Odonata Fauna of Riparian Habitats in Selected Areas of Luzon and Mindoro Region

Randel D. Estacio [1], Reagan Joseph T. Villanueva [2], and Hendrik Freitag [3]

[1] College of Arts and Sciences, Quezon City University
673 Qurino High way, San Bartolome, Novaliches, Quezon City, 1116 Philippines
[2] College of Arts and Education, University of Mindanao
Matina, Davao City, 8000 Philippines
[3] Ateneo de Manila University, Department of Biology, School of Science and Engineering
Loyola Heights Quezon City, 1101 Philippines

DOI: 10.29322/IJSRP.10.08.2020.p10498
http://dx.doi.org/10.29322/IJSRP.10.08.2020.p10498

Abstract- Odonata is considered as potential indicator of environmental disturbances. Despite of great efforts in recording the Odonata Fauna of the Philippines in general, the Riparian habitats in Bataan/Subic Bay (Luzon) and Mt. Hinunduang/Baroc River Catchment (Mindoro) are still unexplored. Due to the continuous forest and freshwater habitat destruction, faunal survey of Odonata species is urgent. The present study surveyed selected riparian habitats in these regions in December 2015 to April 2016. A total of two hundred six species belonging to twenty genera (*Heteronaias, Brachydiplax, Diplacodes, Macrodiplax, Neurothemis, Orthetrum, Pantala, Potamarcha, Trithemis, Zyxoma, Neurobasis, Cyrano, Rhinocypha, Agriocnemis, Ischnura, Pseudagrion, Teinobasis, Euphaea, Coeliccia*, and *Risiocnemis*) were recorded and seven endemic species of the family Platycnemididae, Euphaeidae, and Calopterygidae were documented in both regions. From the collected specimens, one species under the family Platycnemididae is new to science but additional collection and evaluation are needed. The data collected contribute to the understanding of Odonata diversity and distributions in the regions and support future conservation and management strategies.

Index Terms- Odonata, Riparian habitats, Faunal Survey, Diversity and Distribution, Conservation.

I. Introduction

Order Odonata is an order of carnivorous insects, encompassing the dragonflies (Anisoptera) and the damselflies (Zygoptera) and they are among the most ancient of winged insects, which have existed since the Triassic (Kalkman et al. 2008). Adult odonates are medium to large size, conspicuous and/or brightly colored insects and are aerial predators hunting by sight (Kalkman et al. 2008).

Dragonflies are generally larger, and perch with their wings held out to the sides while damselflies have slender bodies, and hold their wings over the body when at rest (Orr et al. 2004). They are generally found at or near fresh water although some species roam widely and may be found far from their breeding sites (Orr et al. 2004; Corbet 1999). The larvae are predatory, aquatic and occur in all manner of inland waters (Kalkman et al. 2008; Orr et al. 2004; Corbet 1999).

The Philippine Odonata and its taxonomy are still insufficiently known (Hämäläinen 2004). As described by Hämäläinen (2004), the country has high percentage of endemism in terms of its Odonata Fauna. Luzon, being the largest island in the Philippines has wide ranging lists of interesting Odonata Fauna, some of which are endemic to the island or in a particular region of the island (Villanueva et al. 2012; Gapud 2004; Hämäläinen 2004).

The study of Villanueva and Gil (2011), in the island of Catanduanes provided forty two Odonata species that are a new record of the island and three species are new to science. In 2012, a total of sixty Odonata species were recorded in Isabela and Quezon province and three of which were new to science and four were new island records in Luzon (Villanueva et al. 2012). Odonata recorded in Dumaran island in the northeastern Palawan sub-region also supports the claim that endemism per region or per island is very high in the country. These discoveries denote that there are still more to explore (Villanueva 2011), from virtually unexplored main islands up to the smallest islands in the archipelago. However, the number of critical or nearly endangered species is also significantly increasing (International Union for Conservation of Nature 2011). Species that were previously identified are not actually seen and remain elusive at present time (Villanueva 2011). Human activities and increasing number of population contribute to the deterioration and destruction of habitat, which leads to the increased number of Odonata species that are considered critical or nearly endangered (Hämäläinen 2004).

