

Odonatofauna in the freshwater system of Kibalabag, Malaybalay City, Bukidnon, Philippines

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Abstract. *Guadalquiver DME, Nuneza OM, Villanueva RJT. 2022. Odonatofauna in the freshwater system of Kibalabag, Malaybalay City, Bukidnon, Philippines. Biodiversitas 23: 1857-1863.* Despite the critical importance of freshwater ecosystems to human populations and biodiversity, many anthropogenic practices continue to imperil such habitats. An excellent way to monitor the integrity of these ecosystems is through bioindicator organisms like insects of order Odonata, which are highly sensitive to environmental changes. In Malaybalay City, Philippines, the freshwater system in barangay Kibalabag is the primary source of potable water. Thus, to gain insight into its integrity and health, the present study seeks to determine adult Odonata species composition and diversity in the area. Opportunistic sampling using sweep netting and handpicking was conducted in four sampling sites. Twenty-five species were identified, comprising 230 individuals under nine families and 21 genera. Endemism of 65% (17 species) was recorded, with five species exclusive to Mindanao Island and three species classified as threatened. A high ratio of Zygopterans to Anisopterans, indicative of pristine conditions, was observed. Computation of biodiversity indices revealed that Site 2 (Wetland) is the most diverse (H' : 2.582) due to habitat variability. Cluster analysis also showed that Sites 1 (Kibalabag falls) and 2 were most similar. Species assemblage in these sites and high richness in Site 1 demonstrated high habitat integrity and good water quality, whereas the species assemblage in Sites 3 and 4 connotes habitat disturbance. The high endemism and moderate diversity showed that the area is a healthy and suitable habitat for Odonata, emphasizing the need for its conservation and proper management.

Keywords: Bioindicators, endemic species, habitat variability, wetland, Zygoptera

INTRODUCTION

Freshwater ecosystems are among the most critical components of our environment. They host 10% of the earth's biodiversity, provide humans with potable water, and filter harmful chemicals in the environment (Dudgeon et al. 2006; Strayer and Dudgeon 2010; Brown and King 2013). They are also excellent sources of food, fiber, and energy (Brown and King 2013). However, despite their importance, freshwater ecosystems are among the most threatened habitats on earth (Dudgeon et al. 2006). The biodiversity loss in freshwater environments was five times higher than in terrestrial environments (Miguel et al. 2017). Major threats such as habitat modification, fragmentation and destruction, invasive species, overfishing, environmental pollution, forestry practices, and climate change also continue to imperil these kinds of ecosystems (IUCN Freshwater Fish Specialist Group 2015).

The area of Kibalabag, in the Province of Bukidnon, Philippines, represents a critical freshwater system that provides essential ecological, cultural, and aesthetic values. Characterized by numerous waterfalls, streams, and creeks, the place hosts the city's primary source of potable water (Malaybalay City Government 2017). It is also the headwaters of Tagoloan River, one of the major rivers in Mindanao that covers and provides services to Bukidnon

and Misamis Oriental (Toledo-Bruno 2009). Because of its biocultural and economic importance, the area is considered sacred by the Tagoloanon tribe, among other tribes in Bukidnon (Toledo-Bruno 2009). It is also regarded as an ecotourism attraction because of the many beautiful waterfalls in the area. It is empirical that the place should be given utmost importance, proper management, and monitoring to conserve its natural state.

An excellent way to monitor the health and state of freshwater ecosystems is through indicator species. Odonata (dragonflies and damselflies) makes excellent indicators of freshwater ecosystem health as it is susceptible to environmental changes (de Oliveira-Junior et al. 2015). Odonata heavily relies on the quality of the water and the surrounding habitat to persist (Catling 2005; Stoks and Córdoba-Aguilar 2012; Miguel et al. 2017; Pranoto et al. 2019). The larval stage could last sometimes years (Stoks and Córdoba-Aguilar 2012). The complex life history of dragonflies and damselflies is heavily linked to the health of aquatic and terrestrial communities, and their presence dramatically affects the community assemblage (Remsburg and Turner 2009). Many Odonata species are habitat-specific and have unique ecological requirements to survive, grow, and reproduce (McPeck 2008). Consequently, they serve as indicators for changes in both

water quality and surrounding vegetation (Dolný et al. 2011; Miguel et al. 2017).

