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Odonata Fauna in Different Types of Vegetation in Ozamiz City, Philippines

Karen M. Tumala[1], Jonry G. Lim[2], Emmarie F. Mapi-ot[2]

[1]High School Department, Misamis University Oroquieta Unit, Oroquieta City, Philippines
[2]Natural Sciences Department, College of Arts and Sciences,
Misamis University, Ozamiz City, Philippines
Corresponding author: Emmarie F. Mapi-ot, email: efmapiot@yahoo.com

Abstract

Odonata is a good environmental indicator. It is sensitive to changes in temperature and weather conditions. The distribution variability of various groups and species of Odonata depends on the habitat and vegetation types. This study aimed to determine the Odonata fauna in different types of vegetation in Ozamiz City. Field sampling using sweep nets was done in agroforest, agricultural, and mangrove areas from January to March 2014 with a total of 180 man-hours. Taxonomic keys and published photographs were used in the identification process. Thirteen species were identified, of which one species is endemic. Family Libellulidae was the dominant family in all vegetation types. The presence of stenotopic endemic species (*Prodasineura integra*) in the agroforest of Site A indicates a good quality habitat for the species. Cluster analysis showed that Odonata species in agroforest and agricultural vegetation have closer similarities. Low diversity was recorded in all vegetation sites. The presence of eurytopic species indicates that the sampling areas are relatively disturbed. Low species richness, diversity, and endemism in all types of vegetation indicate that the disturbed sampled areas could not provide the suitable habitat for Odonata.

Keywords: abundance, dendrogram, habitat, indicators, Libellulidae

Introduction

The widely studied group of insects in the Order Odonata (dragonflies and damselflies) has the potential to indicate the quality of the environment based on the vegetation types. There are about 5,952 extant species of Odonata (30 families, 652 genera), of which 2,941 belong to the suborder Zygoptera (18 families, 308 genera), about 3,011 species belong to the Anisoptera (11 families, 344 genera), and two species of one genus to the suborder Anisozygoptera (Dijkstra et al., 2013).

Odonata is an attractive insect and is an important indicator of water quality (Dolný, 2000). Dragonflies and damselflies as flagship species are significant components of ecosystems, in which they can often be the top predators. Several studies conducted include Odonata relationships with water quality (Azrina et al., 2006), biotope quality (Clark & Samways, 1996; Clausnitzer, 2003), and species richness (Sahlén & Ekestubbe, 2001). The sensitivity of Odonata to environmental conditions makes it excellent biological indicator of environmental conditions (Clark & Samways, 1996; Samways et al., 2010). Its persistence in water is the result of the ecological requirements of adults in the aquatic and terrestrial environment, their selectivity of sites for oviposition, and the effect of aquatic operations while they are still larvae (Corbet, 1999). These characteristics give rise to the close association between each species and its unique habitat. Odonata is susceptible to particular types of habitat changes (Clark & Samways, 1996; Chovanec & Waringer, 2001; Lee Foote & Rice Hornung, 2005). Hence, it is also known as biocontrol agent. Many species of Odonata inhabiting agroecosystems play a crucial role controlling pest populations (Tiple et al., 2008).

Increasing human activities subject many ecosystems to great stress resulting in many species disappearing before any conservation actions take place. Since organisms require certain habitat, the knowledge of their relation to their habitat and vegetation is critical for establishing conservation and management plans (Maleque et al., 2006). There is often a positive correlation between the adult Odonata diversity and abundance with local abundance of vegetation (Remsburg et al., 2008).Vegetation provides critical habitat for Odonata during the larval, adult, and emergence phases of its life cycle. Hence,

