BIODIVERSITAS
Volume 25, Number 11, November 2024
Pages: 4479-4486

ISSN: 1412-033X
E-ISSN: 2085-4722
DOI: 10.13057/biodiv/d251146

Species diversity of Odonata in Mt. Gutom Protected Landscape, Zamboanga del Norte, Philippines

JALILAH P. DICOL[1,♥], EDDIE P. MONDEJAR[1,2,♥♥], REAGAN JOSEPH T. VILLANUEVA[3]
[1]Department of Biological Sciences, College of Science and Mathematics, Mindanao State University - Iligan Institute of Technology. Andres Bonifacio Avenue, Tibanga, Iligan City 9200, Philippines. ♥email: jalilah.dicol@g.msuiit.edu.ph
[2]Terrestrial and Aquatic Biodiversity Laboratory, Premier Research Institute of Science and Mathematics, Mindanao State University - Iligan Institute of Technology. Andre Bonifacio Avenue, Tibanga, Iligan City 9200, Philippines. ♥♥email: eddie.mondejar@g.msuiit.edu.ph
[3]D3C Gahol Apartment. Lopez Jaena St., Davao City, Philippines

Manuscript received: 10 August 2024. Revision accepted: 25 November 2024.

Abstract. *Dicol JP, Mondejar EP, Villanueva RJT. 2024. Species diversity of Odonata in Mt. Gutom Protected Landscape, Zamboanga del Norte, Philippines. Biodiversitas 25: 4479-4486.* Mount Gutom Protected Landscape is one of the remaining natural forests and one of the most important watersheds in the province of Zamboanga del Norte, Philippines. This study aimed to assess the species diversity and endemism of Odonata on Mt. Gutom. The field sampling was conducted on 7-20 December 2022. A combination of sweep netting and opportunistic sampling methods were used to collect samples. The five sampling sites were established in the forested and agricultural areas where water bodies and open areas are present. A total of 331 individuals belonging to 27 species of Odonata and representing 9 families and 18 genera were recorded at the five sampling sites. The endemism of Odonata was recorded at 59.26%, including two species under the near threatened category of the International Union for Conservation of Nature (IUCN). Also, the Philippine endemic *Diplacina bolivari* Selys, 1882 and *Euphaea amphicyana* Ris, 1930 were the most dominant and abundant dragonfly and damselfly species in three sampling sites, respectively. All sampling sites recorded moderate diversity, with a diversity index (H') value ranging from 1.724 to 2.694. Analysis of Similarity (ANOSIM) and dissimilarity between sampling sites showed that the highest average similarities were observed in the sampling sites located along the Sikitan River, agroecosystem, and Lower Gutom (67.41%), while sampling sites in Malikas and Upper Gutom had 90.59% dissimilarity. The results advocate the importance of protecting and conserving Mt. Gutom Protected Landscape to sustain the availability of resources required to support the different taxa present.

Keywords: Anisoptera, endemic species, Malikas, Sikitan River, Zygoptera

INTRODUCTION

Odonata is composed of two suborders, the Anisoptera (dragonfly) and the Zygoptera (damselfly), which are crucial bioindicators of aquatic ecosystem health (Manu et al. 2023). These species, with their cosmopolitan distribution, are mostly found in aquatic environments (Pessacq et al. 2018). Most insects have intricate life cycles, and some species of Odonata larvae exhibit behavioral preferences for background color and the complexity of the environment (Tavares et al. 2018; Brito et al. 2021). Their life cycle's dependence on aquatic ecosystems positions them as bioindicators of aquatic ecosystem health. Many species of odonates can be used as indicators of good habitat quality, and some species can indicate disturbed habitats (Júnior et al. 2015). For instance, western spectre (*Boyeria irene* Fonscolombe, 1838) and beautiful demoiselle (*Calopteryx virgo meridionalis*) were proven to be indicator species of the riparian forest quality index (Martín and Maynou 2016), while the study by Nasirian and Irvine (2017) demonstrated one species of damselfly, *Ischnura ramburii* (Selys, 1857), as a tool for evaluation of heavy metal contamination. This species, *I. ramburii*, can take up heavy metal contamination in aquatic environments. Moreover, all stages of the life cycle of Odonata are predaceous and feed on various insects that inhabit aquatic ecosystems, and some species are restricted to running water habitats (Kalkman et al. 2018; May 2019). Odonata's reproductive success depends on the water reservoir since larvae live in both lotic and lentic environments, and their presence is greatly influenced by habitat morphology as well as the presence and structure of aquatic and riparian vegetation (Vilenica et al. 2020). Furthermore, there are over 6,300 described species of odonates, with an estimated total number of species in the world likely to be around 7,000 (Samways and Deacon 2022), of which more than 300 species of dragonflies and damselflies live in the aquatic ecosystems of the Philippines. The high endemism characterized the Philippine odonates, with Zygopterans composed of 90% endemic species and 40% for Anisoptera (Hämäläinen 2004). However, due to human transformations of land use or land cover, the occurrence of endangered species in most natural areas or the least affected areas was significantly positively correlated with increasing naturalness because it provides suitable conditions. Consequently, habitat degradation and/or the degree of naturalness had an impact on the species composition of odonates (Dolný et al. 2021).