Therefore, this study aims to evaluate the species composition, endemism, distribution, and measure diversity of adult Odonata in the freshwater system of Kibalabag, Malaybalay City, Philippines. This is the first study on Odonata in this area. The data gathered will serve as baseline knowledge and overview on the Odonata fauna of the area, which could help assess the integrity and health of the Kibalabag freshwater system.

MATERIALS AND METHODS

Study area

The study was conducted in Barangay Kibalabag, Malaybalay City, Northern Mindanao, Philippines (8.226322, 125.161484) (Figure 1), covering 5220 hectares at an elevation around 1185.5 meters asl. Characterized by numerous flowing water bodies, the area is regarded as the Tagoloan River's origin and the primary source of drinking water in the city through the Kibalabag River (Malaybalay City Government 2017). The land cover for most of Kibalabag is grassland, but mossy and secondary forests can also be observed in the upstream area. The climate falls under type IV Philippine climate, typified by a more or less even rainfall distribution throughout the year with a yearly average of 2800 millimeters (110 in) and a relatively cooler temperature (18–30°C) than the rest of the country (Toledo-Bruno 2009; Malaybalay City Government 2017). Mt. Kiamo is located within the Barangay's vicinity and serves as one of its jump-off points.

Sampling sites

Four sampling sites were established. Site 1 (8.258,125.174; 8.256, 125.172) is an upstream site surrounding the Kibalabag and Dumagundong falls. The area has an undulating landscape with a low canopy forest cover. The two falls are just adjacent to each other and are said to come from a single source. The stream from the falls descends between high rock formations, which, together with the trees above it, minimize light penetration, especially in Dumagundong Falls.

Site 2 (8.254, 125.171) is also an upstream site. Entrance to the area is marked by shrubs and small trees growing across wet ground. A wetland, covered by thick vegetation (mostly shrubs), can be found in the area along with two small streams on both sides. The first stream is fast-flowing and covered by tall cogon grasses, whereas the second stream is relatively slow-flowing and creeps beside a hill converted into agricultural land. Many small herbaceous plants thrive on the side of the second stream, and part of it is darkened by the side of an adjacent hill still abounding with vegetation.

Site 3 (8.215,125.177) is at Sitio Caleb, which hosts a wide and fast-flowing shallow river. The area is near human settlements and runs through a private resort. A small stream that immediately joins the river was also explored for the site.

Site 4 (8.207,125.150) is on the border of Brgys. Kibalabag and Canayan and referred to as Sabangan. It is where the rivers of the two barangays meet to form the Tagoloan River. Hills surround the place with a land cover of mostly grass and few trees. Shallow water and rocky in most parts characterize the river. Near the area are a poultry farm and a small stream which was also sampled.

