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ODONATA BIODIVERSITY: AN INDICATOR OF ANTHROPOGENIC ACTIVITY IN APONMU FOREST, AKURE, SOUTHWESTERN NIGERIA

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ABSTRACT

Diversity assessment of Odonata (dragonflies and damselflies) in Aponmu forest was carried out to determine its composition, abundance, and distribution. Biodiversity of the taxon was also used as a measure of human activities in the forest. Three study sites were identified at the forest which were: "Ago-Store" Pond (AGO), "Alatori" stream (ALA) and River "Aponmu" (APO). Both adults and larvae specimens of Odonata were collected. Only advanced penultimate and ultimate larvae were collected and were reared to adults. Some physico-chemical parameters that influenced the existence of Odonata within the forest were also investigated. Diversity indices and inferential statistic were applied to the data collected at the forest. Water samples collected were analyzed so as to determine quality of water which houses the immature stages of the fauna. One thousand, three hundred and eighty five individuals were collected from the forest. Most of the species collected were ubiquitous. "Alatori" stream was the richest study site, while river "Aponmu" was the least. Generally, the study indicates that the dominance of ubiquitous species of Odonata with broad niches in the forest may be a result of anthropogenic activity going on in the forest.

Keywords: Biodiversity, Dragonflies, Damselflies, Forest

INTRODUCTION

Most forests in Sub-Sahara Africa are undergoing severe anthropogenic activities which altered the pristine nature of the forest. This alteration consequently caused a change in microclimatic condition of the forest and brings about erosion, flooding, global warming and green house effect. Terrestrial inhabitants of the forest especially shade lovers, nocturnal and crepuscular animals and the inland water dwellers such as sessile macro-invertebrates and other aquatic organisms are at the receiving end of the effect of anthropogenic activity.

Anthropogenic activities identified as stressor of water qualities in most Afrotropical forests, also influenced the vegetative structure of Aponmu forest. Such stressor include agriculture, hydromodification, urban runoff, and discharged of untreated waters from storm sewers (Njiru *et al*., 2008; Raburu, *et al*., 2009). Others are untreated animal wastes from abattoirs (Mathooko, 2001, Arimoro and Ikomi, 2008), domestic household waste and sewage (Rugguiero *et. al*., 2003; Adu, 2012). The consequential effects of these stressors include health problems and loss of biodiversity. Furthermore, most sub-Sahara Africa countries do not monitor the effects of these anthropogenic activities on the forest communities and often havoc would have been done before conservatory measures are anticipated. To prevent this situation there is need for regular assessment of the forests.

Biodiversity assessment of an ecosystem involves comparison of species richness which involves the use of indicator taxon (or taxa).

Selection of the indicator taxon was based on the knowledge of the taxonomy, ecology and distribution of the candidate taxon. The criteria mentioned above also warranted their selection as assessment instrument for the determination of environmental health and landscape status of the forest. The fact that dragonfly and damselfly exploit two different habitats during their lifetime makes them better indicator candidates than birds and butterflies; they can be used to determine the landscape status of both terrestrial and aquatic habitat. Dragonflies have a range of preference for different biotope, from permanent shaded sites to temporary pools (Corbet, 1999). The choice of different biotope by different species has been used as a means of determining the extent to which a landscape has been affected (Samways, 1993). Countries across the world that have used dragonflies as indicator species of environmental health and landscape status of forest include Japan, USA, and Australia (Darwall, *et al.* 2005) and South Africa (Samways, 1993, Clark and Samways 1994). It was therefore hypothesized that response of dragonflies and damselflies to anthropogenic activity can be used as a determinant of health status of a forest community. The objectives of this study are to determine the species composition, abundance and distribution, and also assess the effect of anthropogenic activities on the distribution of the insect fauna at the Aponmu forest

MATERIALS AND METHODS

The determination of the study site was based on two parameters. These were vegetation architecture and the diversity of water bodies in the forest reserve. The consideration of these two parameters was informed by the sensitivity of the insect to anthropogenic activities as well as climatic variability of the forest such as temperature, degree of shadiness and the type of water bodies. Brief description of the three study sites are presented in Table 1. The first study site was the bank of Aponmu River in Aponmu village (07°13.57′ N and 005°02. 92′E). This study site has experienced severe anthropogenic activities including deforestation and water pollution. The second study site was Alatori stream (07°12 30’ N and 005° 03 63’E). Alatori is a big stream that flows across the foot path leading to Babaoku village. Alatori stream is shallow (<0.9 m) and characterized by sandy/loamy substrate, boulders and some quantity of organic matters. The surroundings of the stream were characterized by trees that provided shade on some part of stream channel. Other riparian vegetation at the stream includes palm trees, crop trees, shrubs and grasses. The third study site was Ago-Store Camp; a small pond at the southern part of the camp (07°12. 54′ N and 005° 02.79′E).Ago-store Pond and vicinity is about 60 m^2. The pond is surrounded by short crop trees such as palm trees and cocoa trees, shrubs and grasses. A palm oil mill was located close to the pond. Liquid wastes from the mill were channeled into a small canal meant to drain water away from the pond. All adjoining temporary water bodies and upland vegetation within 300 m radius to each site form part of the study sites.