Odonata became the subject as an ecological indicators (Tiple and Koparde 2015; Henning 2008; Smith et al. 2007), their occurrence in a particular area could indicate good land water condition (Septianella 2014; Henning 2008) since odonates have both aquatic and terrestrial life stages (Bried 2005) and they are also very sensitive to differences in environmental factors such as temperature, oxygen levels, and amount of forest covers (Ramirez 2000). Recent studies also revealed that certain Odonata species demonstrate high association with particular habitats (Gomez-Anaya and Novelo-Guttierrez 2010; Smith et al. 2007).

Despite of the effort in understanding the Odonata Fauna and diversity in the country in general and in Luzon in particular, the Odonata of selected riparian habitats in Bataan/Subic Bay (Luzon) and Mt. Hinunduang/Baroc River Catchment (Mindoro) are still unexplored. Due to continuous forest destruction and other habitat stresses, a faunal survey of Odonata species is urgent. The present study records the Odonata species composition of selected riparian habitats in Bataan/Subic Bay (Luzon) and Mt. Hinunduang/Baroc River Catchment, Oriental Mindoro province. The Collected data will contribute to the information about Odonata in the island and will support the future conservation and management strategies.

Most of the endemic odonate species in the Philippines that are still waiting to be officially described and named are said to be vulnerable to endangerment in the near future due to the loss of their suitable habitats. Primarily, the study focuses on the survey of adult Odonata species in selected riparian habitats in Bataan/Subic Bay (Luzon) and Mt. Hinunduang/Baroc River Catchment (Mindoro) during the months of December 2015 to April 2016. Sites of different altitude and varying vegetation / land use are selected for sampling however, limited to places where government permit are available. The study is limited in determining the diversity, abundances, and richness of Odonata species in Luzon and Mindoro region; identifying adult Odonata species based on their anatomical and morphological characteristics; and classifying them according to species level.

II. METHODOLOGY

2.1 Study Areas

The study was conducted in selected riparian habitats in Bataan (c. 14°64’ N, 120°48’ E)/Subic Bay (c.14°79’ N, 120°23’ E) in Luzon and Mt. Hinunduang/Baroc River Catchment, Roxas, Oriental Mindoro (c. 12°35’ N, 121°30’ E) (see fig. 1). Before the field study was conducted, official consent was obtained from the respective local government units (LGUs), DENR, SENRO, PENRO, and NCIP.

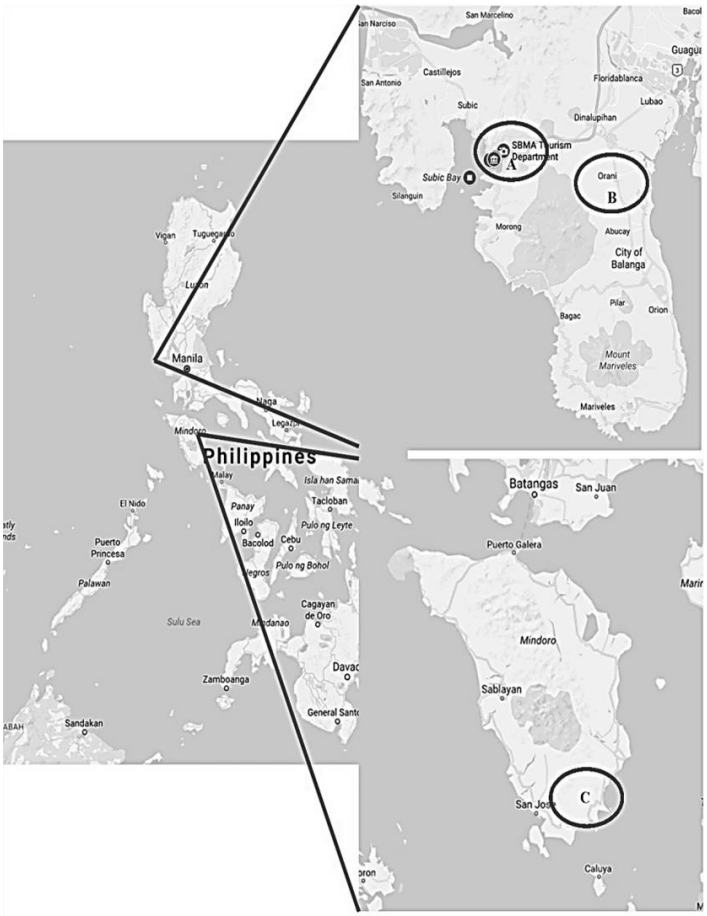


Figure 1. Map of the Three Sampling Sites (A-SBMA, Zambales; B-Bataan; and C-Municipality of Roxas, Oriental Mindoro)