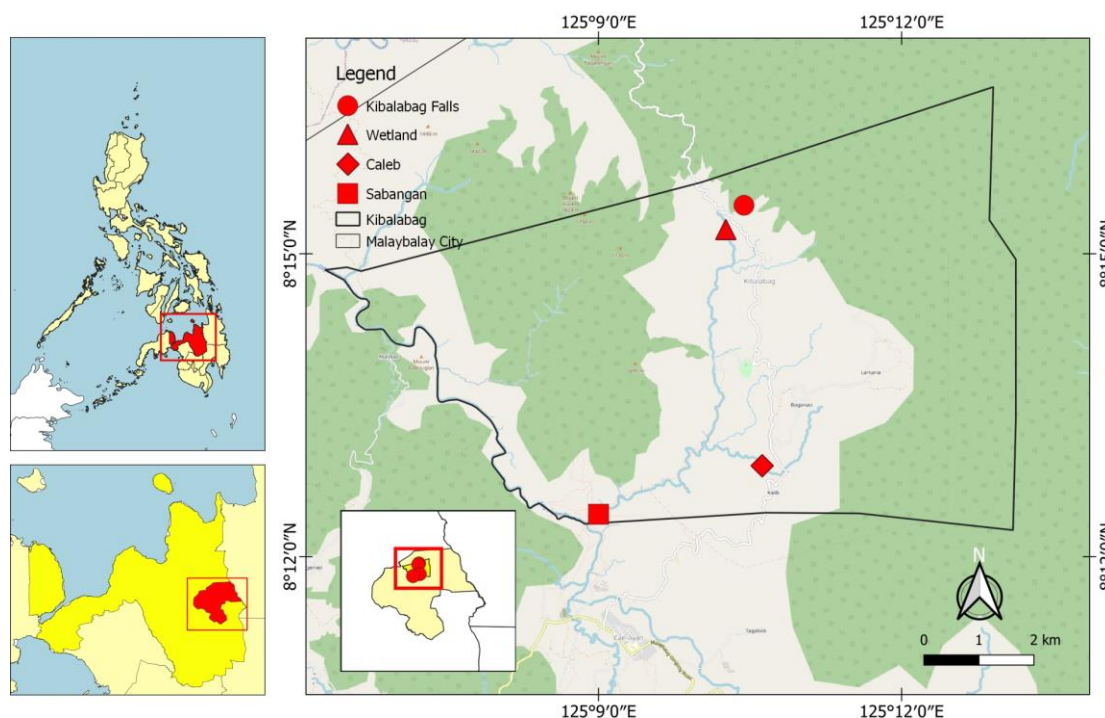


Figure 1. The study area and sampling sites (A) as positioned in Brgy. Kibalabag, Malaybalay City (B), Northern Mindanao, Philippines (C) (redrawn from Kleomarlo 2008; Google Maps, n.d.)

Collection, identification, and analysis of data

Opportunistic sampling was conducted from October 4–16, 2020, at 8.00 to 14.00 hours. A combination of sweep netting and handpicking methods was employed to collect adult Odonata, and voucher specimens collected were placed in paper triangles with wings folded in the back. Preservation was done by submerging the specimens in acetone from 12 (damselflies) to 24 hours (dragonflies) in close containers. After the soaking period, specimens were air-dried, placed in a new labelled paper triangular, and then packed in spacious containers with naphthalene balls to deter insects. Identification was done through a photographic guide (Nuneza and Villanueva 2016) and was verified by the third author. Previous literature was subsequently assessed for species distribution and conservation status (Hämäläinen and Müller 1997; Villanueva 2009; IUCN 2021). Biodiversity indices, i.e., Shannon-Weiner Index and Evenness, were calculated using PAST software version 4.0. To test which study areas were most similar in species composition, Cluster Analysis using Bray-Curtis similarity was also done.

RESULT AND DISCUSSION

Species composition

A total of 25 species comprising 230 individuals from 9 families and 21 genera were documented in Kibalabag, Malaybalay, Bukidnon (Table 1), representing new site locality records. Four species represent new locality records for Bukidnon province, namely *Nannophya pygmaea*, *Coeliccia dinoceris*, *Risicnemis erythrura*, and *Teinobasis annamaijiae*. Of the 25 species listed in the present study, nine belong to the suborder Anisoptera, whereas 16 belong to Zygoptera. The most abundant species observed was the Philippine endemic damselfly-*Igneocnemis atripes*, most prominent in Site 1 but were also found in sporadic numbers on all other sites. The rarest species were the damselflies *Igneocnemis tendipes* and *Drepanosticta lestoides*, both having only a single individual and are endemic. The previous report recorded 36 species in Bukidnon combined from four municipalities (i.e., Impasugong, Sumilao, Manolo Fortich, and Dumulog) (Jomoc et al. 2013) which is higher than the result of this survey. However, in terms of individual localities, Kibalabag has a higher richness as the previous study only recorded 21 species at most in Impasugong, Bukidnon. The species composition is also comparable to other surveys in Mindanao island such as in Bega Watershed (S:27), Lanao del Sur (S: 21) (Dimapinto et al. 2015), Lanao del Norte (S: 26) (Aspacio et al. 2013), Mimbilisan Protected Landscape (S:27) (Ramos et al. 2020), and at Misamis Occidental (S:22) (Mapi-ot et al. 2013). The Anisoptera family of Libellulidae was the most diverse family, with eight species comprising 62 individuals. The family Platynemididae was also the most prominent in the zygopteran suborder,

having six species comprising 65 individuals. Prevalence of male individuals was also observed.

The species richness in the area was moderately high and dominated by damselflies (64%). This high ratio of damselfly to dragonfly indicates a relatively pristine and undisturbed condition (Oppel 2005).