On the other hand, field surveys and taxonomic work are critical to conservation in the Philippines since we cannot protect what we do not know about. Thus, continuing surveys conducted within the National Integrated Protected

Area System (NIPAS) have helped in formulating and updating policies, crafting an environment management plan, and mitigating measures to protect, conserve, and monitor the environment. In protected areas, like Mt. Kitanglad Range Natural Park in Bukidnon, regular biodiversity monitoring has been conducted to help ensure that the populations of flora and fauna, particularly threatened species, are not declining and no illegal activities are conducted. Moreover, forested areas not under the protected area network in the Philippines remain vulnerable to uncontrollable exploitation of resources. The leading causes of deforestation include the expansion of agricultural activity in forested areas, timber logging, and the conversion of forests into human settlements. All these anthropogenic activities threaten Mount Gutom, which is one of the remaining natural forests and most important watersheds in the province of Zamboanga del Norte. Preliminary surveys documented 384 species of flora and fauna, of which 9 are critically endangered, 3 endangered species, 14 threatened species, and 16 vulnerable species. The Philippine tarsier (*Carlito syrichta* Linnaeus, 1758), Philippine deer (*Rusa Marianna* Desmarest, 1822), Philippine warty pig (*Sus philippensis* Nehring, 1886), and Philippine monkeys (*Macaca fascicularis philippensis* I. Geoffroy Saint-Lilaire, 1843) were also documented in the area (Tome et al. 2019). However, no studies have been conducted on Odonata in this area. Hence, this study aims to assess the species diversity of Odonata in Mount Gutom in Barangay Panampalay, Municipality of President Manuel A. Roxas, Zamboanga del Norte, Philippines.

MATERIALS AND METHODS

Study area

Mount Gutom Range is located at 8°20'30.068' N, 123°10'22.368' E, with a maximum elevation of 1,199 meters above sea level (masl). It is near the southern tip of the Municipality of President Manuel A. Roxas, Zamboanga del Norte, Philippines (Figure 1). The peak is dominated by a dipterocarp forest with old and secondary-growth trees, as well as mossy and pine woodland. It covers a total land area of 5,464 hectares, the majority of which is made up of President Manuel A. Roxas' two barangays (Barangay Panampalay and Barangay Tantingan) and a small portion of the Municipality of Katipunan (Barangay Malasay and Barangay Fimagas), as well as the Municipality of Siayan's Barangay Dumugok (Tome et al. 2019).

Description of sampling sites

The selection of sampling sites was based on the types of vegetation in each site, such as grassland, forested area, managed farmland, and presence of water bodies where Odonata usually forage for food. The sampling site 1 is along the riparian of the Sikitan River, located at 08°21.917' N and 123°09.339° E. It has a maximum elevation of 633 masl at the foot of the sampling sites in Malikas and Lower Gutom. It is part of the identified buffer zone, with vegetation dominated by dipterocarp species. Fruit-bearing plants were observed in the area, such as coconut (*Cocos nucifera* L.) planted along the slopes going to the site, and *Ficus* sp. and man-made trails were observed.

Site 2 is located at 08°21' 52. 74" N and 123° 09'37.9" E, and has an elevation of 685 masl. The area is an agroecosystem where anthropogenic activities such as slash-and-burn farming and the presence of coconut, banana (*Musa acuminate* Colla), guava (*Psidium guava* L.), corn (*Zea mays* L.), cassava (*Manihot esculenta* Crantz), and sweet potato (*Ipomoea batatas* (L.) Lam.) were observed.

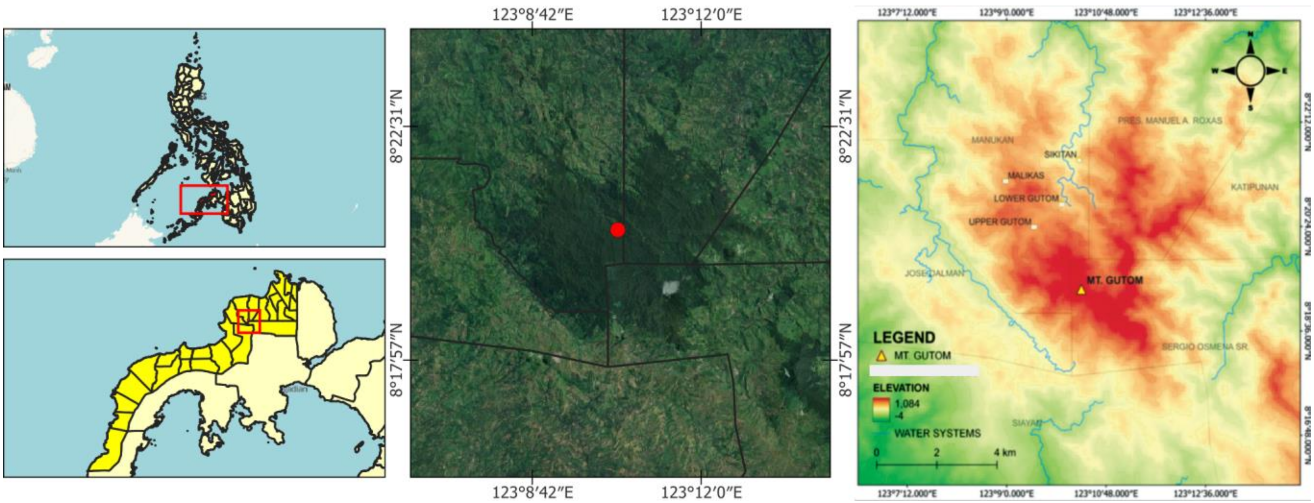

Figure 1. The study area in Mount Gutom Protected Landscape Barangay Panampalay, Municipality of Manuel A. Roxas, Zamboanga del Norte, Philippines

