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Species diversity of Odonata in selected areas of Buru-un, Iligan City and Tubod, Lanao del Norte, Philippines

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Abstract. Odonata is known to be sensitive to structural habitat quality and is a valuable tool to evaluate landscape degradation. This study determined the species diversity of Odonata in Buru-un, Iligan City and Tubod, Lanao del Norte, Philippines. Eight sites were assessed on August 27 - 31, 2012 and on October 26 - 30, 2012 for a total of 98 man-hours. Sweep nets were used for collection. Twenty six species were identified from all sampling sites. Lake Babuyan (Site 4) and Kalilangan Spring (Site 5) had the highest species richness. *Trithemis aurora*, an oriental species, was the most abundant species. Moderate species diversity was recorded with low endemism (35 %).
Key Words: Species diversity, endemism, habitat, richness, *Trithemis aurora*.

Introduction. Biodiversity loss is a global phenomenon. Its impact may be greatest in the tropics where majority of species are distributed. This long-recognized pattern of increasing diversity towards the tropics is exemplified in tropical forests, which take up less than two percent of the Earth's surface, but contain upwards of fifty percent of its biodiversity (Collen et al 2008). Lack of information about the habitat conditions impedes conservation planning in other types of freshwater system and relates equally to focal species that are neither large nor wide-ranging (Abell 2002).

The insect order Odonata (dragonflies and damselflies) includes some of the most ancient and beautiful insects that ever roamed the Earth. It also includes some of the largest flying invertebrates ever to have lived. Approximately 6,000 species and subspecies belonging to 630 genera and 28 families are known all over the world (Sharma et al 2007). Dragonflies and damselflies are well-known invertebrates and are of great value because of their ecological importance. The Odonata comprises a significant animal component of aquatic environments (DiSalvo et al 2003). Odonata is well studied and conserved for it is highly valued, being iconic, aesthetic, and sensitive biological indicators of landscape change. Species of Odonata are both important subjects in their own right as well as important role players in overall biodiversity conservation (Samways 2008).

Odonata is sensitive to habitat structure and is an excellent indicator of changes in habitat structure (Clausnitzer 2004). The group constitutes a valuable tool for various types of bio-assessment and bio-monitoring of aquatic habitats which include the measure of biodiversity, the assessment of water body health or integrity (including water quality and ecosystem function), the monitoring of management or restoration practices, and the detection and prediction of biological impacts of climate warming (Oertli 2008). The detailed knowledge of ecological requirements of Odonata species in lentic and lotic aquatic habitats is a necessary

prerequisite for the application of effective conservation methods for impaired biodiversity (Kazanci 2011).

Given the current lack of representation for invertebrates in global biodiversity assessments, the importance of obtaining a comprehensive assessment for Odonata has to be a priority, requiring extensive new field surveys. This holds especially true for most forests in tropical areas. The data gap in tropical countries is a taxa-wide problem (Clausnitzer et al 2009).

The Philippine Odonata fauna is characterized by a high percentage of endemic species, especially in the suborder Zygoptera, most of which have very limited range (Hamalainen 2004). Quisil et al (2013) documented 49 species with 23 Philippine endemic species in Lanuza and San Agustin, Surigao del Sur. Cayasan et al (2013) recorded thirty-six species belonging to 10 families of which 16 species are Philippine endemic. Villanueva & Cahilog (2012a) reported 10 new records in Tawi-Tawi raising the total number of Odonata recorded to 54 in which three new species records were made for Sanga-Sanga raising the known number in that island to 34. Three species were recorded for the first time in Jolo raising the total number to 18. Another survey of Villanueva & Cahilog (2012b) documented 35 species under 11 families including one new species representing the first odonatological record in the province of Davao del Norte. Villanueva & Gil (2011) also surveyed the Catanduanes Islands where 42 Odonata species are documented to be new on the island, raising the known species of the island to 60 and among the new island records are three *Amphicnemis* species which are new to science.