Most damselflies thrive in pristine, forested, and highly vegetated areas with flowing bodies of water (Seidu et al. 2019). As seen in several studies (Jumawan et al. 2012; Ramos et al. 2020), damselflies usually dominate preserved streams due to their sensitivity to changes in the environments' physical integrity (Silva et al. 2010; Oliveira-Junior et al. 2015, 2019). Lotic systems such as streams and rivers support high abundance and species richness of zygopterans as it provides dense vegetation cover allowing good resting, mating, and breeding environment (Seidu et al. 2019; Ilhamdi et al. 2020). These bodies of water, in the form of pristine streams, rivers, and wetlands, were prominent in the area. Hence, damselflies were most specious in this study. In the Philippines, a high ratio of Zygopterans to Anisopterans was only documented in three previously studied areas, all of which are freshwater systems that are either protected areas (Jumawan et al. 2012; Ramos et al. 2020) or designated watersheds. This observation implies that the habitat integrity of the freshwater systems in Kibalabag can be likened to protected areas and thus deserves equal attention.

Dominance of male specimens was also observed in this survey. This is a common finding among similar surveys (Ramos et al. 2020) and no habitat-related reason was accounted for this observation.

Endemism and conservation status

Seventeen of the species (65%) in Kibalabag are endemic to the country. The shading, vegetation type, and natural spring waters in the area might be responsible for this high endemism observed (Jomoc et al. 2013; Cudera et al. 2020; Ramos et al. 2020). Moreover, five Mindanao Island endemics were also among the species list. Due to their limited range and declining population, two of this Mindanao endemics- *R. erythrura*, and *R. sanguinolenta* have been listed as near threatened while another one-*D. lestoides* is a vulnerable species based on the IUCN (2021). This is also the first record of *R. erythrura* in Central Mindanao (from its distribution in Eastern Mindanao (IUCN 2021)). Hence its discovery here in Kibalabag indicates possible additional range positively impacting its conservation status. Sixteen of the 17 endemics are also Zygopterans, of which most are forest specialists, exacerbating their vulnerability to clearing and deforestation (Oppel 2005; Villanueva 2009). The presence of endemics and threatened species reiterates the importance of conservation measures and proper management of the area to maintain health and avoid disrupting ecological functions that might lead to the harm of these important species.

Table 1. Species composition, distribution, and relative abundance of Odonata

	Distribution	Conservation Status	Site 1 Kibalabag Falls	Site 2 Wetland Area	Site 3 Sitio Caleb	Site 4 Sabangan	Total	RA
Anisoptera								
Corduliidae								
<i>Heteronaias heterodoxa</i>	O	LC	♂2				2	0.87
Libellulidae								
<i>Diplacina bolivari</i>	PE	LC			♂5		5	2.16
<i>Diplacodes trivialis</i>	O	LC			♀3		3	0.43
<i>Nannophya pygmaea</i>	O	LC		♂5			5	2.16
<i>Neurothemis ramburii ramburii</i>	O	LC	♂4	♂5		♂4	13	5.63
<i>Orthetrum pruinosum</i>	O	LC			♂8	♂6	14	6.06
<i>Pantala flavescens</i>	W	LC	♂4	♂2			6	2.60
<i>Trithemis aurora aurora</i>	O	LC		♂3		♂1	4	1.73
<i>Trithemis festiva</i>	O	LC			♂4, ♀3	♂5	12	5.19
Zygoptera								
Amphipterygidae								
<i>Devadatta basilarensis</i>	ME	LC	♂4	♂11, ♀4			19	8.23
Calopterygidae								
<i>Neurobasis anumariae</i>	PE	LC	♂1	♂1	♂2		4	1.73
<i>Vestalis melania</i>	PE	LC		♂12	♂8		20	8.66
Chlorocyphidae								
<i>Rhinocypha colorata</i>	PE	LC		♀4		♂4, ♀8	16	6.93
<i>Rhinocypha sanguinolenta</i>	PE	NT		♀5	♂2		7	3.03
Coenagrionidae								
<i>Ceragrion lieftincki</i>	PE	LC		♂2			2	0.87
<i>Pseudagrion pilidorsum</i>	O	LC		♂5, ♀1		♂6, ♀1	13	5.63
<i>Teinobasis annamaijiae</i>	PE	LC		♂5	♂1		6	2.60
Euphaeidae								
<i>Euphaea amphicyana</i>	PE	LC	♂9	♂7			16	6.93
Platycnemididae								
<i>Coeliccia dinoceras</i>	PE	LC				♂2	2	0.87
<i>Igneocnemis atripes</i>	ME	LC	♂14, ♀6	♀1	♂1, ♀1	♀1	24	10.4
<i>Igneocnemis flammia</i>	PE	LC	♂6, ♀2	♂7, ♀3		♂1	19	8.23
<i>Igneocnemis tendipes</i>	ME	LC		♂1			1	0.43
<i>Prodasineura integra</i>	PE	LC				♂2	2	0.87
<i>Risiocnemis erythrura</i>	ME	NT	♂11, ♀1	♂5			17	7.36
Platystictidae								
<i>Drepanosticta lestoides</i>	ME	VU			♂1		1	0.43
Total number of Individuals			63	89	37	41	231	
Total number of Species			9	17	10	10	25	
Total number of endemic species			7	12	7	5	17	
Male ♂	199							
Female ♀	31							