Site 3 is a secondary lowland dipterocarp forest. It is an open grassland located at 08°21.884' N and 123°09.150' E with an elevation of 820 masl at Sitio Malikas. The terrain in Malikas is mountainous with undulating slopes and approximately one kilometer from the Sikitan River. The species balakat-gubat (*Ziziphus talani*) is the emergent tree, and canopy trees include agoo (*Casuarina equisetifolia* L.) and tuai (*Bischofia javanica* Blume). *Curculigo latifolia* Dryand. ex W.T.Aiton and the fern species *Christella arida* (D.Don) Holttum dominate the ground cover.

Site 4 is located at 08°20.828' N and 123°09.951' E in lower Gutom, with an elevation of 767 masl. This area was identified as part of the protected area of Mt. Gutom and is characterized by a secondary tropical forest and a steep slope. In addition, the agroecosystem in Mt. Gutom is characterized by the presence of a river and stream with a temporary pond. The river within the agroecosystem is characterized by slow-moving water, 4-5 meters wide, presence of boulders within and along the river that allow a person to wade across. Also, trees, shrubs, and grasses are present.

Site 5 is a dipterocarp forest bordered by the Piao River and is situated at the top of Mount Gutom. It has an elevation of 818 masl and is situated at 08°20.325' N and 123°09.458' E. The tanguile (*Shorea polysperma* (Blanco) Merr.) and white lauan (*Shorea contorta*) were the two most common dipterocarp species. The emerging tree was balakat-gubat (*Ziziphus talanai*). For ground cover, ferns, *Selaginella* spp., thick mosses, orchids, and various epiphytic ferns were also present.

Collection, processing, and identification of samples

The study was conducted after the Wildlife Gratuitous Permit was secured from the Department of Environment and Natural Resources (DENR) Regional Office – IX in Pagadian City, Zamboanga del Sur. The collection of samples employed opportunistic sampling, sweep netting (Subramanian 2005), and hand-catching. Field sampling was conducted between 10:00 in the morning until 4:00 in the afternoon on 7-20 December 2022, with a total of 204 man-hours per site involving seventeen field assistants. Collected samples were placed inside the white triangular envelope and labeled with date, time, and location. The voucher specimens were euthanized in a mason jar containing a small amount of ethyl acetate in a cotton ball. Subsequently, dragonfly voucher specimens were submerged in acetone for 24 hours, while Damselflies specimens were submerged for 12 hours (Daso et al. 2021). After soaking for the required hours, all voucher specimens were air-dried and transferred in a new triangular envelope and labeled with time, location, and date. All voucher specimens were brought to the Terrestrial and Aquatic Biodiversity Laboratory at the Premier Research Institute of Science and Technology (PRISM) of Mindanao State University-Iligan Institute of Technology, Iligan City, for initial identification using published monographs of Odonata. In addition, all specimens were photographed according to the required documentation of samples and all samples were verified by Dr. Reagan Joseph Villanueva, an expert in Odonata. Moreover, species endemism was determined using published articles, and that species are naturally occurring in a given geographic location, particularly in the Philippines.

Statistical analysis

The data were analyzed using the Paleontological Statistics software version 2.17c (Hammer et al. 2001) to calculate the diversity indices, which includes the shannon index, evenness, species richness, and dominance. Shannon index was used to determine its relationship to the two component parts of diversity, richness and evenness (DeJong 1975). These indices were used to determine the diversity indices between sampling sites. Also, Primer software version 7 was used to obtain values for the Similarity Percentage (SIMPER), which was used to examine the species contribution to observed changes in species composition between sampling locations. To successfully control the heterogeneity of variance, abundance data were log10 (n+1) transformed prior to statistical analysis (Feng et al. 2014). Furthermore, the percentage of endemism was calculated by dividing the number of endemic species by the total number of species in each sampling site and then multiplied by 100.

RESULTS AND DISCUSSION

Species composition and abundance of Odonata

A total of 331 individuals of Odonata were classified into 27 species, representing 18 genera and 9 families (Table 1). The suborder Anisoptera was represented by the families Libellulidae and Corduliidae. The family Corduliidae was represented by two Philippine endemic species, *Heteronaias heterodoxa* (Selys, 1878) and *Idionyx philippa* (Ris, 1912). The highest number of species was recorded from the family Libellulidae, with nine species, including one Philippine endemic species (*Diplacina bolivari* Selys, 1882). On the other hand, suborder Zygoptera was represented by seven families (Amphipterygidae, Calopterygidae, Chlorocyphidae, Coenagrionidae, Euphaeidae, Platycnemididae, and Platystictidae). Family Platycnemedidae recorded six species: two are Philippine endemic, and four are Mindanao endemic. The family Coenagrionidae is represented by three species, with one classified as a vulnerable species based on the IUCN red list of threatened species (Dow 2020). Family Chlorocyphidae is represented by two near-threatened species, with one being Philippine endemic and the other having a Greater Mindanao distribution. Moreover, sampling site 5 (Upper Gutom) recorded the highest endemicity at 88.88%, followed by site 4 (Lower Gutom) with 77.77% endemicity and site 3 (Malikas), with an endemicity of 75%. Overall, Mt. Gutom Protected Landscape has an endemicity of 62.96%. Furthermore, the Philippine endemic *Euphaea amphicyana* Ris, 1930 was the most abundant species in site 1 (RA = 21.28%). In the agroecosystem (site 2), *Risiocnemis atripes* was the most abundant (RA = 13.46%). In site 3 (Malikas), *R. atrepis*, which has a relative abundance of 26.32%. At lower Gutom (site 4), *Rhinocypha turconii* Selys, 1891 and *E. amphicyana* have a relative abundance of 12.64%. In addition, *Vestalis melania* Selys, 1873, a Philippine endemic, was the most abundant species in site 5, with a relative abundance of 37.04%.