2.2 Sampling Sites

Site 1, Boton River (ca.14°78'67"N 120°29'76"E). This site has an elevation of 110 m asl and is located within the Subic Bay Metropolitan Area. This sampling site is considered as a disturbed primary forest. The Boton Falls is one of the main attractions in Subic Bay wherein travelers from the nearby cities visit the area.

Site 2, Batalan River, Subic Bay (ca.14°43'01"N 120°18'41"E). This area has an elevation of 65 m asl and it is classified as a secondary forest.

Site 3, Orani River (ca. 14°44'15" N 120°24'58" E). The elevation of this site is 460 m asl. The area is located at the foot of Mt. Natib in Bataan. The area is characterized by very steep forested slope.

Site 4, Lower Baroc River (ca.12°35'51"N 121°28'11"E). This area is located in Roxas, Oriental Mindoro and has an elevation of 27 m asl. The sampling area is considered as disturbed farmland. The area is also near the quarrying site.

Site 5, Tagaskan River (ca.12°34'39"N 121°22'24"E), Hinundugan River Tributary at the upper Baroc River

Catchment. The area is located in Brgy. San Vicente, Roxas Oriental Mindoro and it is classified as an extensive farmland with an elevation of approx. 410 m asl.

Site 6, Taugad Daka (ca.12°38'05"N 121°19'33"E), Taugad River Tributary at the upper Baroc River Catchment. The area is located in Brgy. San Vicente, Roxas Oriental Mindoro and it is classified as a disturbed primary forest with an elevation of approx. 530 m asl.

Site 7, Taugad Diit (12°36'39"N 121°20'47"E), Taugad river tributary, upper Taugad Diit River at the upper Baroc River Catchment, this site has an elevation of approx. 525 m asl and is characterized as a secondary forest.

Figure 2. Sampling Sites (A. Boton Falls, B. Boton River, C. Batalan River, Subic Bay, D. Orani River, E-F Tagaskan River, G. Taugad Daka, and H. Taugad Diit)

2.3 Collection and Preservation

The sample collection was conducted twice at all sites during the months of December, 2015 and April, 2016. Opportunistic sampling (Jumawan et al. 2012) was employed to all sampling sites. Odonata were captured through hand picking and by a catching net made from silk cloth with a measurement of 25 x 60 cm. A stretch of 10-15 meters of the river served as the sampling site. Upon arriving at the site, the researcher stayed and caught samples for 60-120 minutes, then proceeded to the next sampling site. The samples were collected from eight o'clock in the morning to five o'clock in the afternoon.

Preservation of the specimen was based on the methods used by Mapi-ot, Taotao, Nuneza, and Villanueva (2013). Each captured specimen was placed in an empty white triangular envelope with its wings folded and labeled according to the time, place and day it was collected. Specimens from each site were euthanized using small amount of acetyl acetate. Preservation of the specimen using acetone depended on the respective suborder (24 hours for dragonflies while 12 hours for damselflies). After soaking in acetone, specimens were air dried and placed in tissue paper and stored in a cool and dry place.

2.4 Specimen Identification

Odonate specimens were identified based on their morphological characteristics, such as head, thorax, abdomen, anal appendages, and wing venation. Specimens were examined and measured using OLYMPUS CX21 compound microscope, OLYMPUS SZ40 stereo microscope equipped with digital adapter LW Scientific MiniVid DCM310 and LEICA EZ4 dissecting microscope. Species were identified from family up to species level using published identification keys (van Tol and Gassmann 2007; van Tol, 2005; Gassmann and Hamalainen 2002; Hamalainen and Müller 1997; Hamalainen 1991; Needham and Gyger 1939; Needham and Gyger 1937). Furthermore, the primary researcher also visited the collections of Dr. Reagan Joseph T. Villanueva in Davao City and Dr. Victor L. Gapud in University of the Philippines, Los Baños for comparison, confirmation and verification of the collected specimens.