Note: O: Oriental; W: Worldwide; PE: Philippine Endemic; ME: Mindanao Endemic; RA: Relative Abundance; LC: Least Concern; NT: Near Threatened; VU: Vulnerable

Distribution and assemblage per site

Site 2 showed the highest species richness (17 species) and abundance (89 individuals). *Devadatta basilarensis*, with 15 individuals, was the dominant species in the site. Individuals of this Philippine endemic species were noted along the perimeters of a fast-flowing stream surrounded by thick vegetation with water seepages. This habitat was also shared with *V. melania* and *R. sanguinolenta*, both forest specialists (Villanueva 2009). Its wetland section was the only site to host *C. lieftincki* and *N. pygmaea*, a relatively uncommon, small dragonfly. Only a single individual of the Mindanao endemic species, *I. tendipes*, was collected in this study, particularly in the 2nd stream of Site 2.

Various unique and essential species in Site 2 signify the crucial advantage of varying habitat conditions to hosting rich and diverse species assemblage (Hart et al. 2014; Seidu et al. 2019). Data here supports the need to maintain a diversified body of water in managing ecosystems to conserve diverse Odonata fauna and related freshwater biodiversity.

The lowest species richness was noted in Site 1 (S:9). This finding was due to the perceived homogenous habitat condition of the rocky and fast-flowing streams, mostly accommodating damselflies. Additionally, there were minimal aquatic vegetations observed, consequently resulting in a small occurrence of larvae.

Another study found that vegetation structure in both aquatic and terrestrial habitats significantly impacts the richness of Odonata, especially as vegetation is an essential larval requirement (Remsburg and Turner 2009). Although the site had the lowest richness, the area still serves as a suitable habitat for a high abundance of damselflies which merits conservation. In particular, *E. amphicyana*, *I. atripes*, *I. flammea*, and *R. erythrura* were found primarily on this site. These damselflies are endemic forest specialists that thrive only in flowing streams with intact and undisturbed surroundings (Villanueva 2009). Their dominance in this site shows that the place is indispensable as a host to sensitive species of Odonata. In comparison, Sites 3 and 4 with slightly higher richness (S:10) were dominated by common oriental dragonflies and widespread endemic damselflies like *R. colorata*, which are capable of tolerating relatively disturbed areas (Villanueva 2009).

These imply that sites 2 and 3 are moderately disturbed, as reflected in human settlements and infrastructure building (Site 3) and waste products from a nearby poultry farm (Site 4). This agrees with Miguel et al. (2017) that species richness is not a suitable parameter to assess habitat integrity of Odonata assemblage but rather, species composition and taxonomic distinctness.

Similarity of sites

Bray-Curtis similarity revealed two distinct clusters (Figure 3). Sites 1 and 2 formed one cluster for their 47% similarity. This may be attributed to their proximal location in the Kibalabag river's upstream and similar pristine

conditions. These findings demonstrate that although richness differs, the two areas have similar value in hosting important species. On the other hand, Sites 3 and 4, located downstream, were 30% similar, reiterating their akin disturbing nature. With the clear differentiation of these two clusters, the Kibalabag water source can be inferred to have a relatively optimal condition since it is in the upstream area.

Biodiversity indices

Computation of biodiversity indices revealed that Site 2 has the highest diversity ($H' = 2.582$), followed by Sites 3 ($H' = 2.014$), 4 ($H' = 1.993$), and 1 ($H' = 1.892$) (Table 2). Citing previous Odonata surveys in Mindanao, Shannon values for the Odonata group can go as low as 0.5-1.2 in urban and degraded areas near human settlements (Mapi-ot et al. 2013; Mapi-ot and Enguito 2014; Perez and Bautista 2020) to values approaching 3.0 in clean aquatic systems in the primary-secondary forest (Cayasan et al. 2013; Jomoc et al. 2013; Malawani et al. 2014; Ramos et al. 2020). Based on this, relatively high diversity can be inferred from Site 2, while moderate diversity can be observed in Sites 1, 3, and 4. High heterogeneity of microhabitats and vegetation positively affects diversity, as observed in Site 2. Evenness values also reveal that all sites have a relatively even distribution with minimal dominant species (Cerdá et al. 2012). This moderate to high diversity seen in Kibalabag reiterates its integrity and suitability as an Odonata habitat.