Table 1: Physical characteristics of the three study sites in Aponmu forest, Akure, southwestern Nigeria

Description	Ago-Store Pond (AGO)	Alatori Stream (ALA)	River Aponmu (APO)
Type	Pond/Wetland (Temporary)	Big Stream (Permanent)	Small River (Permanent)
Vegetation	Tree, oil palm tree, shrub, bamboo	Tree, tree crop, shrub	Tree, shrubs and grass
Insolation	Moderately opened	Some areas are opened	Opened

Water Clarity	Clear	clear	Clear
Bottom Substrate	Silt, detritus dead and organic matter	Sand and boulders	Rock, boulders sand and dead organic matter
Aquatic plants	Water lily, *Ficus* sp, *Oriza* sp.	Hornwort arrowhead etc.	Hornwort *Panicum sp. Oriza. Sp*
Human Disturbance	Clearing of the riparian vegetation, detergent, and waste from oil palm mill.	Trampling of vegetation by the grazing cattle, and detergent	Trampling of vegetation by the grazing cattle, waste from oil palm mill, domestic waste and human excrement Detergent, clearing of riparian vegetation.

Sampling and preservation of adult specimens

Sampling of the adults was carried out between 10.00 am and 4.00 pm under favourable weather conditions once every two months for a period twenty four months using insect sweep net of 70 cm wide orifice. All encountered species of dragonflies and damselflies were collected. In the laboratory, all adult specimens were killed by dipping them in acetone for a minute (Dijkstra per. Com.) after which each specimen was removed and body arranged in regular form and then soaked in acetone for a minimum of 12 hours. Hereafter the specimens were removed and then air - dried on a tissue paper. Each of the specimens was then kept in a transparent small nylon bag (2 x 4 cm) , sealed and then placed inside a 3 x 5 cm envelope. All envelopes were labeled with specimen locality including the study site, type of water body, name of water body, and date of collection. The specimens were then stored in insect boxes.

Identification of adult specimens

All specimens collected were identified to the lowest taxonomic level using standard identification manuals (Vick, 2003; Dijkstra and Clausnitzer (In press); Silsby and Trueman, 2002). They were also cross-referenced with over 2,892 images of Afrotropical Odonata species on the World Wide Web (www.africa-dragonfly.net/global/results).

Sampling larvae**:** Sampling of larvae was carried out between 9.00 am and 2.00 pm on every sampling day. Penultimate and ultimate larvae of dragonflies and damselflies were collected at the banks of the three study sites and were reared to adults at the laboratory. Banks of the water bodies were the best place to collect Odonata larvae since they need semi- submerged riparian vegetation as support during emergence (Chelmick, 2007).

Rearing of larvae

Aquaria were set up in an airy and shaded part of the laboratory. All the larvae were reared together in the laboratory under the same environmental condition. Each of the aquaria contained 2-3 cm deep dechlorinated water. Larvae were transferred into small rearing cages made out of metal netting rolled into a cylinder of 6 cm width and 15 cm height, and covered at the top with an inverted plastic petri dish. To ensure correct association of larvae and adults, only one larva was placed in each cage at a time to prevent cannibalism, (Samways and Wilmot, 2003). A stick was placed inside the cage as support, on which the larva climbs before the eclosion to teneral adult. To guarantee high quality standard of larvae that was reared, the cages were labeled according to the particular locality of specimens, including type of water body (e.g. River), name of waterbody (e.g. Aponmu), and date of collection. Maggots collected from poultry droppings were used to feed the larvae twice a day in place of aquatic macro-invertebrate such as insect larvae or other small aquatic animals of lesser sizes. Leftover food was removed every morning while the water in the aquaria was replaced every two days. Emerged teneral adult from aquarium were placed inside cuticle hardening netted-box for few hours to allow for cuticle harden, and then preserved for identification.

Water sampling

The physical and chemical characteristics of the water bodies at the study sites were investigated for a period of two years. Water samples were collected bimonthly from each site throughout the sampling period. This was done to determine the physical and chemical characteristics of the water bodies in the study sites. Seven parameters were determined. They are temperature (ambient and water), pH, conductivity, dissolved oxygen, turbidity, water current velocity and water depth. Water and ambient temperature was recorded using mercury-in glass thermometer. Conductivity, pH, turbidity, and dissolved oxygen (DO) was determined according to APHA (1998) methods. Water current velocity was estimated by displacement method, using a float, meter rule and stop clock as used in Schlosser (1992) and Adu (2007). Water depth was measured using a calibrated stick (Adu, 2007; Arimoro, 2008).