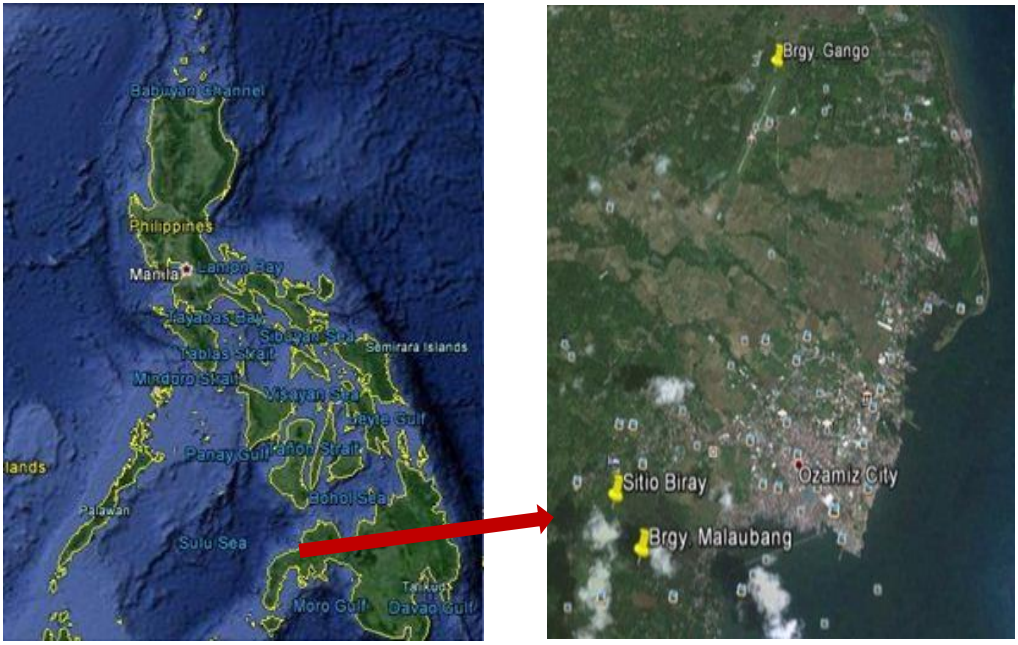
this study aimed to determine the Odonata fauna in different types of vegetation in Ozamiz City. Specifically, the abundance, distribution and diversity of Odonata species were determined in agroforest, agricultural and mangrove areas. The study also aimed to assess the quality of the living conditions of Odonata and describe the habitat characteristics using the environmental parameters of the three different vegetation types.

Materials and Methods

Study area

Ozamiz City is the study area. The location of the city is in the southern part of the province of Misamis Occidental. The City nestles at the western side of the entrance of Panguil Bay in Region 10 in Northwestern Mindanao. The Municipality of Clarin is the northern boundary of the city. Iligan Bay and Panguil Bay are bounding the east, separating the city from the two geographically nearby cities Cagayan de Oro and Iligan. Tangub is the southern boundary while the Municipality of Don Victoriano is bounding the west part.

Figure 1 shows the map of Ozamiz City and the location of the three sampling sites. Site A (Sitio Viray, Brgy. Molicay) is an agroforest. Site B (Brgy. Gango) is an agricultural area. Site C (Brgy. Malaubang) is a mangrove area.



Site A. Brgy. Molicay Sitio Viray

Site B. Brgy. Gango

Site C. Brgy. Malaubang

Figure 1. Map of Ozamiz City and the three sampling sites (http://www.google.com.ph/maps, 2014).

The geographical location of Site A is 8°10'41.07'' N 123°49'17.85'' E (Figure 2). It is an agroforest along the Labo River located at 722.07 meters above sea level (masl). Trees (*Acacia* sp., *Cocos nucifera*), bushes (*Eugenia* sp., *Loheria* sp.) and carabao grasses (*Paspalum conjugatum*) were the dominant plants observed in the area. The place is the passageway for people. Many tadpoles and water striders (*Gerris s*p.) inhabit the mini pond found adjacent to the river.

Figure 2. Agroforest in Site A.

The geographical location of Site B is 8°11'13.70" N 123°50'46.11" E. The site is at 505.05 masl. Agricultural plants such as banana (*Musa* sp.) and corn (*Zea mays*) were observed in the area (Figure 3). The site is along the Labo River which serves as the primary source of water for the farmers. Grasses and vines were the dominant riparian vegetation in the area.

Figure 3. Agricultural area in Site B.

The geographical location of Site C is 8°08'23.20" N 123°49'25.84" E. The site is at 208.18 masl. The people in the area refer to this place as the fish sanctuary. Mangroves were the dominant vegetation in the area. The waters are brackish. Tidal influx coming from the adjacent sea affects the area. A mango tree (*Mangifera indica*) provides shade in the area where zygoptera Odonata species could thrive (Figure 4). The place is near the residential area and serves as a common passageway for the people.