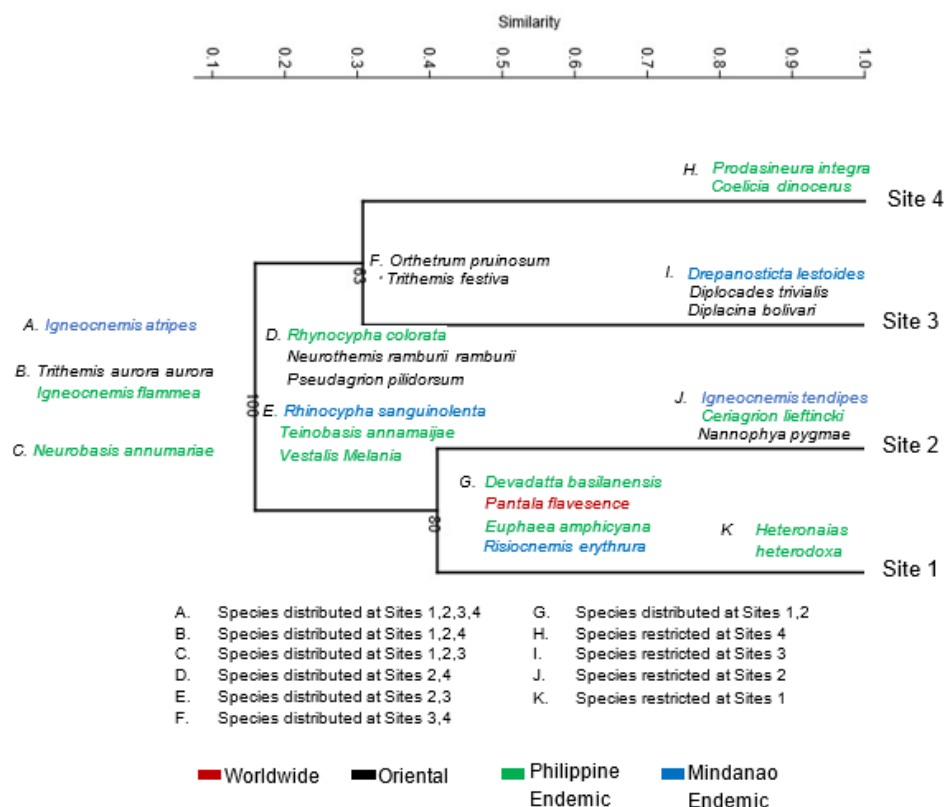


Figure 3. Dendrogram showing cluster analysis annotated with the distribution of Odonata species in the four sampling sites

Table 2. Biodiversity Indices of Odonata across sampling sites in Kibalabag, Malaybalay, Bukidnon

	Site 1	Site 2	Site 3	Site 4
Taxa	9	17	10	10
Individuals	67	89	37	41
Shannon H'	1.892	2.582	2.014	1.993
Evenness	0.737	0.778	0.749	0.734

In conclusion, this study provided an overview of the Odonatafauna in the freshwater system of Kibalabag. The area is home to 25 species of Odonata, 17 of which are endemic, and three have a threatened status. A high ratio of Zygopterans to Anisopterans, a characteristic of pristine and protected landscapes in the Philippines, was also observed. Moreover, the species assemblage in Sites 1 and 2 and high richness in Site 2, both located upstream of the riverine system, demonstrated high habitat integrity and good water quality, beneficial to Odonata. Water bodies with high habitat variability enable high diversity. Therefore, it should be given utmost importance in conservation as they cater to various Odonata species and, consequently, higher sympatric freshwater diversity. The high level of endemism and moderate to high diversity observed connotes that the area is healthy and suitable habitat for Odonata. However, as host to some threatened fauna and with its ecological and economic significance, the area warrants sustenance and proper ecological management.