Photographs of the site and representative species were taken during the sampling by the use of a smartphone. The preserved specimens where photographed by the use of a digital camera.

III. RESULTS AND DISCUSSION

3.1 Diversity, Abundance, and Richness of Odonata in Luzon and Mindoro

The study surveyed selected riparian habitats in Luzon and Mindoro region during the months of December 2015 to March 2016. A total of 206 specimens belonging to twenty eight species in twenty genera (*Agriocnemis*, *Ischnura*, *Pseudagrion*, *Teinobasis*, *Risiocnemis*, *Coeliccia*, *Rhinocypha*, *Cyrano*, *Euphaea*, *Neurobasis*, *Heteronaias*, *Diplacodes*, *Neurothemis*, *Orthetrum*, *Pantala*, *Potamarcha*, *Trithemis*, *Brachydiplax*, *Macrodiplax*, and *Zyxomma*) were recorded and seven endemic species of the family Platycnemididae, Euphaeidae, and Calopterygidae were documented in the study sites (Table 1 and Table 2). Sample species of Anisoptera and Zygoptera collected from this study were found in figures 3 and 4.

Table 1. Species' Abundance and Diversity in the Different Sampling Sites in Luzon

	Luzon Region			Total	%
	Boton River	Batalan River, Subic Bay	Orani River		
Altitude	c.110m asl	c.65m asl	c.460m asl		
Land Cover	Disturbed Primary Forest	Secondary Forest	Steep Forested Slope		
Suborder Zygoptera					
Family Calopterigidae					
Neurobasis luzoniensis[b]	1	1	9	11	18.0
Family Chlorocyphidae					
Cyrano unicolor	-	-	4	4	6.6
Rhinocypha colorata	13	3	5	21	34.4
Family Euphaeidae					
Euphaea refulgens[b]	6	-	4	10	16.4
Family Platycnemididae					
Risiocnemis pulchra[a]	2	-	2	4	6.6
Risiocnemis serrata[a]	-	-	1	1	1.6
Risiocnemis sp.[a]	1	-	-	1	1.6
Family Coenagrionidae					
Pseudagrion p. pilidorsum	-	-	2	2	3.3
Suborder Anisoptera					
Family Corduliidae					
Heteronias heterodoxa	-	-	2	2	3.3
Family Libellulidae					
Diplacodes trivialis	2	-	-	2	3.3
Pantala flavascence	-	1	-	1	1.6
Trithemis aurora	1	-	-	1	1.6
Zyxomma obtusum	-	-	1	1	1.6
Total Number of Individuals	26	5	30	61	100
Total Number of Species	7	3	9		
Total Number of Endemic Species	4	1	4		