Figure 4. Mangrove area in Site C.

Sampling process, identification, and analysis of data

The sampling period was from January to March 2014 with a total of 180 man-hours. Opportunistic sampling was done for the three sampling sites. Sweep nets were used to collect Odonata specimens for identification and preservation in the laboratory. The samples were stored in small envelopes or folded paper triangles. Soaking the samples in acetone for about 24 hours and drying them ensured the proper preservation of the specimen in case there would be a need to verify further their identification. Taxonomic keys and published photographs were used to identify the samples. Identification was verified by an expert. BioDiversity PRO software version 2.0 was used to determine the Shannon-Weiner diversity index and to run the cluster analysis for Odonata species. Air humidity and atmospheric temperature are important parameters measured at the sampling sites.

Results and Discussion

Table 1 shows 13 species of Odonata belonging to three families (Coenagrionidae, Protonueridae, and Libellulidae) recorded in the area. *Prodasineura integra* (Figure 5) is an endemic species while all others are oriental species. Family Libellulidae under the suborder Anisoptera dominated the three sampling sites. Similar result was shown in earlier studies in other areas of the Philippines (Quisil et al., 2014; Mapi-ot et al., 2013; Villanueva & Mohagan, 2010) and other countries (Tang et al., 2010). Among those belonging to Family Libellulidae, *Diplacodes trivialis* (18.18%), *Orthertum sabina sabina* (16.83%) and *Neurothemis ramburii* (13.64%) were common species in three sampling sites. Family Libellulidae constitutes the highest abundance (eight species) because the species of this group are widespread and common that breed in ponds, lakes, marshes, irrigation canals, rice and corn fields (Clausnitzer, 2003). These species reproduce principally in still waters or lentic habitats, although larvae of some species are stream dwellers (Gillott, 2005). They are high-flying insects and can tolerate any type of growing vegetation.

Table 1. Species composition and distribution of Odonata in Ozamiz City.

Suborder	Species	Distribution	No. of individuals per site			Total	*RA (%)
			A	B	C		
Zygoptera	**Family Coenagrionidae**						
	Agriocnemis sp.	Oriental	8	6	-	14	9.09
	Agriocnemis femina femina	Oriental	12	-	-	12	7.79
	Agriocnemis rubescens intermedia	Oriental	-	-	2	2	1.30
	Ischnura senegalensis	Oriental	-	-	5	5	3.25
	Family Protoneuridae						
	Prodasineura integra	Endemic	3	-	-	3	1.95
Anisoptera	**Family Libellulidae**						
	Diplacodes trivialis	Oriental	7	9	12	28	18.18
	Tholymis tillarga	Oriental	4	-	-	4	2.60
	Orthetrum sabina sabina	Oriental	8	10	8	26	16.83
	Agrionoptera insignis	Oriental	-	-	4	4	2.60
	Neurothemis sp.	Oriental	-	8	-	8	5.19
	Neurothemis ramburii ramburii	Oriental	6	8	7	21	13.64
	Trithemis aurora	Oriental	8	10	-	18	11.67
	Macrodiplax cora	Oriental	-	-	9	9	5.84
Total no. of species	**13**		**8**	**6**	**7**		
Total no. of individuals	**154**		**56**	**51**	**47**		
Total no. of endemic species	**1**		**1**	**0**	**0**		

*RA-Relative abundance

Figure 5. *Prodasineura integra* **in tandem (Philippine Endemic).**

Many species of Libellulidae are adaptable to various environments with a wide variety of habitats. They can also thrive in waters with low dissolved oxygen levels or the highly eutrophic environment, and a few species can thrive the brackish waters (Farizawati et al., 2014). Some species belonging to family Libellulidae can glide or take migratory flights. (Tennessen, 2003). The studies of Kalita and Ray (2015), Basumatary et al. (2015), and Farizawati et al. (2014) reported a high abundance of organisms under family Libellulidae. The group consists of many eurytopic species that are flexible in extremely varied habitats and are able to tolerate pollution (Orr et al., 2004). In the study of Steytler and Samways (1995) in an artificial lake created for insect conservation in South Africa, dragonflies of the Family Libellulidae that colonized the area were eurytopic and vagile. Marinov (2011) also found a dragonfly species of the Family Libellulidae that was well adapted to various environmental situations.