Data analysis

Species richness of the study sites was determined using diversity indices Margalel index, *d*, Shannon-Wiener index (H`), Evenness index (E) and Simpson's Dominion index (C). Data collected from physico-chemical analysis of water were analyzed using one-way analysis of variance (ANOVA).

RESULTS

A total of one thousand three hundred and eighty five specimens of Odonata were collected at the forest. Out of which six hundred and sixty seven were dragonflies while seven hundred and eighteen were specimens of damselflies. Most of the specimens were from Alatori stream (ALA) see table 2. Of the three study sites, Alatori Stream was most diverse in terms of species richness (H' = 4.21, Evenness = 0.95). Seventy one Odonata species were collected at the site (Alatori Stream) (see table 3). Although species distribution at the site was not the best, it was however good enough since its distribution in the site was 95%. All other diversity indices used were also high (Margalef 10.65; Simpson *d*: 0.98). River Aponmu (APO) had the least number of species (32) and was the site with the highest value of Evenness (E: 0.97).This revealed that the distribution of species of Odonata at the study site was the best when compared to other study sites at the forest. Shannon Wiener index (H': 3.44) and Margalef index (5.37) revealed that the site is the poorest in term of species diversity. However, Simpson dominance index (*d*: 0.97) revealed that the site was better than Ago-Store in terms of species dominance (*d* for AGO: 0.96). Thirty-five species of Odonata were represented at Ago-Store Pond (AGO). This was better than River Aponmu (APO: 32), Evenness was least in the forest (E = 0.92). Shannon –Wiener index (H`= 3.47) and Margalef index (5.87) revealed that the study site was richer than APO see table 3. Since all Evenness values obtained in all the study sites is closer to one than zero it can be deduced that the species distribution and relative abundance was good. Table 4 presents the mean values of physical and chemical variables at the study sites. Table 5 presents the water quality data range and analysis of variance (ANOVA) results for differences in water quality at the sites. There was significant relationship in the quality some of the physico-chemical parameters observed in the forest (pH, temperature, turbidity, and dissolved oxygen). Of the three hundred and forty eight (348) Odonata larvae reared, 42% emerged to teneral adults. Mortality rate was 58%, which shows that an average of four larvae survived, out of nine larvae reared bimonthly from each study site for a period of two years. Most times emergence took place at dawn, although some extend beyond. The rearing tank that housed larvae collected from AGO, had the highest percentage (16%), and followed by that of APO (14%). The tank with the least percentage of emergences was ALA (12%). The number of larvae reared and the number of insects (teneral adults) that emerged in the laboratory are shown in figures 1-3. The minimum duration before emergence was six days (*Acisoma panorpoides*). However, this was subject to the maturity of the larva at the time of collection (Corbet, 1999).

Table 2: **Checklist of Odonata fauna of Aponmu Forest**. Abbreviation: AGO = Ago-store pond, ALA = Alatori Stream, APO = River Aponmu

TAXA	FAMILY	AGO	ALA	APO	TOTAL
Gynacantha bullata Karsch, 1891	AESHNIDAE	16	0	0	16
Heliaeshna sembe Pinhey, 1962		14	0	0	14
Aethiothemis mediofasciata Ris in Martins, 1908	LIBELLULIDAE	9	0	0	9
Atoconeura luxata Dijkstra,2006		0	15	0	15
Atoconeura biordinata Karsch,1899		14	0	0	14
Atoconeura eudocia (Kirby,1908)		8	0	0	8
Brachythemis lacustris (Kirby,1889)		0	12	9	21
Brachythemis leucosticte (Burmeister,1839)		0	14	12	26
Bradinopyga cornuta Ris,1911		0	0	8	8
Congothemis dubia (Frazer,1954)		7	18	0	25
Congothemis leakeyi (Pinhey, 1955)		0	6	0	6
Congothemis erythraea (Brulle,1832)		0	8	0	8
Congothemis sanguinolenta (Burmeister,1839)		0	8	0	8
Lokia erythromelas (Ris,1910)		0	10	12	22
Micromacromia flava (Longfield,1947)		0	0	9	9
Neodythemis klingi (Karsch,1890)		0	6	0	6
Hadrothemis infesta (Karsch,1891)		8	12	0	20
Nesciothemi snigeriensis Gambles,1966)		0	8	7	15
Nesciothemis farinose (Forster,1898)		0	8	9	17
Nesciothemis pujoli Pinhey,1971		0	10	0	10
Orthetrum africanum (Selys,1887)		0	6	0	6
Orthetrum brachiale (Palisot de Beauvois,1817)		18	8	12	38
Orthetrum caffrum (Burmeister,1839)		0	8	0	8
Orthetrum chrysostigma (Burmeister,1839)		24	13	13	50
Orthetrum hintzi Schmidt,1951		0	9	0	9
Orthetrum kristenseni Ris, 1911		5	0	0	5
Orthetrum Julia Kirby,1900		5	16	11	32
Orthetrum machadoi Longfield,1955		0	6	0	6
Orthetrum sabina (Drury,1773)		4	0	8	12
Orthetrum stemmale (Burmeister,1839)		8	8	9	25

