Collection was on monthly basis between 8.00 am and 2.00 pm for eleven month. Each specimen caught have their wings folded together above the body and then placed in a triangular envelope for processing and preservation in the laboratory. Pairs of mating males and females caught in tandem were placed together in the same envelope. Data on collection and information such as locality, date, time and the collector's name were recorded for each specimen.

Processing of specimens for preservation involved immersing the insects (in triangular envelopes) in acetone for 12 hr. Afterward, removed and placed on tissue paper to dry in open air before storage in improvised cellophane envelopes. All specimens collected were identified to the lowest taxonomic level by an Odonatology expert.

Similarity Test

Similarity test on the community structure of the odonate species sampled at the four study sites were carried using Soerensen's Quotient. This measure has the advantage of not requiring an estimate of the number of individual of each species (Gaten, 2000).

Soerensen's quotient for site X and Y is given as $2J / (A+B)$, where: A = number of species in site X, B = number of species in site Y, J = number of species common to both. The value will be close to 1.0 for two compared sites that have common species and for dissimilar sites the value will be close to 0.0. Coefficient of similarity was estimated from the value obtained in the Soerensen's quotient analysis (Sarmistha et. al., 2009; Adu and Ogbogu, 2013).

<0.3 = strongly dissimilar, 0.3-0.4 = moderately dissimilar, 0.4-0.5 = slightly dissimilar, 0.5-0.6 = slightly similar, 0.6-0.7 = moderately similar, > 0.7 = strongly similar.

Data analysis

To examine the abundance and distribution of species in the study sites the number of individuals collected per species was recorded. Diversity indices (Simpson, Shannon Wiener, Margalef and Evenness) were used to determine the richness of Odonata at the four study sites and also to compare the distribution of species among the sites.

RESULTS

A total of 195 individuals specimens representing 36 species in six families (Table 1) were collected from the four study sites identified in the campus. Of these, 157 individuals were members of sub-order Anisoptera. The rest (thirty-eight) were members of suborder Zygoptera, representing eight species in four families: Calopterygidae, Chlorocyphidae, Coenagrionidae and Platycnemididae (See table 2). The 157 anisopteran collected represented 28 species in two families (Aeshnidae and Libellulidae). Species collected at the study sites were classified into common and scarce species. The common species were those that occurred 7 times or more at each of the sites (Common = > 7) while the scarce species were those that were collected once or twice (Scarce = < 2). The three most common species in this study include *Orthetrum brachiale*, *Trithemis dicroa* and *Orthetrum chrysostigma* (Table 3). *Orthetrum chrysostigma* was well represented in all the study sites except Biological Garden (Table 3). The most scarce species include *Heliaeschna longifieldae* and *Mesocnemis singularis* (Table 4). Only a specimen each of this species were sampled at the campus (OR and BG). Some stenotopic species encountered at the study sites include, *Heliaeschna sembe*, *Heliaeschna longifieldae*, *Chlorocypha curta* and *Chlorocypha rubida*. A total of 70 individuals in four families (Libellulidae, Aeshinidae, Chlorocyphidae and Platycnemididae) were collected by Opa Reservoir (OR).

Table 1: A checklist of species of Odonata recorded from Obafemi Awolowo University, Ile-Ife