In this study, most of the eurytopic libellulids were found in the three sampling sites. The dragonfly *Diplacodes trivialis* belonging to Family Libellulidae is a widespread eurytopic species that was recorded in the three sampling sites. This eurytopic species is also common in streams in a forest reserve that occupies most of a school campus in

Malaysia (Choong et al., 2008). *Orthertum sabina sabina* is also a eurytopic species that is very tolerant to habitat disturbance (Mitra, 2013). *Neurothemis* sp. is also a eurytopic species that does not require forest as essential habitat and continue to flourish even in disturbed habitat (Orr, 2006).

Site A (agroforest area) has the greatest number of individuals (56) belonging to three families with Libellulidae as the highest in number. Endemic species (*Prodasineura integra)* collected was from this site. This endemic species inhabits areas with suitable vegetation (Villanueva et al., 2011; Villanueva & Mohagan, 2010). The presence of *Prodasineura integra* indicates that the agroforest in Site A – Sitio Viray has a relatively good quality occupying area due to the presence of numerous shaded areas to which this endemic species can thrive. Majority of the Philippine endemic species of Odonata are forest specialists and prefer pristine areas. They are stenotopic species and highly sensitive to habitat disturbance (Clausnitzer, 2003). Forest species are highly sensitive to water quality and the water should be presumably free of chemical pollutants. The physical pollution by high sediment load in the water possibly is not favorable for larval growth, consequently affecting adult density and composition (Villanueva, 2010). Hence, from management point of view, it is important to consider conservation effort for the stenotopic species that are highly sensitive to habitat changes and are often confined in less disturbed areas.

The presence of water bodies in the area was ecologically significant because they support concrete and significant hydrological, chemical and biological processes for stenotopic species (Malawani et al., 2014). Despite the presence of *Prodasineura integra* in Site A, majority of the Odonata species recorded in the area were eurytopic which still indicates habitat disturbance. Nevertheless, the presence of shaded patches in Site A may have supported the highly sensitive stenotopic species, *Prodasineura integra.*

In Site B (agricultural area), six species were recorded. All species collected were oriental in distribution. *Neurothemis* sp. was documented only from Site B and not in other sampling sites. This species is quite tolerant to its aquatic environment (Amelia et al., 2006) and thrives well in this area. Site C (mangrove area) has the lowest number of individuals (47 individuals) collected that belong to seven species of family Libellulidae and Coenagrionidae. However, *Agriocnemis rubescens intermedia*, *Ischnura senegalensis*, *Agrionoptera insignis* and *Macrodiplax cora* are four species collected from the mangrove area but not sampled from the other sites. According to Chandana et al. (2012), mangrove ecosystem provides habitat for millions of insects which in turn supply foods for Odonata. The low abundance of Odonata in Site C may be attributed to water salinity. Odonata nymphs are more sensitive to salinity gradient (Kosterin, 2010; Chandana et al., 2012).

The similarity of species composition using Bray-Curtis cluster analysis showed that Site A (agroforest) and Site B (agricultural area) are of closest similarities (Figure 6). The finding may be due to the vegetation types of the two areas. They both have a river ecosystem with the same source, and they have the closest similarities. Whereas, Site C (mangrove area) was the least similar. This site shares a few species. Salinity might be one of the factors affecting the abundance of species in the area (Kosterin, 2010). Although salinity gradient was relatively small, it appeared to influence the plant-associated macroinvertebrate richness and density like the Odonata negatively. As salinity decreases, the abundance of most macroinvertebrate thriving in plants also decreases (Brucet et al., 2012). Thus, the result of the survey implies that the species were not able to establish an excellent assemblage, and the community is not a favorable habitat in general for Odonata species, resulting to unique Odonata dwellers in this site.