Chalcostephia flavifrons Kirby,1889		8	12	9	29
Palpopleura albifrons Legrand,1979		7	0	7	14
Palpopleura lucia (Drury,1773)		10	14	12	36
Palpopleura portia (Drury,1773)		13	17	11	41
Sympetrum fronscolmobii (Selys,1840)		0	6	0	6
Sympetrum navasi Lacroix,1921		0	8	8	16
Trithemis aenea Pinhey,1961		0	0	9	9
Trithemis arteriosa (Burmeister,1839)		14	0	13	27
*Trithemis dichroa*Karsch, 1893		0	5	0	5
Trithemis grouti Pinhey,1961		6	0	0	6
Trithemis imitate Pinhey 1961		0	10	0	10
Phaon iridipennis (Burmeister, 1839)	CALOPTERYGIDAE	0	15	7	22
Saphon ciliate (Burmeister, 1839)		0	9	0	9
Ummac incta (Hagen in Sélys, 1853)		0	6	0	6
*Umma declivium*Förster, 1906		0	5	0	5
Umma mesostigma (Selys, 1879)		0	11	0	11
Umma saphirina Förster, 1916		0	11	0	11
Umma mesumbei Vick, 2003		0	13	0	13
Chlorocypha centripunctata Gambles, 1975	CHLOROCYPHIDAE	0	12	0	12
Chlorocypha consueta (Karsch, 1899)		0	14	0	14
Chlorocypha dahlia Fraser, 1956		0	10	0	10
Chlorocypha autorea		0	9	0	9
Chlorocypha luminosa (Karsch, 1893)		0	10	0	10
Chlorocypha victorae (Förster, 1914)		0	9	0	9
Chlorocypha dispar (Palisot de Beauvois, 1807)		0	12	0	12
Chlorocypha glauca (Selys, 1879)		0	7	0	7
Chlorocyph acurta (Hagen in Selys, 1853)		0	17	0	17
Chlorocypha radix Longfield, 1959		0	13	0	13
Chlorocypha flammea Dijkstra,2009		0	9	0	9
Chlorocypha trifaria (Karsch, 1899)		0	8	0	8
Chlorocypha pyriformosa Fraser, 1947		0	7	0	7
Platycypha auripes (Förster, 1906)		0	5	0	5
Platycypha eliseva Dijkstra, 2008		0	4	0	4

Aciagrion hamoni Fraser, 1955	COENAGRIONIDAE	0	9	0	9
Africallagma vaginale Sjostedt,1917		7	12	0	19
Agriocnemis falcifera Pinhey, 1959		0	0	13	13
Ceriagrion glabrum (Burmeister, 1839)		0	9	14	23
Ceriagrion suave Ris, 1921		0	9	11	20
Ceriagrion whellani Longfield, 1952		8	0	0	8
Ischnura senegalensis (Rambur, 1842)		10	10	12	32
Pseudagrion bernadi Terzani, 2001		12	0	0	12
Pseudagrion bicoerulans Martin, 1907		9	0	9	18
Pseudagrion kersteni (Gerstäcker, 1869)		13	18	12	43
Pseudagrion melanicterum Selys, 1876		0	13	0	13
Pseudagrion risi Schmidt, 1936		14	15	12	41
Pseudagrion sublacteum (Karsch, 1893)		0	12	0	12
Pseudagrion torridum Selys, 1876		0	8	0	8
Teinobasis alluaudi (Martin, 1896)		0	8	0	8
Mesocnemis saralisa Dijkstra, 2008	PLATYCNEMIDIDAE	7	8	0	15
Mesocnemis singularis Karsch, 1891		*8*	*10*	*8*	26
Oreocnemis phoenix Pinhey, 1971		*5*	*8*	*3*	16
Platycnemis nyansana Forster,1916		*3*	*0*	*9*	12
Chlorocnemis nigripesi Selys, 1886	PROTONEURIDAE	11	10	0	21
Chlorocnemis superb Schmidt, 1951		*0*	*8*	*0*	8
Elattoneura centrafricana Lindley, 1976		*10*	*8*	*0*	18
Elattoneura incerta Pinhey, 1962		*12*	*12*	*0*	24
Elattoneura glauca (Selys, 1860)		*11*	*0*	*0*	11
Elattoneura nigra Kimmins, 1938		*10*	*14*	*0*	24
Elattoneura lliba Legrand, 1985		*0*	*10*	*11*	21
Elattoneura pasquinii Consiglio,1978		*0*	*8*	*0*	8
Elattoneura vrijdaghi Fraser, 1954		*0*	*0*	*12*	12
	TOTAL	348	716	321	1385