Table 1. Species composition, distribution, conservation status, relative abundance of Odonata in Mt. Gutom, Zamboanga del Norte, Philippines

Taxa	Sampling sites					Total (RA)
	S1: Sikitan (RA)	S2: Agroecosystem (RA)	S3: Malikas (RA)	S4: Lower Gutom (RA)	S5: Upper Gutom (RA)	
Suborder Anisoptera						
Family Corduliidae						
Heteronaias heterodoxa (Selys, 1878) [LC] [PE]	5 (5.32)	3 (2.88)	0	3 (3.45)	2 (7.41)	13 (3.93)
Idionyx philippa (Ris, 1912) [LC] [PE]	0	0	0	1 (1.15)	0	1 (0.30)
Family Libellulidae						
Diplacina bolivari (Selys, 1882) [LC] [PE]	10 (10.64)	21 (6.73)	0	9 (10.34)	0	40 (12.10)
Neurothemis ramburii (Kaup, 1866) [LC] [O]	0	8 (7.69)	3 (15.79)	5 (5.75)	0	16 (4.83)
Neurothemis terminata Ris, 1911) [LC] [O]	0	1 (0.96)	0	3 (3.45)	0	4 (1.21)
Orthetrum pruinosum subsp. *clelia* (Selys, 1878) [LC] [O]	4 (4.26)	4 (3.85)	0	7 (8.05)	0	15 (4.53)
Orthetrum sabina (Drury, 1773) [LC] [O]	2 (2.13)	2 (1.92)	2 (10.53)	0	0	6 (1.81)
Orthetrum testaceum (Burmeister, 1839) [LC] [O]	0	1 (0.96)	0	0	0	1 (0.30)
Pantala flavescens (Fabricius, 1798) [LC][W]	3 (3.19)	0	0	0	0	3 (0.91)
Trithemis aurora (Burmeister, 1839) [LC] [O]	0	8 (7.69)	0	0	0	8 (2.42)
Trithemis festiva (Rambur, 1842) [LC] [O]	0	7 (6.73)	0	0	0	7 (2.11)
Suborder Zygoptera						
Family Amphipterygidae						
Devadatta basilanensis Laidlaw, 1934) [LC] [ME]	4 (4.26)	4 (3.85)	3 (15.79)	8 (9.20)	0	19 (5.74)
Family Calopterygidae						
Vestalis melania (Selys, 1873) [LC] [PE]	3 (3.19)	5 (4.81)	0	6 (6.90)	10 (37.04)	24 (7.25)
Family Chlorocyphidae						
Cyrano angustior Hämäläinen, 1989 [NT] [GMIE]	0	0	0	0	1 (3.70)	1 (0.31)
Rhinocypha sanguinolenta Lieftinck, 1961 [NT] [PE]	0	2 (1.92)	0	3 (3.44)	1 (3.70)	6 (1.81)
Rhinocypha turconii Selys, 1891 [LC] [PE]	10 (10.64)	7 (6.73)	0	11 (12.64)	1 (3.70)	29 (8.76)
Family Coenagrionidae						
Ischnura senegalensis (Rambur, 1842) [LC] [O]	0	1 (0.96)	0	0	0	1 (0.30)
Pandanobasis cantuga (Needham & Gyger, 1939) [VU] [ME]	0	0	0	1 (1.15)	0	1 (0.30)
Teinobasis annamaijae Hämäläinen & Müller, 1989 [LC] [O]	5 (5.32)	0	0	2 (2.30)	1 (3.70)	8 (2.42)
Family Euphaeidae						
Euphaea amphicyana Ris, 1930 [LC] [PE]	20 (21.28)	4 (3.85)	0	11 (12.64)	0	35 (10.57)
Family Platycnemididae						
Coeliccia dinocerus Laidlaw, 1925 [LC] [PE]	5 (5.32)	0	0	4 (4.60)	1 (3.70)	10 (3.02)
Risiocnemis appendiculata (Brauer, 1868) [LC] [ME]	0	0	0	2 (2.30)	2 (7.41)	4 (1.21)
Risiocnemis atripes (Needham & Gyger, 1941) [LC] [ME]	8 (8.51)	14 (13.46)	5 (26.32)	4 (4.60)	0	31 (9.37)
Risiocnemis erythrura (Brauer, 1868) [NT] [ME]	0	0	1 (5.26)	0	0	1 (0.30)
Risiocnemis fuligifrons Hämäläinen, 1991 [LC] [PE]	6 (6.39)	8 (7.69)	2 (10.53)	3 (3.44)	0	19 (3.02)
Risiocnemis tendipes (Needham & Gyger, 1941) [LC][ME]	5 (5.32)	3 (2.88)	2 (10.53)	0	0	10 (3.02)
Family Platystictidae						
Drepanosticta flavomaculata (van Tol, 2005) [LC] [ME]	4 (4.26)	1 (0.96)	1 (5.26)	4 (4.60)	8 (29.63)	18 (5.44)
Total of No. of Individuals	94	104	19	87	27	331
Total No. of Species	15	19	8	18	9	27
Total No. of PE	7	7	1	9	5	9
Total No. of ME	4	4	5	5	2	7
Total No. of GMIE	0	0	0	0	1	1
% Endemism	73.33	57.89	75	77.77	88.88	62.96