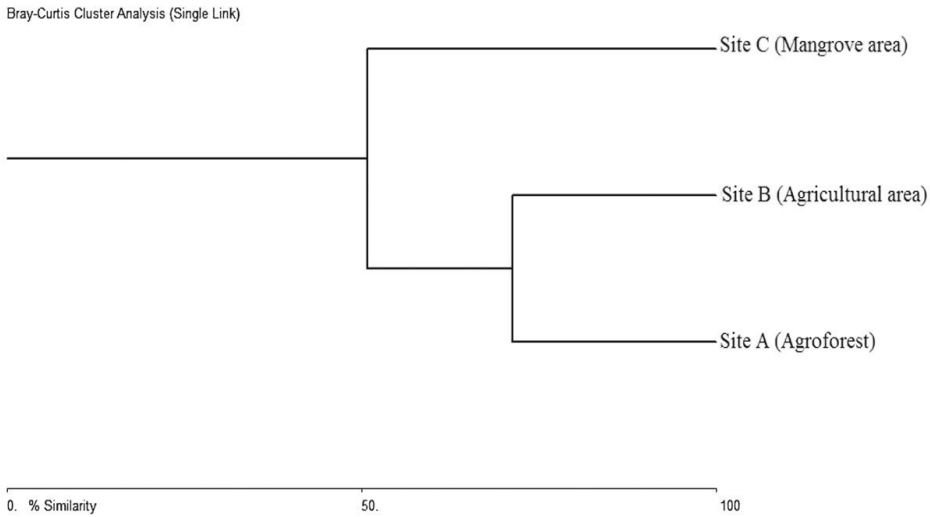


Figure 6. Dendrogram of cluster analysis of Odonata species composition in the sampling sites.

The number of species and their equitability or evenness affects the Shannon-index. According to Magurran (2013), a more even distribution characterizes the greater number of species. Shannon-Weiner diversity index was low at all sampling sites (Table 2). The result indicates that the sampling sites are relatively disturbed due to anthropogenic disturbances such as the presence of passageways and human settlements near the sampling sites. Disturbances are most influential for Odonata (Remsburg et al., 2008). As stressed by Oppel (2006), habitat disturbance even for small-scale subsistence farming has a tremendous impact on Odonata diversity. The sampling sites were located in the lowlands which are generally more suitable for tolerant species. Location of the sampling sites played an important factor in determining diversity and richness of Odonata. The richness of the community was limited to widespread species due to suitability and adaptability to their habitat (Hawking & New, 1999).

All sites appeared to have an even distribution indicating that there is no competition among species. *Diplacodes trivialis*, *Orthetrum sabina sabina* and *Neurothemis ramburii ramburii* in three sites contribute to the evenness of the Odonata species. These species are eurytopic and could inhabit a wide-range of environmental conditions

which have contributed to the evenness of species. The presence of these Libellulidae species could be attributed to the habitat condition of which these species favor sandy bottom with small rocks and considerable amount of sunlight (Westfall & Tennessen, 1996). The value of evenness in Site C was relatively small due to some factors such as its mangrove type of vegetation and salinity gradient. According to Aspacio et al. (2013), vegetation type affects dragonfly diversity and abundance. The result only implies that in undisturbed habitats, the abundance of Odonata is more of endemic and vulnerable highly sensitive stenotopic species, which prefer clean water systems. Whereas, in disturbed habitat, widespread and common eurytopic species were abundant because of their tolerance to the anthropogenic pressures present in the area. Malawani et al. (2014) reported competition of species for food and territory influences mainly the evenness value.

Table 2. Biodiversity indices of Odonata in three sites.

Indices	Site A. Brgy. Molicay-SitioViray	Site B. Brgy. Gango	Site C. Brgy. Malaubang
Shannon	0.828	0.81	0.782
Dominance	0.845	0.845	0.845
Evenness	0.979	0.959	0.925

Table 3 shows readings of temperature and relative humidity, and the number of individuals collected during the sampling period. Results showed that in higher temperature and lower relative humidity, a large number of samples was collected. Several authors reported that various environmental factors such as temperature, humidity, rainfall, vegetation, and food sources directly affect the diversity and distribution of insect populations (Morais et al., 1999; Kittelson, 2004; Bispo & Oliveira, 2007; Goldsmith, 2007). Monsoon being the major factor in density and distribution of plants leads to increase in abundance of herbivorous insects that are prey for Odonata. The influence of humidity on density and diversity of species is likely to be an indirect effect operating via effects on food availability in an environment. Odonata needs warmth for the activity and efficient metabolism. Thus, most of

them disappear on cool days or when the sun goes behind a cloud. Furthermore, a sunny and fair weather condition would allow a different spectrum of Odonata species (White, 2008). Despite the fact that insects are cold-blooded, Odonata maintains an internal temperature as high as 110°F. Odonata prefers habitat with a diverse vegetation structure of an average air temperature ranging from 26–28°C and sunny weather (Vilenica, 2011).