TAXA	SITE			
	OR	HS	BG	SQ
LIBELLULIDAE				
<i>Acisoma panorpoides</i> Rambur, 1842	5	0	0	2
<i>Aethriamanta rezia</i> Kirby 1889	1	0	1	1
<i>Bradinopyga brachiale</i>	0	1	0	1
<i>Bradinopyga strachani</i> Kirby 1900	0	5	0	0
<i>Chalcostephia flavifrons</i> Kirby 1889	2	0	2	0
<i>Crocothemis divisa</i> Karsch 1898	0	1	3	1
<i>Hadrothemis infesta</i> Karsch 1891	0	0	2	0
<i>Nesciothemis minor</i> Gambles, 1966	2	0	2	0
<i>Nesciothemis pujoli</i> Pinhey 1971	4	0	2	0
<i>Orthetrum abbotti</i> Calvert, 1892	0	0	1	2
<i>Orthetrum brachiale</i> Palisot de Beauvois, 1817	0	2	3	13
<i>Orthetrum chrysostigma</i> Burmeister, 1839	6	3	0	7
<i>Orthetrum hintzi</i> Schmidt, 1951	2	0	2	0
<i>Orthetrum julia</i> Kirby, 1900	1	0	2	7
<i>Orthetrum microstigma</i> Ris, 1911	5	0	0	4
<i>Orthetrum trinacria</i> Selys, 1869	1	0	1	0
<i>Orthetrum stemmale</i> Selys, 1869	0	1	4	0
<i>Palpopleura lucia</i> (Drury, 1773)	0	1	2	0
<i>Palpopleura portia</i> (Drury, 1773)	2	0	0	2
<i>Pantala flavescens</i> (Fabritius, 1798)	1	0	0	2
<i>Rhyothemis fenestrina</i> Rambur, 1842	1	0	2	0
<i>Rhyothemis semihyalina</i> (Desjardins, 1835)	3	0	0	0
<i>Trithemis arteriosa</i> Burmeister, 1939	3	0	2	2
<i>Trithemis dichroa</i> Karsch, 1893	9	0	0	8
<i>Trithemis grouti</i> Pinhey, 1961	4	0	0	2
AESHNIDAE				
<i>Gynacantha manderica</i> Grünberg, 1902	0	1	2	0
<i>Heliaeschna longfieldae</i> Gambles, 1967	0	0	1	0
<i>Heliaeschna sembe</i> Pinhey, 1962	0	0	2	0
CALOPTERYGIDAE				
<i>Phaon iridipennis</i> Burmeister, 1839	1	0	1	0
CHLOROCYPHIDAE				
<i>Chlorocypha curta</i> (Hagen, 1853)	6	1	1	0
<i>Chlorocypha rubida</i> (Hagen in Selys, 1853)	2	0	1	0
COENAGRIONIDAE				
<i>Ceriagrion glabrum</i> Burmeister, 1839	3	2	3	2
<i>Pseudagrion kersteni</i> Gerstaecker, 1869	2	1	1	5
<i>Pseudagrion melanicterum</i> Selys, 1876	0	0	0	2
PLATYCNEMIDIDAE				
<i>Mesocnemis singularis</i> Karsch, 1891	1	0	0	0
<i>Platycnemis sikassoensis</i> Martin, 1912	3	0	0	0
Total	70	19	43	63

Table 2: Odonata families represented at the four study sites in Obafemi Awolowo University, Ile Ife.

Family	OR	HS	BG	SQ	TOTAL
Aeshnidae	0	1	5	0	6
Libellulidae	52	14	31	54	151
Calopterygidae	1	0	1	0	2
Chlorocyphidae	8	1	2	0	11
Coenagrionidae	5	3	4	9	21
Platycnemididae	4	0	0	0	4
Total	70	19	43	63	195

Abbreviation: OR; Opa Reservoir, HS: Health Science, BG: Biological Garden, SQ: Staff Quarters

Table 3: The most common species of dragonfly and damselfly sampled at the four study sites in Obafemi Awolowo University, Ile Ife.

Taxa	Study Site	Number of Species
<i>Acisoma panopoides</i>	OR	7
<i>Orthetrum brachiale</i>	SQ	18
<i>Orthetrum chrysostigma</i>	SQ	16
<i>Orthetrum Julia</i>	SQ	10
<i>Orthetrum microstigma</i>	OR	9
<i>Trithemis arteriosa</i>	OR	7
<i>Trithemis dichroa</i>	OR	17
<i>Chlorocypha curta</i>	OR	8
<i>Ceriagrion glabrum</i>	OR and BG	10
<i>Pseudagrion kersteni</i>	SQ	9

Species collected 7 times or more at each of the sites (Common = > 7). Abbreviation OR; Opa Reservoir, HS: Health Science, BG: Biological Garden, SQ: Staff Quarters

Table 4: The scarcest species of dragonfly and damselfly sampled at the four study sites in Obafemi Awolowo University, Ile Ife

Taxa	OR	HS	BG	SQ
<i>Bradinopyga brachiale</i>	-	2	-	2
<i>Hadrothemis infesta</i>	-	-	2	-
<i>Heliaeschna longifieldae</i>	-	-	1	-
<i>Heliaeschna sembe</i>	-	-	2	-
<i>Mesocnemis singularis</i>	2	-	2	-
<i>Orthetrum trinacria</i>	2	-	2	-
<i>Phaon irridipennis</i>	2	-	2	-
<i>Pseudagrion melanicterium</i>	-	-	-	2

Species collected once or twice (Scarce = < 2). Abbreviation OR: Opa Reservoir, HS: Health Science, BG: Biological Garden, SQ: Staff Quarters

Table 5: Diversity of species of Odonata in the four study sites at Obafemi Awolowo University, Ile-Ife.