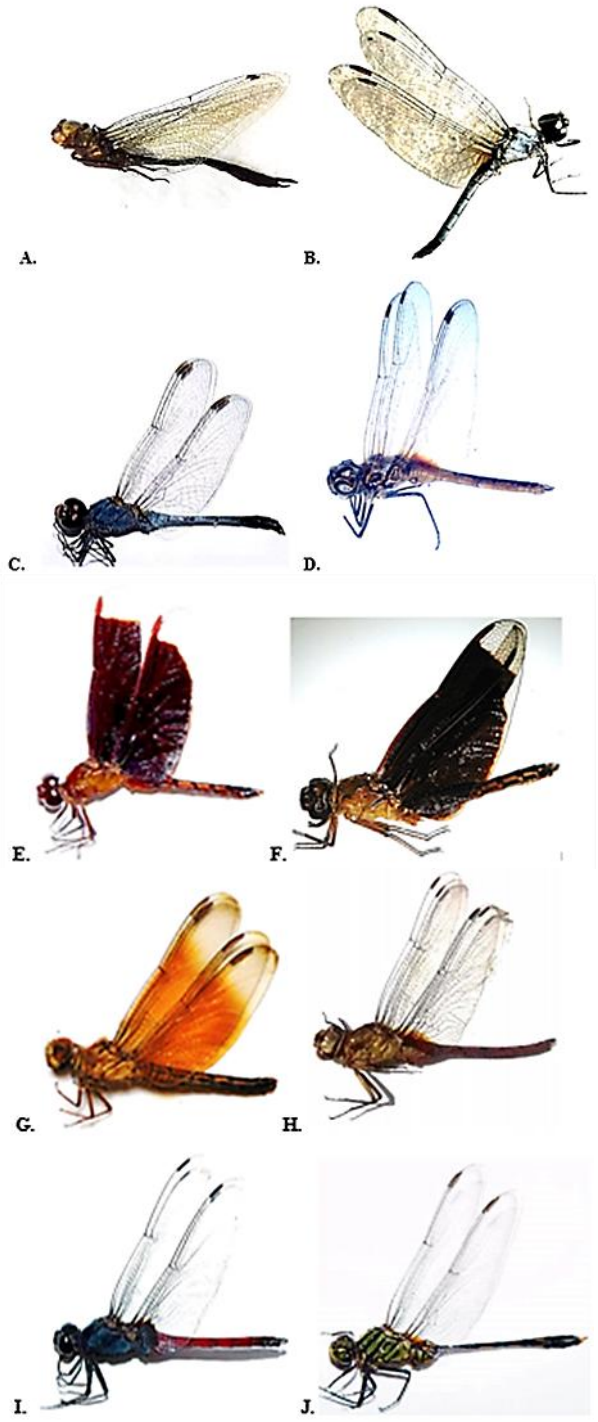
[a]Endemic species in Luzon, [b]Endemic species in Luzon and Mindoro

Table 2. Species' Abundance and Diversity in Different Sampling Sites in Mindoro

	Mindoro Region				Total	%
	Lower Baroc River	Tagasakan River	Tauga Daka River	Tauga Diit River		
Altitude	c.27m asl	c.410m asl	c.530m asl	c.525m asl		
Land Cover	Disturbed Farmland	Extensive Farmland	Disturbed Primary Forest	Secondary Forest		
Suborder Zygoptera						
Family Calopterigidae						
Neurobasis luzoniensis[b]	-	4	1	18	23	16.1
Family Chlorocyphidae						
Rhinocypha colorata	-	-	4	14	18	12.6
Family Euphaeidae						
Euphaea refulgens[b]	-	-	-	3	3	2.1
Family Platycnemididae						
Coeliccia brachysticta[a]	-	4	-	-	4	2.8
Risiocnemis asahinai[a]	-	10	4	15	29	20.3
Family Coenagrionidae						
Agriocnemis f. femina	9	3	-	-	12	8.4
Ischnura senegalensis	2	-	-	-	2	1.4
Pseudagrion p. pilidorsum	-	8	3	2	13	9.1
Suborder Anisoptera						
Family Libellulidae						
Brachydiplax chalybea	-	2	-	-	2	1.4
Diplacodes trivialis	5	-	-	-	5	3.5
Macrodiplax cora	2	-	-	-	2	1.4
Neurothemis ramburii	-	-	-	1	1	0.70
Neurothemis terminate	-	1	-	2	3	2.1
Orthetrum chrysis	-	1	-	-	1	0.70
Orthetrum pruinosum clelia	-	1	-	-	1	0.70
Orthetrum Sabina	-	-	-	1	1	0.70
Pantala flavascence	-	-	-	2	2	1.4
Potamarcha coengener	-	1	-	-	1	0.70
Trithemis aurora	-	5	3	4	12	8.4
Trithemis festiva	-	6	1	-	7	4.9
Trithemis pallidinervis	-	1	-	-	1	0.70
Total Number of Individuals	18	47	16	62	143	100
Total Number of Species	4	13	6	10		
Total Number of Endemic Species	0	3	2	3		

[a]Endemic species in Mindoro, [b]Endemic species in Luzon and Mindoro

Table 1 and 2 revealed that in terms of the number of individuals per species or abundance, the surveyed areas in Mindoro region is more abundant as compared with the surveyed areas in Luzon region. A total of one hundred forty three (143) individual species were collected from Mindoro, while there are sixty one (61) individual species which were collected in Luzon. In terms of total number of species, a total of twenty one (21) Odonata species were collected from Mindoro while there are only thirteen (13) Odonata species collected in Luzon.