Table 3. Temperature, relative humidity, and number of individuals collected.

Date	Temperature (°C)	Atmospheric humidity			Total No. of individuals
		Wet (°C)	Dry (°C)	RH (%)	
1. January 31, 2014	25	23	25	85	22
2. February 2, 2014	28	25	28	79	31
3. February 20,2014	30	26	30	73	34
4. March 4, 2014	31	27	31	74	43
5. March 8, 2014	26	24	26	85	24
Average	**28**	**25**	**28**	**79.2**	**154**

Conclusion and Recommendation

The presence of eurytopic species indicates that the three vegetation types in Ozamiz City are relatively disturbed. Hence, species diversity and endemism of Odonata are relatively low. The species richness is also low and is mostly characterized by the common, widely-distributed and tolerant eurytopic species. The presence of only one stenotopic species in Site A also implies the presence of human-related disturbance in the area.

Further research may focus on the life cycles and distribution of Odonata in various vegetation types. Sampling during summer months may assess further the diversity of Odonata that are more abundant at higher temperatures.

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Literature Cited

Amelia, Z. S., Che Salmah, M. R., & Abu Hassan, A. (2006). *Diversity and distribution of dragonfly (Odonata: Insecta) in the Kerian River basin, Kedah-Perak, Malaysia*. North Sumatra, Indonesia: Universitas Sumatera Utara Repository.

Aspacio, K. T., Yuto, C. M., Nuñeza, O. M., & Villanueva, R. J. T. (2013). Species diversity of Odonata in selected areas of Buru-un, Iligan City and Tubod, Lanao del Norte, Philippines. *Animal Biology & Animal Husbandry Bioflux*, *5*(2), 145-155.

Azrina, M. Z., Yap, C. K., Ismail, A. R., Ismail, A., & Tan, S. G. (2006). Anthropogenic impacts on the distribution and biodiversity of benthic macroinvertebrates and water quality of the Langat River, Peninsular Malaysia. *Ecotoxicology and Environmental safety*, *64*(3), 337-347. doi: 10.1016/j.ecoenv.2005.04.003

Basumatary, P., Adhikary, D., Daimary, M., Basumatary, N., & Daimary, A. (2015). A preliminary study on the diversity of odonata in Bodoland University and its vicinity, Assam, India. *International Journal of Scientific and Research Publications*, *5*(6), 387-394.

Bispo, P. C., & Oliveira, L. G. (2007). Diversity and structure of Ephemeroptera, Plecoptera and Trichoptera (Insecta) assemblages from riffles in mountain streams of Central Brazil. *Revista Brasileira de Zoologia*, *24*(2), 283-293. doi: http://dx.doi.org/10. 1590/S0101-81752007000200004

Brucet, S., Boix, D., Nathansen, L. W., Quintana, X. D., Jensen, E., Balayla, D., ... & Jeppesen, E. (2012). Effects of temperature, salinity and fish in structuring the macroinvertebrate community in shallow lakes: Implications for effects of climate change. *PloS One*, *7*(2), e30877.

Chandana, E. P. S., Rajapaksha, A. C. D., & Samarasekara, W. G. K. H. A survey of odonate assemblages associated with selected wetland localities in southern Sri Lanka. *Asian Journal of Consevation Biology*, *1*(2), 67-73.

Choong, C., Orr, B., & Dow, R. (2008). Checklist of dragonflies of UKM Campus including Bangi Forest Reserve, Bangi-Selangor, Malaysia. *Agrion*, *12*(1), 40.

Chovanec, A., & Waringer, J. (2001). Ecological integrity of river–floodplain systems—assessment by dragonfly surveys (Insecta: Odonata). *Regulated Rivers: Research and Management*, *17* (4-5), 493-507. doi: 10.1002/rrr.664

Clark, T. E., & Samways, M. J. (1996). Dragonflies (Odonata) as indicators of biotope quality in the Kruger National Park, South Africa. *Journal of Applied Ecology, 33*(5), 1001-1012. doi: 10.2307/2404681

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.