Note: CS: Conservations Status; DS: Distribution Status; GMIE: Greater Mindanao Island Endemic; LC: Least Concern; ME: Mindanao Endemic; NT: Near Threatened; O: Oriental; PE: Philippine Endemic; RA: Relative Abundance; VU: Vulnerable; W: Worldwide

Species diversity of Odonata

Table 2 shows the biodiversity indices of Odonata on Mt. Gutom. All sampling sites demonstrate a moderate diversity index and an overall Shannon diversity index of H′ = 2.891. In addition, the sampling site in lower Gutom recorded the lowest dominance value (D = 0.07808) and evenness of E = 0.8215. Hence, lower Gutom recorded the highest diversity index among the five sampling sites, with H′ = 2.694. Moreover, the agroecosystem (S = 19 species) showed the highest in species richness (S = 19 species), while lowest in the sampling site in Malikas (S = 8).

Analysis of similarity between sampling sites

Figure 2 shows the cluster analysis based on the species composition of Odonata at five sampling sites on Mt. Gutom. The result shows that Sikitan, agroecosystem, and Lower Gutom had the highest average similarities at 6.18% (Table 3). Species that contributed to the observed similarities in the three sampling sites were *D. bolivari* (8.11%), *R. turconii* (7.26%), *E. amphicyana* (6.40%), *Risiocnemis atripes* (6.33), *Risiocnemis fuligifrons* (5.54), *Devadatta basilanensis* Laidlaw, 1934 (5.54), *Orthetrum pruinosum* subsp. *clelia* (5.34%) and *V. melania* (5.34%).

On the other hand, a comparison between Malikas and three sampling sites (Sikitan, agroecosystem, and Lower Gutom) revealed 58.09% average dissimilarity (Table 4), and three species were identified to contribute to the observed dissimilarity. These include *D. bolivari* (average dissimilarity of 5.29%), *Euphea amphicyana* Ris, 1930 (4.88%), and *R. turconii* (4.74%). Furthermore, the sampling sites of Malikas and Upper Gutom had a 90.59% average dissimilarity. The species that contributed to these are *V. melania* (9.33%), *R. atripes* (8.48%), and *D. basilanensis* (7.23%).

Table 2. Biodiversity indices of Odonata in Mt. Gutom, Zamboanga Del Norte, Philippines

Indices	Sampling sites					Overall
	Site 1: Sikitan	Site 2: Agroecosystem	Site 3: Malikas	Site 4: Lower Gutom	Site 5: Upper Gutom	
Species richness (S)	15	19	8	18	9	27
Dominance (D)	0.09846	0.09523	0.1579	0.07808	0.2428	0.0675
Shannon (H′)	2.52	2.605	1.955	2.694	1.724	2.891
Evenness (E)	0.8289	0.7123	0.8831	0.8215	0.6231	0.6674

Table 3. Results of SIMPER analysis of similarity between sampling sites

Species	Ave. abundance	Ave. similarity	Sim/SD	% contribution	% cumulative
Diplacina bolivari	2.65	8.11	37.46	12.03	12.03
Rhinocypha turconii	2.37	7.26	8.76	10.77	22.80
Euphaea amphicyana	2.43	6.40	3.17	9.50	32.30
Risiocnemis atripes	2.22	6.33	5.57	9.39	41.69
Risiocnemis fuligifrons	1.88	5.54	5.14	8.22	49.91
Devadatta basilanensis	1.85	5.34	25.47	7.92	57.84
Orthetrum pruinosum	1.81	5.34	25.47	7.92	65.76
Vestalis melania	1.75	5.12	9.94	7.60	73.36

Table 4. Results of SIMPER analysis of dissimilarity between sampling sites

Species	Ave. dissimilarity	% contribution	% cumulative
Malikas vs. Sikitan, agroecosystem, and Lower Gutom			
Diplacina bolivari	5.29	9.11	9.11
Euphaea amphicyana	4.88	8.40	17.50
Rhinocypha turconii	4.74	8.16	25.67
Malikas vs. Upper Gutom			
Vestalis melania	9.33	10.29	10.29
Risiocnemis atripes	8.48	9.36	19.65
Devadatta basilanensis	7.23	7.98	27.63