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REFERENCES

- Aspacio KT, Yuto CMM, Nuñez OM, Villanueva RJ. 2013. Species diversity of Odonata in selected areas of Buru-Un, Iligan City and Tubod, Lanao Del Norte, Philippines. *Anim Biol Anim Husb Intl J Bioflux Soc* 5 (1): 116-126.
- Brown C, King J. 2013. Environmental flows in shared watercourses: Review of assessment methods and relevance. In: Earle A, Jägerskog A, Öjendal J (eds). *Transboundary Water Management: Principle and Practice*. Earthscan Publisher, London.
- Catling PM. 2005. A Potential for the use of dragonfly (Odonata) diversity as a bioindicator of the efficiency of sewage lagoons. *Can Field-Naturalist* 119 (2): 233. DOI: 10.22621/cfn.v119i2.111.
- Cayasan RD, Limitares DE, Gomid JVS, Nuñez OM, Villanueva RJ. 2013. Species richness of Odonata in selected freshwater systems in Zamboanga Del Sur, Philippines. *AACL Bioflux* 6 (4): 378-393.
- Cerdá X, Angulo E, Caut S, Courchamp F. 2012. Ant community structure on a small Pacific island: Only one native species living with the invaders. *Biol Invasions* 14 (2): 323-339. DOI: 10.1007/s10530-011-0065-0.
- Cudera RB, Razon BC, Millondaga KJI. 2020. Cultural and ecological significance of Odonata (Insecta) to the t'boli of Lake Sebu, Mindanao, Philippines. *Biodiversitas* 21 (6): 2536-54. DOI:10.13057/biodiv/d210627.
- Dimapinto FA, Nuñez OM, Villanueva RJ. 2015. Species diversity of adult Odonata in selected areas of Lanao Del Sur, Philippines. *AACL Bioflux* 6 (4): 421-32.
- Dolný A, Bárta D, Lhota S, Drozd P. 2011. Dragonflies (Odonata) in the Bornean Rain Forest as indicators of changes in biodiversity resulting from Forest Modification and Destruction. *Trop Zool* 24 (1): 63-86.
- Dudgeon D, Arthington AH, Gessner MO, Kawabata Z-I, Knowler DJ, Lévêque C, Naiman RJ, Prieur-Richard AH, Soto D, Stiassny ML, Sullivan CA. 2006. Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biol Rev* 81 (02): 163. DOI: 10.1017/S1464793105006950.
- Hämäläinen M, Müller RA. 1997. Synopsis of the Philippine Odonata, with lists of species recorded from Forty Islands. *Odonatologica* 26 (3): 249-315.
- Hart LA, Bowker MB, Tarboton W, Downs CT. 2014. Species composition, distribution and habitat types of Odonata in the ISimangaliso Wetland Park, KwaZulu-Natal, South Africa and the associated conservation implications. *Plos One* 9 (3). DOI: 10.1371/journal.pone.0092588.
- Ilhamdi ML, Idrus AAL, Santoso D, Hadiprayitno G. 2020. Community structure and diversity of Odonata in Suranadi Natural Park, West Lombok Indonesia. *Biodiversitas* 21 (2): 718-723. DOI: 10.13057/biodiv/d210238.
- IUCN. 2021. The IUCN Red List of Threatened Species. Version 2021-3. 2021. <https://www.iucnredlist.org>.
- IUCN Freshwater Fish Specialist Group. 2015. Major Threats 2015.
- Jomoc DJG, Flores RRC, Nuñez OM, Villanueva RJ. 2013. Species richness of Odonata in selected wetland areas of Cagayan de Oro and Bukidnon, Philippines. *AACL Bioflux* 6 (6): 560-70.
- Jumawan K, Medina M, Villanueva RJ. 2012. Annotated list of Odonata from Mainit Hot Spring Protected Landscape, Compostella Valley, Mindanao Island, Philippines. *Philipp J Syst Biol* 6 (1): 14-27.
- Malawani AD, Ampang-Macabuat NM, Nuñez OM, Villanueva RJ. 2014. Odonata of Lanao Del Sur, Mindanao, Philippines. *Intl Res J Biol Sci* 3 (1): 42-48.
- Malaybalay City Government. 2017. Infrastructures and Utilities.
- Mapi-ot EF, Enguito MRC. 2014. Species richness of adult Odonata in Labo River, Ozamiz City, Philippines. *J Multidiscip Stud* 3 (1): 421-32. DOI: 10.7828/jmds.v3i1.628.
- Mapi-ot EF, Taotao AU, Nuñez OM, Reagan JT. 2013. Species diversity of adult Odonata in selected areas from Misamis Occidental Province, Philippines. *Aquac Aquarium, Conserv Legis. Intl J Bioflux Soc* 6 (4): 421-32.
- McPeck MA. 2008. Ecological factors limiting the distributions and abundances of Odonata. In: Cordoba-Aguilar A (eds). *Dragonflies and damselflies: Model organisms for ecological and evolutionary research*. Oxford University Press, United Kingdom.
- Miguel TB, Oliveira-Junior JMB, Ligeiro R, Juen L. 2017. Odonata (Insecta) as a tool for the biomonitoring of environmental quality. *Ecol Indic* 81 : 555-566. DOI: 10.1016/j.ecolind.2017.06.010.
- Nuneza O, Villanueva RJ. 2016. Photographic Guide to Dragonflies and Damselflies of Mindanao, Philippines (Unpublished Work). Mindanao State University- Iligan Institute of Technology.
- Oliveira-Junior JMB de, Shimano Y, Gardner TA, Hughes RM, Marco Júnior P de, Juen L. 2015. Neotropical dragonflies (Insecta: Odonata) as indicators of ecological condition of small streams in the Eastern Amazon. *Aust Ecol* 40 (6): 733-44. DOI:10.1111/aec.12242.
- Oliveira-Junior JMB, Dias-Silva K, Teodósio MA, Juen L. 2019. The response of Neotropical dragonflies (Insecta: Odonata) to local and regional abiotic factors in small streams of the Amazon. *Insects* 10 (12): 446. DOI:10.3390/insects10120446.
- Oppel S. 2005. Habitat associations of an Odonata community in a lower montane rainforest in Papua New Guinea. *Intl J Odonatol* 8 (2): 243-57. DOI: 10.1080/13887890.2005.9748256.
- Perez ES, Bautista MG. 2020. Dragonflies in the city: Diversity of Odonates in urban Davao, Philippines. *J Agric Sci Technol A* 10 (1): 12-19. DOI: 10.17265/2161-6256/2020.01.002.
- Pranoto MDP, Mardiono D, Widiyanti T, Pertiwi RAP, Az Zhara F, Izzati N. 2020. Short communication: Diversity of dragonflies (Ordo: Odonata) on the natural reserve areas of Mts.Sigogor and Picis, Ponorogo District, Indonesia. *Asian J For* 9 (1): 27-31. DOI: 10.13057/bonorowo/w090103.