Despite the many regions in the Philippines that were surveyed for Odonata, no data are available for Buru-un, Iligan City and Lake Babuyan, Tubod, Lanao del Norte. Lake Babuyan in particular is the oldest lake in Tubod, Lanao del Norte. The main objective of this study is to document the species diversity of Odonata. It also aims to determine the endemism, similarity of sampling sites in terms of species composition and relative abundance of Odonata.

Material and Method. The study was conducted in Buru-un, Iligan City and Tubod, Lanao del Norte, Philippines (Figure 1). Eight sampling sites were established.

Site 1, Mimbalut stream/falls, Buru-un, Iligan City. This stream in barangay Buru-un, Iligan City (8° 28' 52'' N and 120° 14' 22'' E) with elevation of 60 masl is approximately 300 m from the main road. This sampling site is located near the Mimbalut falls. Part of this area is being developed into a recreational commercial park. The site is shady with many trees surrounding the area such as mahogany (*Swietenia mahogani*).

Site 2, Mimbalut stream, Buru-un, Iligan City. This stream in Mimbalut, Buru-un, Iligan City (8° 35' 45'' N and 120° 29' 30'' E) with elevation of 70 masl is located approximately 400 m from the main road and 200 m away from the first sampling site. This site is surrounded with mahogany (*S. mahogani*), carabao grass (*Paspalum conjugatum*) and other bushy grasses. The stream area is open and exposed to sunlight especially at noon.

Site 3, Mimbalut stream, Buru-un, Iligan City. This stream (8° 47'50'' N and 120° 34' 32.4''E) with elevation of 72 masl is located 470 m away from the main road and 70 m away from the second sampling site. The site is surrounded by star apple (*Chrysophyllum cainito* Linn.) and mahogany trees (*S. mahogani*) and is near the rocky cliff. The stream has wild "gabi-gabi" (*Colocasia esculenta*) plants which grow along its banks.

Site 4, Lake Babuyan is located in Barangay Malingao, Tubod, Lanao del Norte (07º 59' 17.1" N and 123 º 52' 30.7" E) with elevation of 405 masl. The whole lake is S-shaped and surrounded with corn, coconut and banana fields. Fishing is a common activity in the lake.

Site 5, Kalilangan Spring is located in Barangay Kalilangan, Tubod, Lanao del Norte (07º 59' 59.4" N and 123º 52' 30.7" E) with elevation of 254 masl. The spring is mainly used for bathing. The spring is surrounded with trees like "talisay" (*Terminalia catappa).* Water spinach (*Ipomoea aquatica*) was found flourishing in the spring's waterways.

Site 6, Bualan River is located in Barangay Bualan, Tubod, Lanao del Norte (07º 59' 46.4" N and 123º 55' 31.0" E) with elevation of 540 masl. It is a fast-flowing river and its left side is covered with big trees and mossy rocks. The site is shaded by big trees that are abundant in the area. Fishing and catching shrimps are some of the common activities in the river.

Site 7, Stream 1 is located in Barangay Bualan, Tubod, Lanao del Norte (07º 59' 37.3" N and 123º 55' 08.3" E) with elevation of 558 masl. Site 7 is covered with big trees and tall grasses.

Figure 1. Map showing the Philippines and the study areas (Google Earth 2013).

Different kind of ferns were noticed in the area. In this very shallow stream some species of fishes were found.

Site 8, Stream 2 is located in Barangay Malingao, Tubod, Lanao del Norte (07º 59' 49.4" N and 123º 55' 31" E) with elevation of 532 masl. The stream is slow-flowing. The upper part of the stream is surrounded with green grasses where cattle are grazing. The middle part of the stream is shaded with branches of "talisay" (*T. catappa)* and bamboo. Mosses and ferns were present in the area.

Eight sites were assessed on August 27 – 31, 2012 and on October 26 – 30, 2012 for a total of 98 man-hours. Adult Odonata collection was done using sweep nets. Collected samples were stored in paper envelopes. Specimens were soaked in acetone for 12 hours, air dried and placed in labeled envelopes. Identification of species collected was based on published studies and confirmed by the fourth author.