Table 3: Diversity of dragonflies and damselflies in the three study sites of Aponmu Forest, Akure Southwestern, Nigeria

	AGO	ALA	APO
Total no. of individuals	348	716	321
Total no. of taxa	35	71	32
Margalef index *d*	5.81	10.65	5.37
Shannon-Wiener index (H`)	3.47	4.21	3.44
Simpson's Dominance index (c)	0.96	0.98	0.97
Evenness (E)	0.92	0.95	0.97

Table 4: The mean and standard deviation values of physical and chemical factors at the three study sites in Aponmu Forest. AGO: Ago-store Pond, ALA: Alatori Stream, and , APO: River Aponmu

Study Site	pH	Conductivity (µmho/cm)	Turbidity NTU	Ambient Temp. (°C)	Water Temp. (°C)	DO (mg/l)	Water current velocity (m/s)	Water depth (cm)
AGO	7.43±0.15	179.33±4.81	0.03±0.01	28.83c±0.27	25.33±0.41	8.58±0.23	0.25±0.03	4.15±0.36
ALA	7.43±0.13	184.25±6.37	0.02±0.00	28.13±0.28	24.13±0.44	10.15±0.37	0.28±0.02	3.84±0.19
APO	7.46±0.08	193.25±9.41	0.04±0.01	29.33±0.35	25.50±0.55	9.48±0.35	0.27±0.02	4.23±0.16

Table 5: Water quality data range and ANOVA results for differences in water quality at the three study sites. AGO: Ago-Store Pond, ALA: Alatori Stream and APO : River Aponmu.

	AGO	ALA	APO	df	F.Statistics	F.critical
*pH	6.8 - 8.27	6.88 - 8.27	7.1- 8.04	7	4.93	3.79
Conductivity (µmho/cm)	150 - 202	150 - 240	150 - 264	7	3.23	3.79
*Turbidity (NTU)	0.01- 0.06	0.01 – 0.04	0.01 - 0.08	7	3.87	3.79
*Ambient Temp. (°C)	28 -31	27 -30	27 - 30	7	4.60	3.79
*Water Temp. (°C)	22 -27	22 - 26	22 - 27	7	4.24	3.79
*Dissolved oxygen (mg/L)	7.6 -10.86	8.63 - 11.54	8.1 - 11.58	7	3.87	3.79
Water curr.vel. (m/s)	0.01 – 0.03	0.24 - 0.45	0.2 - 0.46	7	1.04	3.79
Water depth (cm)	6.9 – 8.6	2.5 - 4.6	3.3 – 4.9	7	1.26	3.79