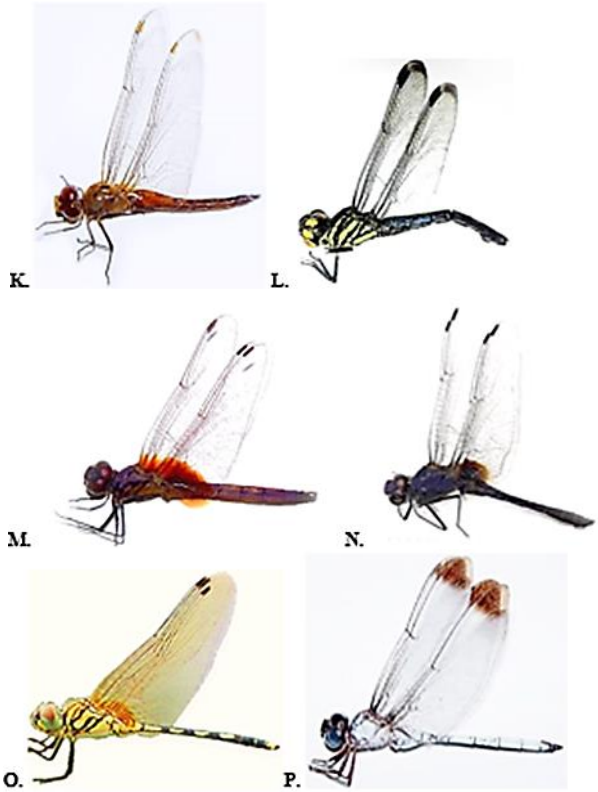
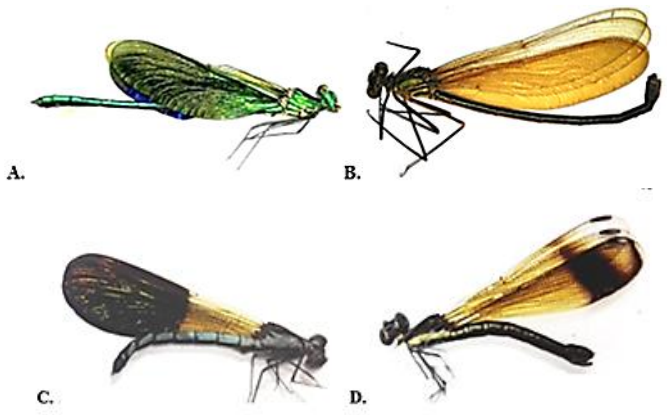


Figure 3. Sample Anisoptera: A. *Heteronaias heterodoxa* (Selys, 1878) (male); B. *Brachydiplax chalybea chalybea* Brauer, 1868 (male); C. *Diplacodes trivialis* (Rambur, 1842) (male); D. *Macrodiplax cora* (Brauer, 1867) (female); E. *Neurothemis ramburi ramburi* (Brauer, 1866) (male); F - G *Neurothemis terminata terminata* Ris, 1911, (F) male and (G) female; H. *Orthetrum chrysis* (Selys, 1891) (male); I. *Orthetrum pruinosum clelia* (Burmeister, 1839) (male); J. *Orthetrum sabina sabina* (Drurry, 1770) (male); K. *Pantala flavescens* (Fabricius, 1798) (female); L. *Potamarcha coengener* (Rambur, 1842) (female); M. *Trithemis aurora* (Burmeister, 1839) (male); N. *Trithemis festiva* (Rambur, 1842) (male); O. *Trithemis pallidinervis* (Kirby, 1889) (male); P. *Zyxoma obtusum* Albarda, 1881 (male).