Results and Discussion. Twenty six species belonging to seven families and 21 genera were categorized into 15 anisopterans and 11 zygopterans. Table 1 shows the distribution of the Odonata in eight sampling sites. Site 4, Lake Babuyan and Site 5, Kalilangan Spring had the highest species richness (12) which could be due to the size of these sampling areas. These sites have large sampling areas and more sampling time was spent. Site 1, had the least species richness (2). Oppel (2006) found that in Papua New Guinea open sunny areas, artificial ditches and temporary puddles in sunny areas were much more widespread and preferred by more species. In the natural forest, the variety of habitats preferred was wider and more evenly distributed, with species-rich assemblages found in running waters (rivers and creeks) as well as in the forest interior. According to Kazanci (2011), the habitat of each Odonata species has different properties in accordance with its different ecological requirements. The long larval period in aquatic environments played a critical role in the distribution and population size. Habitat quality describes the distribution and population size of Odonata species in various aquatic ecosystems.

Trithemis aurora of family Libellulidae was very abundant (20.16 %), and was widely distributed in different sampling sites. Studies of Tiple et al (2012), and Emiliyamma & Radhakrishnan (2002) in India, and Norma-Rashid et al (2008) in Singapore showed that *Trithemis aurora* is a very common species and is widely distributed in the area. *Rhinocypha colorata* (18.22 %) was abundant, although this species is not widely distributed in all sampling sites.

Figure 2 shows that out of the 26 species recorded, 21 species belong to families Coenagrionidae and Libellulidae. Keize & Kalkman (2009) reported that Coenagrionidae and Libellulidae are the two worldwide largest families of Odonata and dominated the dragonfly fauna of standing water in every continent. Kalkman et al (2008) also stated that the two largest families, Coenagrionidae and Libellulidae, are relatively well known, because most species are noticeable and many favor open habitats, although in absolute numbers they still represent a large proportion of species to be described.

Cayasan et al (2013) showed that among the 36 species in Zamboanga del Sur, Philippines, 16 are from family Libellulidae and another six species are from Coenagrionidae. Villanueva & Cahilog (2012b) documented 11 species from Libellulidae and five from Coenagrionidae among 35 species documented. Quisil et al (2013), Villanueva & Cahilog (2012a), Villanueva & Gil (2011), and Villanueva (2011) found Family Libellulidae to be the most represented while Family Coenagrionidae is the second most represented.

There were only nine endemic species (35 % endemism) found in the eight sites. Studies in some areas in the Philippines also showed low endemism. A 32 % endemism was recorded in Misamis Occidental (Mapi-ot et al 2013), 44 % endemism in Zamboanga del Sur (Cayasan et al 2013), and 47 % endemism in Surigao del Sur (Quisil et al 2013). The low endemism in Iligan City and Lanao del Norte is attributed to anthropogenic activities. More endemic species were recorded for Zygoptera (4) than Anisoptera. Kalkman et al (2008) reported that the percentage of endemic Zygoptera is almost always much higher than the percentage of endemic Anisoptera. In the Philippines, endemism of Anisoptera is 31 % and 86 % for Zygoptera. Only two species, *Drepanosticta krios* and *Risiocnemis atripes*, collected from Site 1 (Buru-un) are Mindanao endemic. Clausnitzer et al (2009) stated that island endemic species are the most threatened and this is true not only for species restricted to islands such as the Philippines, but also for those species restricted to terrestrial habitat islands such as remnant forest patches.

The fauna of the Philippines has a high number of endemic species (more than 60% of the named species) sharing elements with both the Oriental and the Australasian fauna. Its numerous islands have facilitated speciation, resulting in a high number of endemic species (Kalkman et al 2008).