Corbet, P. S. (1999). *Dragonflies: Behaviour and ecology of Odonata*. Harley Books.

Dijkstra, K. D. B., Bechly, G., Bybee, S. M., Dow, R. A., Dumont, H. J., Fleck, G., ... & Ware, J. (2013). The classification and diversity of dragonflies and damselflies (Odonata). In Z.-Q. Zhang (Ed.) Animal Biodiversity: An Outline of Higher-level Classification and Survey of Taxonomic Richness (Addenda 2013). *Zootaxa*, *3703*(1), 36-45. doi: http://dx.doi.org/10.11646/zootaxa.3703.1.9

Dolný, A. (2000). On the use of dragonflies (odonata) for biological monitoring of water quality. *Acta Facultas Rerum Naturalium Universitatis. Ostraviensia (Biol.-Ecol.)*, 192, 89-104.

Farizawati, S., Fauzi, M., Ruslan, M. Y., Norma-Rashid, Y., Ng, Y. F., & Idris, A. G. (2014). The diversity of odonates in five islands within the west coast of Peninsular Malaysia. *Academic Journal of Entomology*, *7*(3), 102-108. doi: 10.5829/idosi.aje.2014.7.3.855

Gillott, C. (2005). *Entomology (*3rd ed). Netherlands: Springer.

Goldsmith, S. (2007). Density of longhorned beetles (Coleoptera: Cerambycidae) differs at different elevations in Hawaiian montane forest. *The Southwestern Naturalist*, *52*(3), 364-370. doi: http://dx.doi.org/10.1894/0038-4909 (2007) 52[364: DOLBCC]2.0.CO;2

Hawking, J. H., & New, T. R. (1999). The distribution patterns of dragonflies (Insecta: Odonata) along the Kiewa River, Australia, and their relevance in conservation assessment. *Hydrobiologia, 392*(2), 249-260.

Kalita, G. J., & Ray, S. D. (2015). Studies on the diversity and habitat preference of odonates in DeeporBeel Bird Sanctuary, Kamrup, Assam. *Journal of Entomology and Zoology Studies*, *3*(2), 278-285.

Kittelson, P. M. (2004). Sources of variation in insect density on *Lupinus arboreus* Sims: Effects of environment, source population and plant genotype. *The American Midland Naturalist*, *152*(2), 323-335. doi: http://dx.doi.org/ 10.1674/0003-0031(2004)152 [0323:SOVIID]2.0.CO;2

Kosterin, O. E. (2010). A glance at the Odonata of the Cambodian coastal mountainous regions: End of dry season in 2010. *International Dragonfly Fund–Report*, *29*, 1-75.

Lee Foote, A., & Rice Hornung, C. L. (2005). Odonates as biological indicators of grazing effects on Canadian prairie wetlands. *Ecological Entomology*, *30*(3), 273-283. doi: 10.1111/ j.0307-6946.2005.00701.x

Magurran, A. E. (2013). *Measuring biological diversity*. New Jersey, USA: John Wiley & Sons.

Malawani, A. D., Ampang-Macabuat, N. M., Nuñeza, O. M., & Villanueva, R. J. T. (2014). Odonata of Lanao del Sur, Mindanao, Philippines. *International Research Journal of Biological Sciences*, *3*(1), 42-48.

Maleque, M. A., Ishii, H. T., & Maeto, K. (2006). The use of arthropods as indicators of ecosystem integrity in forest management. *Journal of Forestry*, *104*(3), 113-117.

Mapi-ot, E. F., Taotao, A. U., Nuñeza, O. M., & Villanueva, R. J. T. (2013). Species diversity of adult Odonata in selected areas from Misamis Occidental Province, Philippines. *Aquaculture, Aquarium, Conservation & Legislation-Bioflux*, *6*(4), 421-432.

Marinov, M. (2011). Damselflies and Dragonflies of the Nakorotubu Range, Ra and Tailevu Provinces, Viti Levu, Fiji. *A rapid biodiversity assessment of the Nakorotubu Range, Ra and Tailevu Provinces, Fiji. RAP Bulletin of Biological Assessment*, *59*, 90-128.