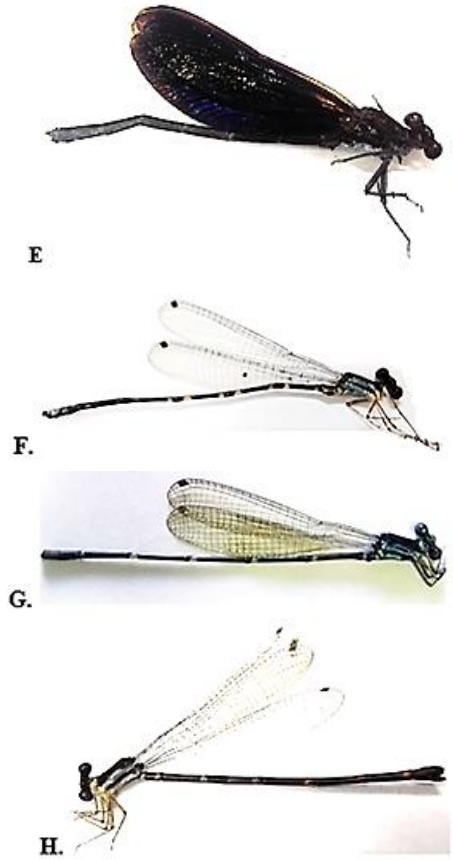


Figure 4. Sample Zygoptera: A -B. *Neurobasis luzoniensis* Selys, 1879 (A) male (B) female; C-D. *Rhinocypha colorata* Hagen in Selys, 1869 (C) male and (D) female; E. *Euphaea refulgens* Hagen in Selys, 1853 (male); F. *Coeliccia brachysticta* Ris, 1912 (male); G. *Risiocnemis asahinai* Kitagawa, 1990 (male); H. *Risiocnemis pulchra* Hämäläinen, 1991 (female).

Using the data from the tables 1 and 2, the diversity index of the surveyed areas from the two regions were calculated using Shannon-Wiener Index and Simpson's Index. Based from the results, Mindoro region is considered to have a diverse community of Odonata with Shannon-Wiener Index value of 4.96 and Simpson's index value of 8.96 as compared to Luzon region with Shannon-Wiener Index value of 3.95 and Simpson's index value of 5.23. This means that species collected from Mindoro is greater than the number of species collected from Luzon. The results also denotes that the species found in Mindoro are evenly distributed as compared to Luzon. Thus, surveyed areas in Mindoro are diverse than the surveyed areas in Luzon (see Table 3).

Table 3. Shannon-Wiener Index and Simpson's Index Values of the Sampling Sites

Sampling Areas	Shannon-Weiner Index (H) value	Simpson's Index (D) value
Luzon Region	3.95	5.23
Boton River	2.95	3.13
Batalan River	1.90	2.27
Orani River	3.95	5.92
Mindoro Region	4.96	8.96
Lower Baroc River	2.39	2.84
Tagaskan River	3.73	8.03
Tauga Daka River	3.33	4.92
Tauga Diit River	3.40	4.90

Furthermore, Shannon-Wiener index and Simpson's index values shown in Table 3 which denotes that when it comes to the surveyed areas in Mindoro, Tagaskan River is considered to be the most diverse area among the four sampling sites with Shannon-Wiener index value of 3.73 and Simpson's index value of 8.03. This denotes that Odonata community in Tagaskan River has a large number of species that are evenly distributed within the area as compared to the other. Furthermore, sampling areas in Luzon is primarily dominated by few number of species, and among the three sampling sites is Orani River which is considered to have a diverse community with Shannon-Wiener index value of 3.95 and Simpson's index value of 5.92 as compared to Boton River, and Batalan River with the least diverse among the three sampling sites.

The results revealed that majority of Anisoptera are found in the low altitude area, similar results were also found in the study of Medina et al. in 2015, this pattern is attributed to the generally large body size of the species in this suborder, which increases the ability of the organism to move freely or migrate and consequently dispersion and distribution (Van Tol and Gassmann 2007). Furthermore, in larger species, thermoregulation is made possible by solar radiation, and thus they are more frequently found in open areas (Van Tol and Gassmann 2007). Meanwhile, Zygotera are commonly found in high altitude area, due to smaller body size, thermoregulation seems to be by convection, thereby permitting occupation of shaded places such as forest (Van Tol and Gassmann 2007). Given that most of the sampling areas were mainly surrounded by open areas (pasture) and degraded riparian forest, it is to be expected that species of the suborder Anisoptera are predominant in the two regions.

Libellulidae was the most diverse family and with the highest number of species being collected. This cosmopolitan family is considered to be the largest among other families with 1,012 species identified worldwide and 190 species of this family are oriental. According to Mapi-ot et al. (2013), oriental species are most likely found in disturbed areas (Figure 5).