Table 1

Distribution of Odonata in the sampling sites

Species	Site 1. Buru-un	Site 2. Buru-un	Site 3. Buru-un	Site 4. Lake Babu-yan	Site 5. Kalilan-gan Spring	Site 6. Bualan River	Site 7. Stream 1	Site 8. Stream 2	Total	RA (%)
Suborder: Anisoptera										
Gomphidae										
*Ictinogomphus tenax	0	0	0	1	0	0	0	0	1	0.39
Libellulidae										
Acisoma p. panorpoides	0	0	0	0	1	0	0	0	1	0.39
*Diplacina bolivari	0	0	0	0	0	2	0	0	2	0.78
*Diplacina braueri	0	0	0	0	2	0	0	0	2	0.78
Diplacodes trivialis	0	0	0	2	1	3	1	0	7	2.71
Neurothemis r. ramburii	0	2	2	2	1	0	1	2	10	3.88
Neurothemis t. terminata	0	0	0	2	1	1	0	1	5	1.94
Orthetrum pruinosum clelia	0	0	0	0	2	1	0	0	3	1.16
Orthetrum s. sabina	0	0	0	19	3	1	0	0	23	8.91
Pantala flavescens	0	0	0	6	1	1	0	0	8	3.10
Potamarcha congener	0	0	0	3	0	1	0	0	4	1.55
Rhyothemis phylis subphylis	0	1	0	0	0	0	0	0	1	0.39
Tholymis tillarga	0	0	0	2	0	0	0	0	2	0.78
Trithemis aurora	0	3	2	27	4	12	3	1	52	20.16
Zyxomma obtusum	0	0	1	0	0	0	0	0	1	0.39
Suborder: Zygoptera										
Coenagrionidae										
Agriocnemis f. femina	0	0	0	0	0	0	0	4	4	1.55
Agriocnemis pygmaea	0	0	0	1	0	0	0	0	1	0.39
*Agriocnemis rubescens intermedia	0	5	0	0	0	0	0	1	6	2.33
*Ceriagrion lieftincki	0	2	0	0	0	0	0	0	2	0.78
Ischnura senegalensis	0	0	0	1	0	0	0	0	1	0.39
Pseudagrion microcephalum	0	0	0	15	0	0	0	0	15	5.81
Pseudagrion p. pilidorsum	0	4	3	0	19	1	4	5	36	14.00
Chlorocyphidae										
*Rhinocypha colorata	0	0	2	0	27	8	10	0	47	18.22
Platycnemididae										
**Risiocnemis atripes	4	0	0	0	0	0	0	0	4	1.55
Platystictidae										
**Drepanosticta krios	4	0	0	0	0	0	0	0	4	1.55

Species	*Site 1. Buru-un*	*Site 2. Buru-un*	*Site 3. Buru-un*	*Site 4. Lake Babu-yan*	*Site 5. Kalilan-gan Spring*	*Site 6. Bualan River*	*Site 7. Stream 1*	*Site 8. Stream 2*	*Total*	*RA (%)*
Protoneuridae										
**Prodasineura integra*	0	0	4	0	5	2	4	1	16	6.20
Total # of Individuals	8	17	14	81	67	33	23	15	258	-
Total # of Endemic Species	2	2	2	1	3	3	2	1	9	-
Total # of Species	2	6	5	12	12	11	6	6	26	-

RA (%) – Percent Relative Abundance, ** Mindanao Endemic, *Philippine Endemic Species.