Diversity Index	OR	HS	BG	SQ
Number of species	24	11	23	17
Total Abundance	70	19	43	63
Simpson 1-D	0.94	0.86	0.95	0.90
Shannon H'	2.96	2.20	3.05	2.53
Evenness	0.81	0.82	0.92	0.74
Margalef	5.41	3.39	5.8	3.86

Abbreviation: OR = Opa Reservoir, HS = Health Sciences Building, SQ = Staff Quarter, BG = Biological Garden

Table 6: Odonata Community Similarity Test using Sorensen's Quotient in Obafemi Awolowo, University, Ile-Ife

Paired study sites	Sorensen's Quotient Value	Similarity Status
OR/HS	0.23	Strongly Dissimilar
OR/SQ	0.58	Slightly Similar
OR/BG	0.6	Moderately Similar
HS/BG	0.32	Moderately Dissimilar
HS/SQ	0.43	Dissimilar
BG/SQ	0.2	Strongly Dissimilar

Abbreviation: OR = Opa Reservoir, HS = Health Sciences Building, SQ = Staff Quarter, BG = Biological Garden

The Biological Garden was the most diverse in terms of species richness ($H' = 3.05$), followed by OR ($H' = 2.96$). Twenty four species of dragonflies and damselflies were collected at OR which had a species richer than study site BG (Table 5). The study site (BG) also had the highest value for Margalef (5.8) and Simpson dominance (0.95). Evenness value (species distribution) was also the best at the site ($E = 0.92$). Health Sciences (HS) had $E = 0.82$, Opa Reservoir (OR) had $E = 0.81$ and Staff Quarter had evenness of 0.74 (see table 5).

Two study sites OR/SQ and OR/BG were found to have similar Odonata community structure; OR/SQ slightly similar (0.58) and OR/BG moderately similar (0.6). Four

compared study sites were dissimilar; BG/SQ and OR/HS were strongly dissimilar, while HS/BG and HS/SQ were dissimilar (Table 6).

DISCUSSION

A total of 195 specimens of dragonflies and damselflies were sampled at the Obafemi Awolowo University Ile-Ife. All the specimens identified were identified to lowest taxonomic level. All the 195 specimens belong to 36 species in six families (see table 6). Libellulidae and Coenagrionidae were well represented in the campus. Out of the 36 species occurring at the campus, 28 species were members of sub-order Anisoptera: Family libellulidae has 25 species of the total species sampled in the campus (69.44%) and

family Aeshnidae had just three species represented. Most of the libellids sampled are widespread and are tolerant of disturbed habitats. For instance *Orthetrum brachiale*, *Orthetrum chrysostigma* and *Orthetrum julia*. Vick (2003) also agreed with this observation by stating that *Orthetrum sp.* are widespread in secondary and disturbed forests. *Orthetrum stemmale* is also tolerant of disturbed habitat. *Ceriagrion glabrum* and *Pseudagrion kersteni* was generalist in this study, for they were represented in all the study sites. *Ceriagrion glabrum* is widespread across West Africa (Dijkstra and Clausnitzer, 2015). *Ceriagrion glabrum* prefers standing water or sluggish water. *Pseudagrion kersteni* prefers open streams and can tolerate disturbed habitat (Samways, 2008 and Dijkstra and Clausnitzer, 2015). The study site with largest number of specimens was Opa Reservoir spillway stream (OR). The stream provided the necessary vegetative structures that supported breeding of Odonata fauna. For example *Commelina diffusa*, *Commelina erecta*, *Amaranthus hybridus* and *Acroceras zizaniodes* occurring at the stream provided oviposition site for endophytic species. The stream water is also available for those that oviposit in the water. The adjacent forest also had the right vegetative architecture for the immature adults and reproductive females. These groups of odonates prefer inhabiting adjacent uphill forest rather than the open water to avoid the aggressive male who may feed on immature adults or forcefully mate the unwilling female (Corbet, 2004).

All families of Odonata found occurring at the Obafemi Awolowo University, Ile-Ife were sampled at the Biological Garden (BG) while only two Odonata families were found to be at the Staff Quarters (SQ), which were Libellulidae and Coenagrionidae. The species sampled were ubiquitous that are tolerant of human activities (such as *Orthetrum brachiale*, *Orthetrum chrysostigma*, *Orthetrum julia* and *Pseudagrion kersteni*). Stenotopic species (species with narrow niche) were sampled at the BG (*Chlorocypha curta*, *Chlorocypha rubida* *Gynacantha manderica* *Heliaeschna longifieldae* and *Heliaeschna sembe*). All these contributed to the dissimilarity in the Odonata community structure of the two study sites. Opa Reservoir and Staff Quarters (OR/SQ) had similar