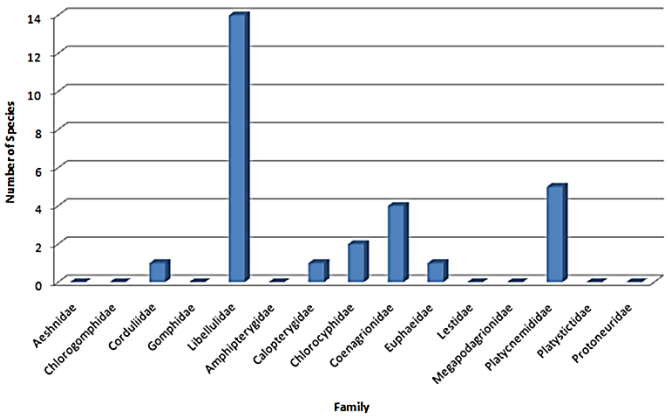


Figure 5. Species records among families occurring in Luzon and Mindoro

High altitude hosts endemic species such as *Risiocnemis pulchra* and *Risiocnemis asahinai*, this is because endemic species of Odonata prefers forested and apparently undisturbed areas.

There are several species that are expected on the regions but that have not yet been found. *Procordulia moroensis*, *Rhinocypha turconi*, *Vestalis melania* are some of the previously recorded species which were not found during the survey. The absence of several expected and previously recorded species might be accounted for by the weather condition affecting the region during the survey. Further, surveying on the regions is necessary during more favorable weather conditions. This is especially important to locate the "expected" species and find more material of some interesting species. From the collected specimens, one species under the family Platycnemididae is new to science but considered as an additional collection of the specimen and an evaluation is needed.

IV. CONCLUSION AND RECOMMENDATIONS

Tagaskan River and Taugad Diit at the upper Baroc River Catchment in Mindoro Region has the highest number of species collected among all the studied sites, but their fauna consist mainly of a widespread species. Anisoptera are predominant species which found in the two regions because most of the sampling areas were mainly surrounded by an open areas and degraded riparian forest. The Anisoptera are found in the low altitude area, while the Zygotera are found in the high altitude area.

Both regions are considered to be a diverse areas, although endemism is low. Libellulidae is the most diverse family with the highest number of species collected, while the endemic species such as *Risiocnemis pulchra* and *Risiocnemis asahinai* are found in higher altitude due to habitat preferences. Furthermore, from the collected specimens, one species under the family Platycnemididae is new to science but it is already an additional collection of the specimen and an evaluation is needed.

Previously recorded species from the respective regions were not found during the survey due to unfavorable weather condition affecting the region during the survey and the increased disturbance (e.g. conversion of forest into agricultural land). Further surveys in these sites are necessary to prove

whether these taxa still occur in the areas and to record further rare taxa that were probably missed out.

ACKNOWLEDGMENT

The authors would like to thank the late Dr. Victor Gapud (University of the Philippines Los Baños) for identification and verification of some species. The primary author would like to thank CHED for a Faculty Development Scholarship, and to his family especially Mrs. Clarissa De Leon Estacio and Mr. Rolito Arcamo Estacio, his parents for their unwavering support. Also sincere thanks are also due to the CHED PHERnet program for funding the field sampling in Mindoro. Lastly, the authors are very thankful to DENR, NCIP and all involved LGUs of Mindoro, especially Bgy. San Vicente, Roxas, Capitan Sescar, Barangay Tanod Rodel and Inoy for their support and permission to conduct this study.

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AUTHORS

First Author – Randel D. Estacio, Assistant Professor, College of Arts and Sciences, Quezon City University. Email: jaischneider17@gmail.com
Second Author – Reagan Joseph T. Villanueva, College of Arts and Education, University of Mindanao. Email: rjtvillanueva@gmail.com
Third Author – Hendrik Freitag, Associate Professor, Ateneo de Manila University, Department of Biology, School of Science and Engineering. Email: freitag.ateneo@yahoo.com

Correspondence Author – Randel D. Estacio, Assistant Professor, College of Arts and Sciences, Quezon City University. Email: jaischneider17@gmail.com. Mobile number: +639479685282