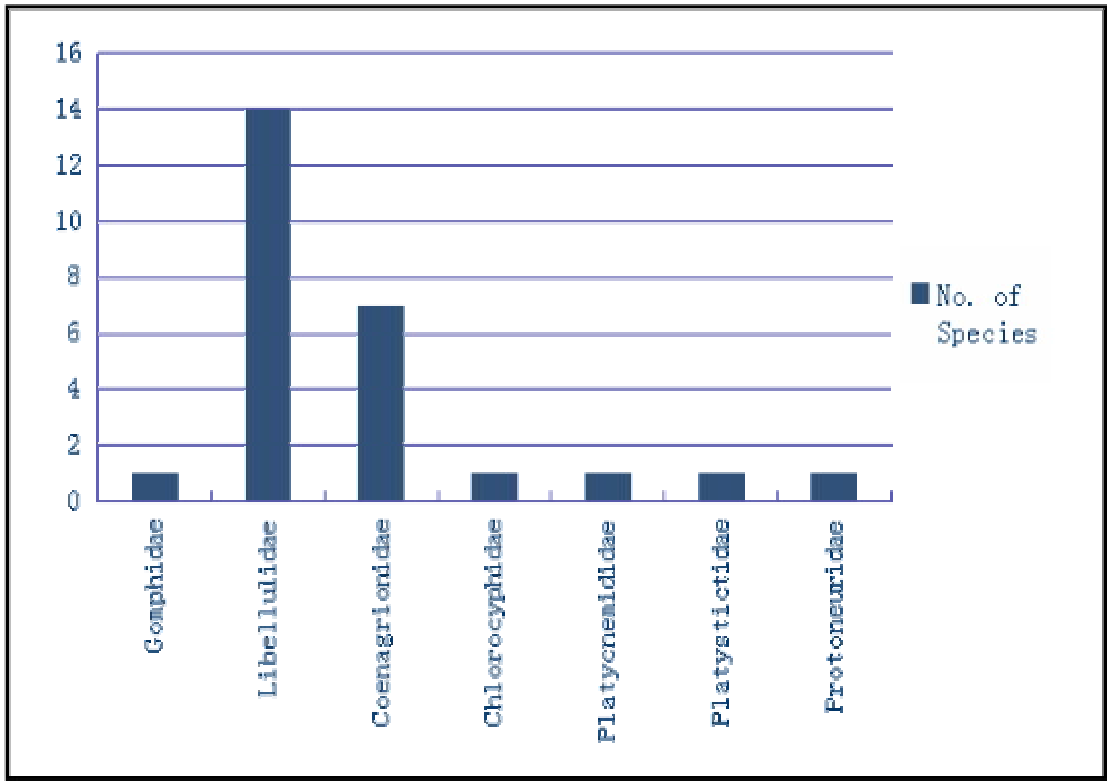

Figure 2. Species richness per Family.

Table 2 shows the biodiversity indices in eight sampling sites. The sampling sites were found to have moderate diversity except site 1 in Buru-un, Iligan City since there were only two species found in the area. A more or less even distribution was recorded in eight sites. Site 1 had uneven distribution but the two species documented in the sites were not found in other sites. Species associated with temporary puddles in the forest, small temporary creeks, and the forest interior comprise almost a third of the total Odonata assemblage in the natural rainforest, and most of them could not be found in the modified forest.

Modification of the forest caused by human subsistence gardening may lead to a loss of approximately 25 % of the species associated with closed canopy forest habitats (Oppel 2006). Undisturbed and disturbed sites showed different Odonata diversity. Dolny et al (2011) stated that habitat type is an important factor for the composition of dragonfly assemblages. The species spectrum of Odonata assemblages changes significantly in relation to habitat degradation. Endemic species are more vulnerable to forest deforestation than commonly-caught species, whereas anthropogenic disturbance in a locality would result in widespread species colonization. This only shows that in undisturbed habitats the Odonata present are more of the endemic and vulnerable species which only prefer clean fresh water systems whereas in a disturbed habitat, widespread and common species were found to be abundant because of their tolerance to anthropogenic pressures.

Table 2

Biodiversity indices in the eight sampling sites

Specification	*Site 1. Buru-un*	*Site 2. Buru-un*	*Site 3. Buru-un*	*Site 4. Lake Babuyan*	*Site 5. Kalilangan Spring*	*Site 6. Bualan River*	*Site 7. Stream 1*	*Site 8. Stream 2*
Species	2	6	5	12	12	11	6	7
Individual	8	17	14	81	67	33	23	15
Shannon	0.6932	1.8746	1.7105	1.8833	1.6958	1.9816	1.5088	1.7095
Evenness	0.2789	0.7544	0.6883	0.7578	0.6825	0.7944	0.6072	0.6879

Table 3 shows that the stream sampling sites 3 and 7 are closely related (83 %) in terms of distribution and abundance of Odonata species. The similarity may be due to shared vegetation and since both sites are partly shaded with slow-flowing water.