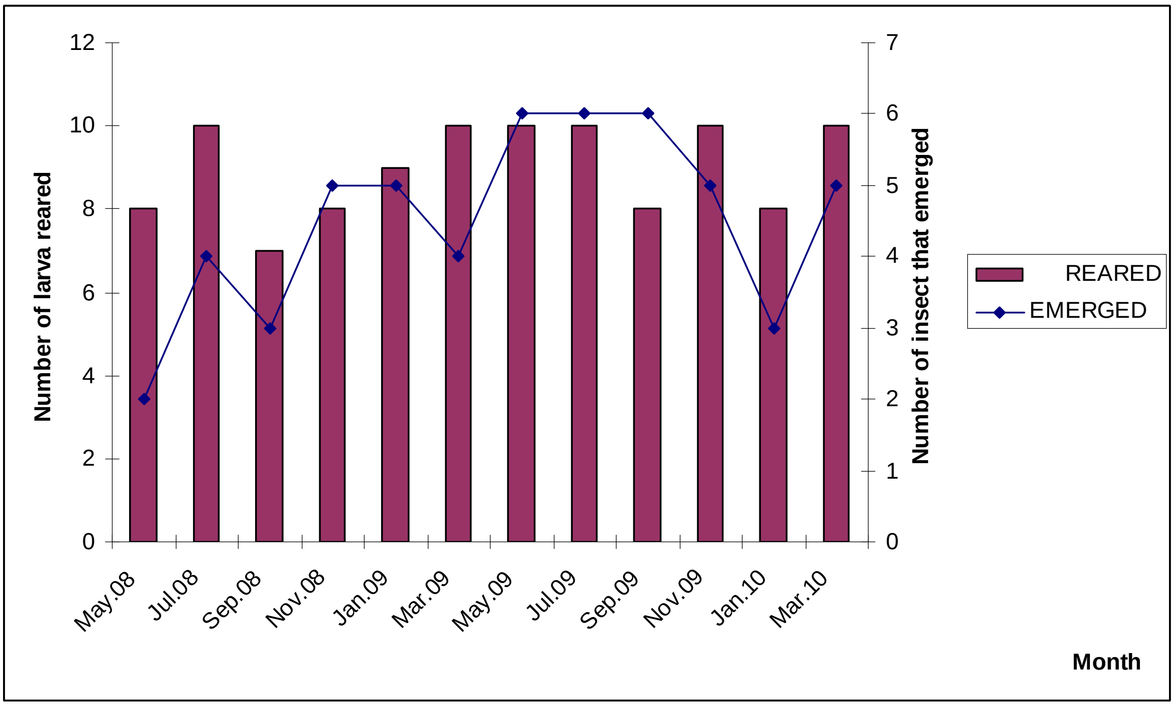

Figure 1: Emergence of Odonata adults from larvae collected from Ago-Store Pond

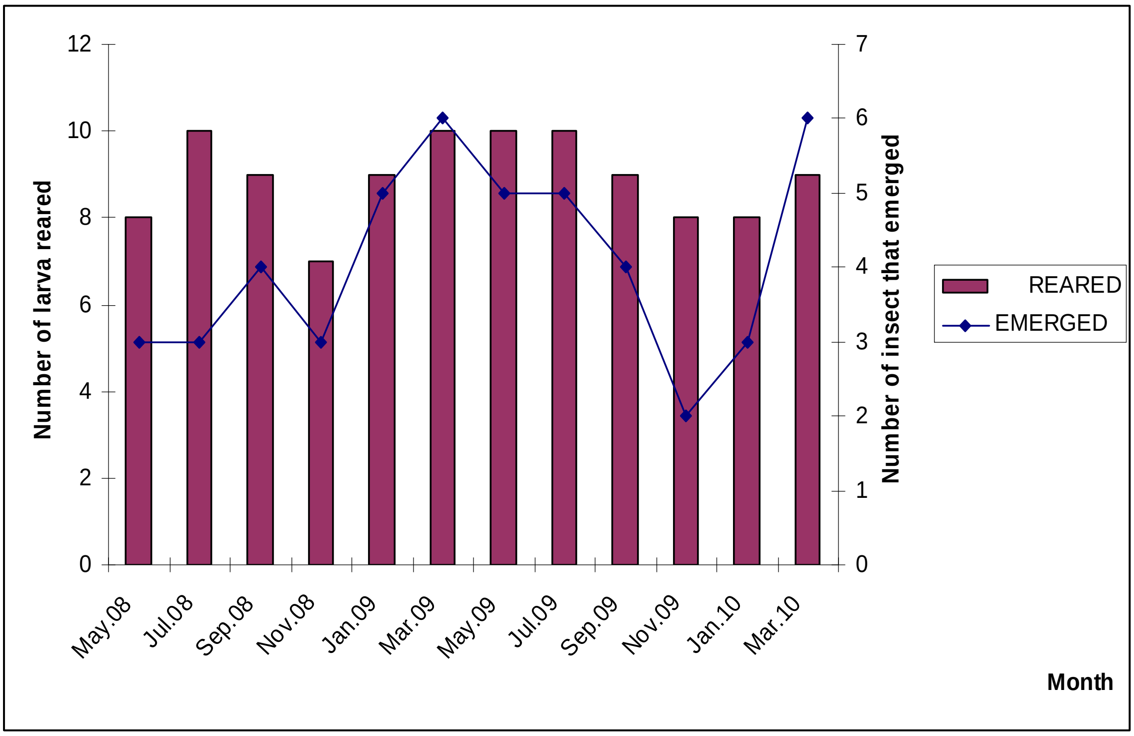

Figure 2: Emergence of Odonata adults from larvae collected from Alatori Stream

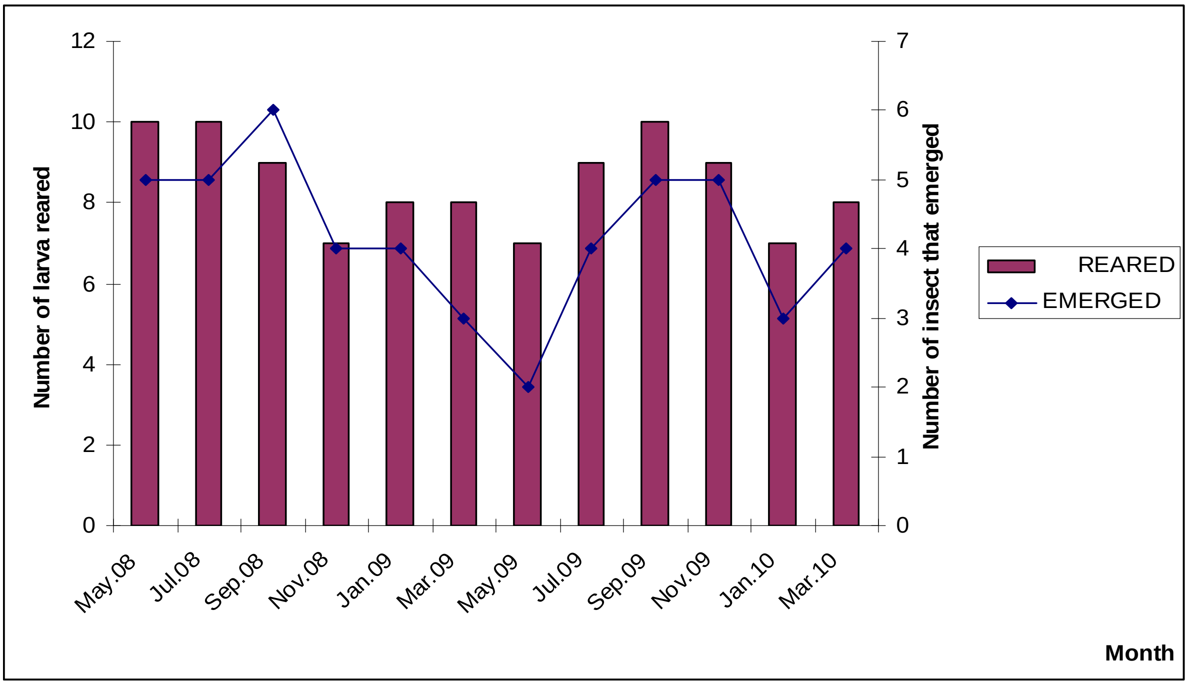

Figure 3: Emergence of Odonata adults from larvae collected from River Aponmu

DISCUSSION

The general attributes of the physical environmental variables exhibited at the study sites agreed with most of the previous studies carried out in tropical inland waters (McLachlan, 1977; Vick, 2003; Chelmick, 2007). Temperature affects many of the physical, chemical and biological characteristics of water bodies. It affects the amount of dissolved oxygen, rate of photosynthesis and metabolism of Odonata larvae found in the study sites. Larvae are found to burrow into the sediments in high temperature waters (Corbet, 1999). The survival of larvae dwelling in intermittent water bodies are determined by the temperature of the air. Therefore ambient temperature is an important physical factor that determines the behaviour, morphological and physiological changes in Odonata (Corbet, 1999). It also plays a significant role in the emergence of the larvae to teneral adults (Sternberg, 1996). The pond-dwelling Odonata can tolerate high temperatures better than those that inhabit streams and rivers. Naturally flowing water has a low temperature when compared with stagnant water without canopy. The differences in the microclimatic condition of the water bodies (pond and flowing water) was responsible for the diversity in Odonata fauna occurring at the study sites

Shaded part of Aponmu is characterized by lower ambient temperature, which is typical of Afrotropical forest. Parts of the study sites have vegetation canopy over the water channels. This caused the temperature of the water to be lower than that of surrounding open water. Parts of Alatori Stream (ALA) have tree canopies over their waters, thereby making them to have low temperatures. The lower ambient and water temperature that was experienced in part Alatori Stream (ALA) was responsible for the occurrence of shade lovers such as *Elattoneura*, and *Chlorocnemis* species (Protoneuridae), *Atoconuralaxata* (Libellulidae), *Saphociliata* (Calopterygidae) and crepuscular species of Aeshnidae(*Gynancanthan* spp).
Most species with narrow niches (stenotopic) found in open waters are brightly coloured. This

was partly influenced by ambient temperature of the environment, a phenomenon known as Reversible Temperature-induce Colour Change (RTCC). Species that are dull coloured upon maturation are not usually influenced by RTCC (O'Tarrel, 1964 and Corbet, 1999). In this study RTCC was noticed in brightly coloured zygopterans such as *Chlorocypha*, *Platycypha*, and *Umma* species as occurred in Alatori Stream. In Anisoptera, RTCC occur in *Sympetrum fronscolombii* and *Thermochoria equivocate*.