Figure 2. Bray-Curtis similarity analysis of the five sampling sites

Discussion

Species composition of Odonata

Among the nine families recorded on Mt. Gutom, the family Libellulidae was found to have the highest number of species recorded. This family is one of the major groups that dominate standing water and have a strong tolerance to anthropogenic disturbances (Medina et al. 2015). They can thrive in waters with low dissolved oxygen levels (Suhaila et al. 2016), and a few species inhabit brackish water habitats (Mapi-ot and Enguito 2014). On Mt. Gutom, eight species of the family Libellulidae were found in the agroecosystem, and only one species, *Pantala flavescens* (Fabricius, 1798), was absent. *Pantala flavescens* is associated with small standing water. Thus, it was not recorded in the agroecosystem since *P. flavescens's* favored breeding habitat is at seasonal pools, pans, and dams, which it rapidly colonizes after rain (Loftie-Eaton et al. 2020). This may explain the absence of *P. flavescens* since the field sampling was conducted in December 2022, which is a wet season in the Philippines. In addition, among the species of the family Libellulidae, *D. bolivari* was the most abundant species, with a relative abundance of 12.12%. This species was recorded at sampling sites 1, 2, and 4, where aquatic habitats such as rivers and streams are present. Aquatic habitats play a vital role in the family Libellulidae. The study conducted by Brito et al. (2021) demonstrated the influence of aquatic macrophytes on the diversity of Libellulidae larvae and adults. Aquatic macrophytes serve as refuge sites from predators and food sources (Misteli et al. 2022), while they also serve as ovipositing sites and perches for adults.

Moreover, most of the recorded zygopterans were endemic species, with only two oriental species (*Ischnura senegalensis* (Rambur, 1842) and *Teinobasis annamaijae* Hämäläinen & Müller, 1989). The family Platycnemididae recorded the greatest number of species (n = 6 spp.), which are all endemic. Notable occurrences of one near-threatened species, *Risiocnemis erythrura* (Brauer, 1868), were documented only at sampling site 3 (Malikas), which is a partially open canopy and one (1) kilometer away from the water source. Also, two species demonstrated widespread distribution at Mt. Gutom sampling sites. These include *R. atripes* and *R. fuligifrons,* both of which were recorded in all sampling sites except in sampling site 5 (Upper Gutom). The species of *Risiocnemis* Cowley, 1934 have been documented as being confined to small, clear streams in shady rainforest environments, occurring from lowland up to lower montane forests (Estacio et al. 2020).

On the other hand, Mt. Gutom recorded a remarkable pattern of species endemism, with sampling site 5 showing the highest percentage of endemism (88.88%), followed by site 4 (77.77% endemism) and lowest in site 3 (Malikas), with 75% endemism. Sampling sites 3, 4, and 5 are both secondary forests. According to Novelo-Gutiérrez et al. (2021), the number of endemic species is strongly related to forests since forest odonates have narrower elevation ranges and forest ecosystems have relatively stable ecological conditions, which promote the high number of forest endemics in the tropical mountains than in open-habitat odonates. In addition, an open habitat, such as the agroecosystem, is a disturbed habitat where anthropogenic activities are commonly observed (Novelo-Gutiérrez et al. 2021). Furthermore, three near-threatened and one vulnerable species were recorded in the forested habitats of Mt. Gutom. This indicates that Mt. Gutom is an important habitat for forest-dwelling species of Odonata.

Species diversity of Odonata

In terms of species diversity, Lower Gutom demonstrates the highest species diversity index among the five sampling sites. This study was conducted during the wet season, and frequent rainfall was experienced during field sampling, which consequently affected the sampling efficiency and the number of foraging Odonata species in aquatic and terrestrial habitats. Environmental factors, such as the luminosity of sunlight, air temperature, relative humidity, water pH, dissolved oxygen, and depth of water bodies, are reported to influence the species abundance and diversity of Odonata. During the wet season, anoxia was detected in the entire 24-hour cycle, and the highest variability in dissolved oxygen was observed during sunlight (Calvão et al. 2018). This may explain the observed variability in diversity indices between sampling sites in the study area. In addition, anthropogenic activities may also play a vital role in species assemblages since generalist species tend to favor and thrive in disturbed and modified habitats. In contrast, habitat specialists are more sensitive to environmental changes. Furthermore, the agroecosystem in Mt. Gutom is characterized by the presence of a river and stream with a temporary pond. The river within the agroecosystem is characterized by slow-moving water, 4-5 meters wide, presence of boulders within and along the river that allow a person to wade across. Also, trees, shrubs, and grasses are present. This habitat characteristic favors many species of odonates as they can be perched in shady areas when the air temperature is too high.

According to Ulfah et al. (2019), the higher the diversity, the lower the dominance. In this study, the lowest evenness was recorded in Upper Gutom due to the abundance of *V. melania* (RA = 37.04%). Only one species of dragonfly (*Heteronaias heterodoxa* (Selys, 1878)) was documented in the area, possibly due to the low light availability, which may influence dragonfly assemblage composition by limiting adults' finding of habitat and limiting their persistence in the area, resulting in lower colonization success (De Marco et al. 2015). Also, semi-closed canopy or shaded area vegetation and bad weather, such as heavy rain, affect the distribution of Odonata species. Sunlight penetration wasn't observed during our sampling days staying in Upper Gutom. Hence, Upper Gutom recorded the lowest diversity index among the five sample sites.