Odonata community structure (Slightly similar = 0.58) due to the following reasons: large numbers of specimens were sampled at the two study sites, most of the libellulids and coenagrionids found occurring in the campus were well represented at the two study sites. Biological Garden and Staff Quarters (BG/SQ) was strongly dissimilar (0.2) because of the following reasons. BG was a garden which was used for research purposes; there was limited protection of the fauna and flora community of the garden. SQ was residential quarters of staff members of the university. Anthropogenic activity was predominant at site regardless of fragment of bushes and abandoned farms seen around. The vegetative cover of Opa Reservoir spillway stream (OR) and Biological Garden (BG) appeared similar, this was responsible for similarity in composition of species sampled at the two study sites. Very few aeshnids were collected in this study, this was probably because sampling was conducted in the day time, contrary to twilight when they (Aeshnidae) are active. Almost all aeshnids collected in this study were from Biological Garden (BG) except Health Sciences where a specimen of *Gynacantha manderica* was caught. Sometimes aeshnid may be encountered in the daytime if the forest is shaded. The aeshnids sampled at the Biological Garden (BG), include *Gynacantha manderica*, *Heliaeschna longifieldae* and *Heliaeschna sembe*. *Gynacantha manderica* sampled at the HS may probably be on transit (or disturbed) before been caught. HS was not having the right vegetative covering that could provide the right habitat for this fauna. Biological Garden where most of the aeshnids were caught was fairly shaded and cooler. This agreed with the observation of Amelia *et al*, (2006) which revealed that the aeshnids prefer shaded and cool sanctuary. It is however assumed that more species of Aeshnidae would have been collected if the sampling was carried out at twilight.

The presence of species of Aeshnidae, Chlorocyphidae and Calopterygidae at the BG is evidence that Biological Garden is ecologically healthy. These three families have low tolerant level for human disturbance, and are very sensitive to ecological habitat and environment changes (IUCN, 2010). The vegetation of the Staff Quarters and Health Sciences were regularly cleared so that the

environment will not be too bushy. This activity disrupts the natural habitat of odonates inhabiting the sites, and was responsible for few species recorded at the two sites. This observation is in line with the assertion made by (Watanabe, *et al.*, 2004) that vegetation covering can lead to decline in population of adult Odonata. This was also supported by Samways and Wilmot (2003) who stated that right vegetation covering can cause increase in species diversity. The paired Opa Reservoir and Biological Garden (OR/BG) had the highest score for the similarity test (Moderately Similar = 0.6). These study sites had so many things in common; they almost have the same number of species. OR had 24 species while BG had 23 species. The diversity indices values also revealed the closeness in the species diversity at the study sites; Simpson value for OR was 0.94, for BG 0.95, Shannon Weiner for OR was 2.96 and for BG = 3.05 and Margalef values for OR = 5.41 and BG = 5.08.

Although the University community was a 'bee hive' of activities at the period of this study, yet the ecological integrity was healthy as revealed by the outcome of biodiversity indices used. For instance Shannon-Weiner diversity index values at all the study sites were above 2.0 which was an indication of a stable habitat structure; values that are less than 1.0 indicate that there is pollution and degradation of the habitat structure (Arimoro and Ikomi, 2008). All the values were greater than 1.0 and this shows that the forest environment was in a healthy condition (Adu *et al.*, 2014). Other diversity indices used at all the study sites (Simpson range 0.85 - 0.95, Mangalef range 3.86 - 5.8) also confirmed this. Species distribution pattern as revealed by the evenness index shows that odonate fauna were well distributed in all the sites in the campus. For instance none of the values obtained fell below 0.5. The least evenness index value was 0.81 which was much closer to 1.0 than 0.5.

CONCLUSION AND RECOMMENDATION

Obafemi Awolowo University, Ile- Ife is the home of 36 species of dragonflies and damselflies. Approximately 69% of species sampled in the campus were Libellulidae, this is because member of the family are known to

have broad range of adaptation. Few species of Aeshnidae sampled in this study was because sampling was in the day time and Aeshnidae are nocturnal. It is also certain that nocturnal species must have been missed in this study. It is however recommended that further research and monitoring of forest species in campus should be carried out especially at the Biological Garden and at the Opa Reservoir spillway stream where the few stenotopic species were caught. Moreover, sampling at twilight and at night should be introduced so that nocturnal species can be monitored and recorded. Finally Obafemi Awolowo University Biological Garden should enjoy more protection so as to preserve scarce and localised fauna and flora members of the community.

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