Vegetation type affects dragonfly diversity and abundance (Fulan et al 2008). Most of the species present are oriental species of both suborders Anisoptera and Zygoptera. However, a greater number of Anisoptera under family Libellulidae was commonly observed. Family Libellulidae principally dwells in habitats with open canopies (Kiany & Minaei 2009). Site 1 having no similarity at all in any of the sites has high endemism. Endemic species tend to be confined to stable habitats with low dispersal capacity (Gassmann 2004) and in terms of spatial distribution, endemic may occupy limited geographical ranges (Gaston 1991). The other sampling sites were found to have low similarity.

Two Mindanao endemic species were found in the same site (Site 1). *Risiocnemis atripes* (Figure 3) is a Mindanao endemic species (Villanueva 2012). This species was found near Mimbalut waterfalls, Buru-un, Iligan City. *Drepanosticta krios* (Figure 4) is also a Mindanao endemic species. It was found abundant in trickles adjacent to Mimbalut waterfalls. Villanueva (2009) reported that this species is encountered in shaded forest trickles and rivulets. This species is listed in the IUCN-Red list (2012) as nearly threatened.

Table 3

Similarity index in the eight sampling sites

Specification	*Site 1. Buru-un*	*Site 2. Buru-un*	*Site 3. Buru-un*	*Site 4. Lake Babuyan*	*Site 5. Kalilangan Spring*	*Site 6. Bualan River*	*Site 7. Stream 1*	*Site 8. Stream 2*
Site 1. Buru-un	-	-	-	-	-	-	-	-
Site 2. Buru-un	0	-	-	-	-	-	-	-
Site 3. Buru-un	0	62 %	-	-	-	-	-	-
Site 4. Lake Babuyan	0	21 %	22 %	-	-	-	-	-
Site 5. Kalilangan Spring	0	44 %	59 %	50 %	-	-	-	-
Site 6. Bualan River	0	32 %	44 %	52 %	78 %	-	-	-
Site 7. Stream 1	0	62 %	83 %	33 %	56 %	59 %	-	-
Site 8. Stream 2	0	71 %	62 %	32 %	53 %	44 %	61 %	-

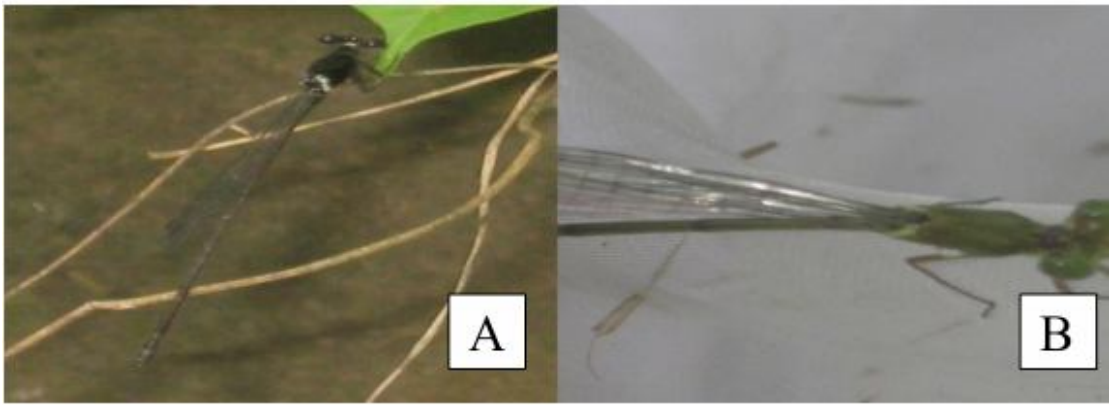

Figure 3. *Risiocnemis atripes.* A – Male, B – Female.

Figure 4. *Drepanosticta krios* (van Tol et al 2008).

Conclusions. The sampling sites had low species richness with low endemism. Most species documented are widespread and oriental species that can tolerate habitat disturbance and are able to survive in human settlements. Moderate species diversity was recorded except for site 1. Site 1 where two Mindanao endemic species were found is a potential good habitat for Odonata.

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