Mitra, A. (2013). *Orthetrum sabina*. The IUCN Red List of Threatened Species 2013: e.T165470A17533255. http://dx.doi.org/10. 2305/IUCN.UK.2013-

Morais, H. C., Diniz, I. R., & Silva, M. S. S. (1999). Caterpillar seasonality in central Brazilian cerrado. *International Journal of Tropical Biology and Conservation*, *47*(4), 1025-1033.

Oppel, S. (2006). Comparison of two Odonata communities from a natural and a modified rainforest in Papua New Guinea. *International Journal of Odonatology*, *9*(1), 89-102. doi**:** 10.1080/13887890. 2006.9748266

Orr, A. G. (2006). Odonata in Bornean tropical rain forest formations: Diversity, endemicity and implications for conservation management. *Forest and Dragonflies.* Sofia, Bulgaria: Pensoft Publishers.

Orr, A. G., Butler, S. G., Hämäläinen, M., & Kemp, G. R. (2004): Insecta: Odonata. In C. M. Yule & H. S. Yong (Eds). *Freshwater Invertebrates of the Malaysian Region* (pp. 409-442). Malaysia: Academy of Sciences.

Quisil, J. C., Nuñeza, O. M., & Villanueva, R. J. T. (2014). Impact of mine tailings on the species diversity of Odonata fauna in Surigao Del Sur, Philippines. *Journal of Biodiversity and Environmental Sciences*, *5*(1), 465-476.

Remsburg, A. J., Olson, A. C., & Samways, M. J. (2008). Shade alone reduces adult dragonfly (Odonata: Libellulidae) abundance. *Journal of Insect Behavior*, *21*(6), 460-468. doi: 10.1007/s10905-008-9138-z

Sahlén, G., & Ekestubbe, K. (2001). Identification of dragonflies (Odonata) as indicators of general species richness in boreal forest lakes. *Biodiversity and Conservation*, *10*(5), 673-690. doi: 10.1023/A:1016681524097

Samways, M. J., McGeoch, M. A., & New, T. R. (2010). *Insect conservation. A handbook of approaches*. UK: Oxford University Press.

Steytler, N. S., & Samways, M. J. (1995). Biotope selection by adult male dragonflies (Odonata) at an artificial lake created for insect conservation in South Africa. *Biological Conservation*, *72*(3), 381-386. doi: 10.1016/0006-3207(94)00052-R

Tang, H. B., Wang, L. K., & Hämäläinen, M. (2010). *A photographic guide to the dragonflies of Singapore*. Singapore: Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore.

Tennessen, K. J. (2003). Odonata (Dragonflies, Damselflies). In V. H. Resh & R. T. Carde (Eds). *Encyclopedia of Insects* (pp. 814-822). Hongkong: Academic Press Hong Kong.

Tiple, A. D., Khurad, A. M., & Andrew, R. J. (2008). Species diversity of odonata in and around Nagpur City Central India. *Fraseria*, *7*, 41-45.

Vilenica, M., Stanković, V. M., & Franković, M. (2011). Dragonfly fauna (Insecta, Odonata) in the Turopolje region (Croatia). *Natura Croatica: Periodicum Musei Historiae Naturalis Croatici*, *20*(1), 141-158.

Villanueva, R. J. T., & Gil, J. R. S. (2011). *Odonata Fauna of Catanduanes Island, Philippines*. IDF.

Villanueva, R. J. T., & Mohagan, A. B. (2010). Diversity and status of Odonata across vegetation types in Mt. Hamiguitan wildlife sanctuary, Davao Oriental. *Asian Journal 0f Biodiversity*, *1*(1), 25-35.

Villanueva, R. J. T. (2010). Adult Odonata community in Dinagat island, the Philippines: Impact of chromium ore mining on density and species composition. *Odonatologica, 39*(2), 119-126.

Westfall Jr, M. J., & Tennessen, K. J. (1996). Odonata. *An Introduction to the Aquatic Insects of North America, 3,* 164-211.

White, E. L. (2008). *New York state dragonfly and damselfly survey: Species lists by county*. Albany, NY: New York Natural Heritage Program.