Analysis of similarity between sampling sites

The analysis of similarity in species composition between sampling sites revealed that habitats that are connected demonstrate a higher similarity in species composition, like Sikitan, agroecosystem, and Lower Gutom, with 67.41% similarity. The foraging behavior of a certain species, such as *Orthetrum pruinosum* subsp. *clelia*, can explain this. This dragonfly species is common and widely distributed along streams and rivers on Mt. Gutom, and they prefer open areas where sunlight directly penetrates the ground. According to Deacon et al. (2020), topography, geographical features, and connectedness between populations have been shown to influence the dispersal of organisms, especially for taxa with low mobility. Moreover, Malikas and Upper Gutom showed an average dissimilarity of 90.59%. These sites are both dipterocarp forests with varying degrees of canopy covering along the river and stream, and mossy forests characterize some parts of Upper Gutom. The moisture content was high in Upper Gutom compared to the other sampling sites. The study conducted by French and McCauley (2018) demonstrated that canopy cover could be an important environmental filter on species distributions of odonata because greater levels of canopy cover resulted in fewer adult visits, and more natural canopy cover decreased the species richness of visitors. This finding is also consistent in the sampling sites between Malikas and the other three sampling sites (Sikitan, agroecosystem, and Lower Gutom) on Mt. Gutom, which showed a 58.09% average dissimilarity. The canopy cover in Malikas is almost 90% close canopy, the width of the river is between 3-5 meters wide, and the depth of the water is low compared to that of the surrounding points; the species that contributed to the dissimilarity are all endemic. According to the study by Koparde et al. (2015), endemic species are associated with high-canopy forests and streams, suggesting the critical habitat requirements of these species.

In conclusion, Mt. Gutom Protected Landscape still harbors many endemic species of Odonata that can only be found in the Philippines, including two near-threatened species. Even though anthropogenic activities were documented, numerous species are still found in the area. Thus, the formulation of conservation measures to protect and mitigate the impact of anthropogenic activities on Mt. Gutom is vital to ensuring the survival of these ecologically important species.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge the Department of Science and Technology—Science Education Institute (DOST-SEI) under the DOST—Accelerated Science and Technology Human Resource Development Program (DOST_ASTHRDP) for the scholarship and financial support given to the first author. We would also like to express our gratitude to the following: Honorable Samie A. Ganduyo, Barangay Captain of Brgy. Panampalay, Honorable Municipal Mayor of Manuel A. Roxas, Zamboanga del Norte, the Licensing, Patent, and Deeds Division of the Department of Environment and Natural Resources-Region IX, and the Community Environment and Natural Resources Office (CENRO) of Manukan.

REFERENCES

Brito JS, Michelan TS, Juen L. 2021. Aquatic macrophytes are important substrates for Libellulidae (Odonata) larvae and adults. Limnology 2: 139-149. DOI: 10.1007/s10201-020-00643-x.

Calvão LB, Juen L, de Oliveira Junior JMB, Batista JD, De Marco Júnior P. 2018. Land use modifies Odonata diversity in streams of the Brazilian Cerrado. J Insect Conserv 22: 675-685. DOI: 10.1007/s10841-018-0093-5.

Daso JM, Arquisal IB, Yuto CMM, Mondejar EP. 2021. Species diversity of Odonata in Bolyok Falls, Naawan, Misamis Oriental, Philippines. AACL Bioflux 14 (2): 664-671.