The presences of pruinose in some genera of Anisoptera and Zygoptera have been attributed to maturity and environment vicissitude (Dijkistra, 2007). Ambient temperature plays major role in environment vicissitude in tropical forest (Dijkstra, 2007). Dull coloured Odonata usually love shaded places and may not pruinose when mature. However, they can develop a sort of camouflage pigment which has also been attributed to the effect of RTCC on the insect (Corbet, 1999).

Ambient temperature influences emergence processes in Odonata. It determines the metabolic processes leading to the withdrawal of insect larvae from the water, the duration of emergence, and the maiden flight. Low ambient temperature delays emergence especially among the bigger species which need a higher ambient temperature for their emergence before dawn.Higher temperature reduces the emergence duration (Trottier, 1973). Low ambient temperature is one of the reasons while nocturnal emerger emerges during the day time (Corbet, 1999; Do, 2011). Emerging in the day time increases the risk of being killed by predators (Thompson, 1990).

The duration for emergence is not the same in all species. Smaller species carry out ecdysis at a shorter duration than the larger ones. For instance a final instar of *Acisomapanorpoides* larva reared in the laboratory in this study emerged 6 days after collection from the river while that of *Notogomphusspinosus* (larger larva) also reared in the laboratory emerged 47 days after collection from the site.

Turbidity and conductivity affect adult Odonata in their choice of where to oviposit, since the two variables often serve as visual cues to adults detecting polarization and reflected light suitable for habitat (Bernath *et al.*, 2002). Naturally, turbid water is repulsive to adult Odonata. The population of larvae in turbid water is always very low when compared with clear water. All the study sites in this study have clear water which was not repulsive to adult Odonata. Conductivity level of the water bodies in this study was mild and could not have negatively affected the osmoregulation process of the insect larvae in the waters.Conductivity is only known to affect Odonata larvae when it is strong enough to interfere with osmoregulation (D'Amico *et al.*,2004).

Odonata larvae respond more to other environmental factors than pH (Corbet, 1999) and can tolerate wide range of pH from strongly acidic (pH 4.0) to strongly alkaline (pH > 8.1). The pH levels of the water in all the study sites are of no effect on their Odonata species composition. For instance pH range of Alatori Stream (with occurrence of 9 Odonata families) was 6.88 – 8.27. It should be observed that Ago-Store Pond (pH 6.8 - 8.27) and River Aponmu (pH 7.1- 8.04) whose pH range falls within that of Alatori Stream have five Odonata families inhabiting their water bodies. Almost all Odonata species inhabiting in the two study sites (AGO and APO) occurred at Alatori Stream. With this observation it can be deduced that Odonata species are fairly in sensitive to pH (Brooks 1994) and it effects on the taxon is not significant. For instance the pH range for the entire study site was between 6.58– 8.27 which had no visible effect on the composition of Odonata fauna of the forest. However Megan (1999) found out that *Ladona julia* was found to be uncommon in acidic habitat while *Leucorrhinia glacialis* was extremely abundant (Megan, 1999). Therefore Odonata species of Aponmu forest can tolerate wide range of pH. This observation is in agreement with the findings of Cannings and Cannings (1994) that stated that Odonata species seemed to respond more to habitat's form and structure than to its acidity and or general nutrient level. Brooks (1994, 1996) stated that Odonata species are relatively insensitive to pH and that species said to be associated with acid water or alkaline are not so much influenced by such condition.

Odonata larvae that inhabit lentic waters (Ponds and Lakes) are found predominantly at the edges, of less than one meter deep. Edges of ponds or lakes are richer in dissolved oxygen than deeper part of the water. Also aquatic macrophites at the water banks are oviposition sites for the mature female insects (Wissinger, 1988). Usually Odonata larvae do not occur deep below 9 meters (Corbet, 1999). When larvae are found in greater depth, they must have accompanied submerged macrophites that got sunk into the bottom of the water (Thonp and Diggiins, 1982). This suggests the reason while all the larvae collected in this study were from the bank of the waters.

CONCLUSION

Most stenotopic species of dragonflies and damselflies of Aponmu Forest appeared to survive in fragments of forest that remain. The absence of some of stenotopic species of Odonata at AGO and APO is a signal that urgent measure should be taken to preserve the natural resources in the forest. Also the survival of the remnants stenotopic species at the forest is doubtful in a few years to come if no action is adequately taken to preserve the forest biodiversity. Therefore the anthropogenic activities going on in the forest should be controlled so that the few forest species and other organisms in the forest would be preserved. With the situation on ground one can conclude that Aponmu forest has lost most stenotopic Odonata fauna which is an evidence that other organisms cohabiting with the lost Odonata fauna would have been lost in the forest as a result of human activities in the forest.

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