- Ramos KAM, Nuneza OM, Villanueva RJ. 2020. Species diversity of Odonata in Mimbilisan Protected Landscape, Misamis Oriental, Philippines. *Asian J Conserv Biol* 9 (2): 280-289.
- Remsburg AJ, Turner MG. 2009. Aquatic and terrestrial drivers of dragonfly (Odonata) assemblages within and among North-Temperate Lakes. *J North Am Benthol Soc* 28 (1): 44-56. DOI: 10.1899/08-004.1.
- Seidu I, Nsor CA, Danquah E, Tehoda P, Oppong SK. 2019. Patterns of Odonata assemblages in lotic and lentic systems in the Ankasa Conservation Area, Ghana. *Intl J Zool* 2019: 3094787. DOI: 10.1155/2019/3094787.
- Silva D de paiva, Marco P De, Resende DC. 2010. Adult Odonate abundance and community assemblage measures as indicators of stream ecological integrity: A case study. *Ecol Indic* 10 (3): 744-52. DOI: 10.1016/j.ecolind.2009.12.004.
- Stoks R, Córdoba-Aguilar A. 2012. Evolutionary ecology of Odonata: A complex life cycle perspective. *Ann Rev Entomol* 57 (1): 249-65. DOI: 10.1146/annurev-ento-120710-100557.
- Strayer DL, Dudgeon D. 2010. Freshwater biodiversity conservation: Recent progress and future challenges. *J North Am Benthol Soc* 29 (1): 344-58. DOI: 10.1899/08-171.1.
- Toledo-Bruno AG. 2009. Linking Social and Biophysical Variables of Water Governance: An Application of the Model. State University of New York College of Environmental Science and Forestry, New York.
- Villanueva RJ. 2009. Odonata of Dinagat Island, the Philippines: Updated species list and notes on conservation of species and habitats. *Not Odonatol* 7 (3): 27-35.