De Marco Júnior P, Batista JD, Cabette HSR. 2015. Community assembly of adult odonates in tropical streams: An ecophysiological hypothesis. PloS One 10 (4): e0123023. DOI: 10.1371/journal.pone.0123023.
Deacon C, Samways MJ, Pryke JS. 2020. Determining drivers of dragonfly diversity patterns and the implications for conservation in South Africa. Biol Conserv 245: 108548. DOI: 10.1016/j.biocon.2020.108548.
DeJong TM. 1975. A comparison of three diversity indices based on their components of richness and evenness. Oikos 26 (2): 222-227. DOI: 10.2307/3543712.
Dolný A, Ožana S, Burda M, Harabiš F. 2021. Effects of landscape patterns and their changes to species richness, species composition, and the conservation value of Odonates (insecta). Insects 12 (6): 478-491. DOI: 10.3390/insects12060478.
Dow RA. 2020. *Pandanobasis cantuga*. The IUCN Red List of Threatened Species 2020: e.T139541671A146602140. DOI: 10.2305/IUCN.UK.2020-1.RLTS.T139541671A146602140.en. Accessed on 26 November 2024.
Estacio RD, Villanueva RJT, Freitag H. 2020. Odonata fauna of riparian habitats in selected areas of Luzon and Mindoro Region. Intl J Sci Res Publ 10 (8): 788-794. DOI: 10.29322/IJSRP.10.08.2020.p10498.
Feng C, Wang H, Lu N, Chen T, He H, Lu Y, Tu XM. 2014. Log-transformation and its implications for data analysis. Shanghai Arch Psychiatry 26 (2): 105-109. DOI: 10.3969/j.issn.1002-0829.2014.02.009.
French SK, McCauley SJ. 2018. Canopy cover affects habitat selection by adult dragonflies. Hydrobiologia 818: 129-143. DOI: 10.1007/s10750-018-3600-5.
Hämäläinen M. 2004. Critical species of Odonata in the Philippines. Intl J Odonatol 7 (2): 305-310. DOI: 10.1080/13887890.2004.9748218.
Hammer Ø, Harper DAT, Ryan PD. 2001. PAST: Paleontological Statistics Software Package for education and data analysis. Palaeontol Electronica 4 (1): 1-9.
Júnior CdSM, Juen L, Hamada N. 2015. Analysis of urban impacts on aquatic habitats in the central Amazon basin: Adult odonates as bioindicators of environmental quality. Ecol Indic 48: 303-311. DOI: 10.1016/j.ecolind.2014.08.021.
Kalkman VJ, Boudot JP, Bernard R, De Knijf G, Suhling F, Termaat T. 2018. Diversity and conservation of European dragonflies and damselflies (Odonata). Hydrobiologia 811: 269-282. DOI: 10.1007/s10750-017-3495-6.
Koparde P, Mhaske P, Patwardhan A. 2015. Habitat correlates of Odonata species diversity in the northern Western Ghats, India. Odonatologica 44 (1/2): 21-43.
Loftie-Eaton M, Hofmeyr S, Tippett RM, Underhill L. 2020. Wandering Glider Pantala flavescens. Biodiversity and Development Institute.
Manu MK, Ashiagbor G, Seidu I, Groen T, Gyimah T, Toxopeus B. 2023. Odonata as bioindicator for monitoring anthropogenic disturbance of Owabi wetland sanctuary, Ghana. Aquat Insects 44 (2): 151-169. DOI: 10.1080/01650424.2022.2108844.
Mapi-ot EF, Enguito MRC. 2014. Species richness of adult Odonata in Labo River, Ozamiz City, Philippines. J Multidisciplinary Stud 3 (1): 86-99. DOI: 10.7828/jmds.v3i1.628.
Martín R, Maynou X. 2016. Dragonflies (Insecta: Odonata) as indicators of habitat quality in Mediterranean streams and rivers in the province of Barcelona (Catalonia, Iberian Peninsula). Intl J Odonatol 19 (3): 107-124. DOI: 10.1080/13887890.2016.1172991.
May ML. 2019. Odonata: Who they are and what they have done for us lately: Classification and ecosystem services of dragonflies. Insects 10 (3): 62-78. DOI: 10.3390/insects10030062.
Medina MN, Cabras A, Villanueva RJ. 2015. Odonata of Island Garden city of Samal and its relation to other small islands in the Philippines. Intl Res J Biol Sci 4 (54): 54-60.
Misteli B, Pannard A, Labat F, Fosso LK, Baso NC, Harpenslager SF, Motitsoe SN, Thiebaut G, Piscart C. 2022. How invasive macrophytes affect macroinvertebrate assemblages and sampling efficiency: Results from a multinational survey. Limnologica 96: 125998. DOI: 10.1016/j.limno.2022.125998.
Nasirian H, Irvine KN. 2017. Odonata larvae as a bioindicator of metal contamination in aquatic environments: Application to ecologically important wetlands in Iran. Environ Monit Assess 189: 436. DOI: 10.1007/s10661-017-6145-6.
Novelo-Gutiérrez R, Londoño GA, Cordero-Rivera A, Flórez–V C, Sandoval-H J, Bota-Sierra CA. 2021. The importance of tropical mountain forests for the conservation of dragonfly biodiversity: A case from the Colombian Western Andes. Intl J of Odonatol 24: 233-247. DOI: 10.23797/2159-6719_24_18.
Pessacq P, Muzon J, Neiss UG. 2018. Order Odonata. In Thorp and Covich's Freshwater Invertebrates (pp. 355-366). Academic Press. DOI: 10.1016/C2015-0-01626-4.
Samways MJ, Deacon C. 2022. Extinction reprieve for the ancient and imperiled dragonflies at the Southern Tip of Africa. Reference Module in Earth Systems and Environmental Sciences. DOI: 10.1016/B978-0-12-821139-7.00047-7.
Subramanian KA. 2005. Dragonflies and Damselflies of Peninsular India-A Field Guide. Project Lifescape. Indian Academy of Sciences, Bangalore, India.
Suhaila AH, MR CS, Huda N. 2016. Composition and distribution of Odonata larvae and its relationship with physicochemical water quality in Northern Peninsular Malaysia. Malaysian J Sci 35 (2): 213-225. DOI: 10.22452/mjs.vol35no2.9.
Tavares RIS, Pestana GC, Rocha AD, Schiavone DC, Guillermo-Ferreira R. 2018. Come to the dark side: Habitat selection of larval odonates depends on background visual patterns. Ecol Entomol 43 (5): 640-646. DOI: 10.1111/een.12643.
Tome RJ, Pagaran CYS, Balbosa JMP, Padao ALC, Nabor MB, Montejar JV, Sangca-on Jr R, Lira LA, Sumangay N, Tumaboc GC, Dumaplas JCP. 2019. Protected Area Suitability Assessment Report. Community Environment and Natural Resources Office, Manukan, Zamboanga del Norte.
Ulfah M, Fajri SN, Nasir M, Hamsah K, Purnawan S. 2019. Diversity, evenness and dominance index reef fish in Krueng Raya Water, Aceh Besar. IOP Conf Ser: Earth Environ Sci 348: 012074. DOI: 10.1088/1755-1315/348/1/012074.
Vilenica M, Pozojević I, Vučković N, Mihaljević Z. 2020. How suitable are man-made water bodies as habitats for Odonata? Knowl Manag Aquat Ecosyst 421 (13): 10. DOI: 10.1051/kmae/2020008.