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Species diversity of Odonata in Bega watershed, Agusan del Sur, Philippines

Keren Jollia M. Nuñeza[1], Olga M. Nuñeza[1*], Reagan Joseph T. Villanueva[2]

[1]*Department of Biological Sciences, College of Science and Mathematics, MSU-Iligan Institute of Technology, A. Bonifacio Ave., Tibanga, Iligan City, Philippines*

[2]*Forestal Healing Homes and Therapeutic Milieu, Forestal Road, Cabantian, Davao City, Philippines*

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Abstract

Odonata is dependent upon habitats with standing or flowing water. Its sensitivity to changes in water ecosystems makes it a good biological indicator. This study aimed to determine the species richness of Odonata in Bega Watershed, Prosperidad, Agusan del Sur, Philippines. A survey was conducted in 12 sites on May 8-14, 2014 using sweep netting and hand catching methods. Twenty-seven species consisting of 11 species of dragonflies and 16 species of damselflies under 10 families and 20 genera were recorded. Of the 27 species, 17 are endemic with 62.96% endemism. Bega Watershed had high species diversity with an uneven distribution of species. Among the sampled sites, sites 2 and 4 had the highest species richness (S=14) while highest species diversity (H'=2.47) was recorded in site 4 which is a relatively undisturbed and intact ecosystem. Highest abundance of Odonata was recorded in Site 1, the first level of Bega falls. *Rhinocypha colorata*, an endemic species, was found to be the most abundant and widespread, being found in seven out of 12 sites. Detrended correspondence analysis showed that Odonata prefers semi-forested riparian areas while Bray-Curtis cluster analysis showed that sites 2 and 4 are the most similar sites. The high level of endemism and moderate to high diversity in most of the sites indicate that Bega watershed is a relatively healthy ecosystem and is of high conservation importance.

***Corresponding Author:** Olga M. Nuñeza ✉ olgamnuneza@yahoo.com

Introduction The insect order Odonata is divided into three suborders – damselflies (Zygoptera), dragonflies (Anisoptera), and primitive dragonflies (Anisozygoptera) (Mitra, 2006). There are eight superfamilies, 29 families, and some 58 sub-families of dragonflies of approximately 600 genera and 6000 known species all over the world (Silsby, 2001). Dragonflies and damselflies are among the most attractive creatures on earth and occur in all types of freshwater and nearby habitats (Springate-Baginski *et al.,* 2009) from the largest lakes and rivers to tiny wetlands (Nelson *et al.,* 2011). They are a flagship group and an important component of aquatic ecosystems, in which they can often be top predators (Balzan, 2012). However, many odonata species are red listed due to habitat fragmentation (Villanueva and Mohagan, 2010) and other anthropogenic activities such as land conversion for agricultural and infrastructural development (Khrokalo, and Prokopov, 2009) and illegal logging resulting to the disappearance of forest cover and hence altering the habitat of Odonata (Villanueva *et al.,* 2012).

Dragonflies and damselflies (Odonata) are highly specialized for a specific wetland habitat (Subramanian *et al.,* 2008). This insect group is recognized as a good indicator of water quality because of its sensitivity to changes in water ecosystems (Bulankova, 1997). Odonata is also used in evaluating biodiversity in secondary or man-made aquatic habitats (Bried and Samways, 2015). The study of Quisil *et al.* (2014) on the impact of mine tailings on the species diversity of Odonata shows that aquatic sites without mine tailings have higher abundance, species richness, and endemism than sites with mine tailings. Adu *et al.* (2014) also found that the dominance of ubiquitous species of Odonata with broad niches in the forest may be a result of anthropogenic activity in the forest. As such, the distribution of Odonata species is determined by habitats suitable for maintaining the population (Malawani *et al.,* 2014). On the other hand, the Odonata can also act as an umbrella species, facilitating the protection of habitat that is crucial for the survival of other species (Bried and Ervin, 2005).

Odonata is widespread and abundant and can be found in all continents with the exception of Antarctica (Kalkman *et al.,* 2008). The number of Odonata species known from the Sicilian Channel (Corso *et al.,* 2012) are very few (20) compared to Bhutan (31) (Mitra, 2006), Srilanka (117) (De Fonseka, 2000), Bangladesh (114), Nepal (172) (Prasad and Varshney, 1995), and North America (462) (Paulson and Dunkle, 2012). The study of Dalzochio *et al.* (2011) in Brazil recorded 33 species.

The Philippines, a tropical country, is characterized by high number of Odonata species and high percentage of endemism (Hämäläinen, 2004). There are about 300 Philippine Odonata species known (Hamalainen and Muller, 1997) with more than 60% endemic (Kalkman *et al.,* 2008) that are highly dependent on aquatic habitats in different forests and their distribution is determined by the habitats that are suitable to maintain their population (Cayasan *et al.,* 2013). Field surveys in various areas in the Philippine archipelago are needed since several parts of the archipelago's main islands like Mindanao are virtually unexplored (Villanueva, 2011a; 2011b). Mindanao, the second largest island in the archipelago has extensive list of flora and fauna, some of which are endemic to the island or in a particular region of the island (Villanueva and Mohagan, 2010). Mindanao contains 130 Odonata species (Hamalainen and Muller, 1997). Moreover, one of the most interesting species of Platycnemididae and Platystictidae are confined to this region (Villanueva, 2011b). Many surveys have been done in various parts of Mindanao like Tawi-Tawi, Sanga-Sanga, and Jolo Islands (Villanueva and Cahilog, 2012), Misamis Occidental (Mapi-ot *et al.,* 2013), Cagayan de Oro and Bukidnon (Jomoc *et al.,* 2013), Lanao del Sur (Malawani *et al.,* 2014; Dimapinto *et al.,* 2015), Zamboanga del Sur (Cayasan *et al.,* 2013), and in Surigao del Sur (Quisil *et al.*, 2013). However, there are still parts of this island that have no Odonata records especially in the Bega Watershed of Agusan

del Sur on the Island of Mindanao which indicates that research and fieldwork are needed in this particular area (Oppel, 2005; Villanueva, 2011b). The only faunal record in Bega Watershed in Agusan del Sur was reported by Calimpong and Nuneza (2015) on avifaunal diversity and Monteclaro and Nuneza (2015) on the richness of fruit bats. Thus, this study aims to determine the species richness, species diversity, distribution, endemism, and conservation status of Odonata in Bega Watershed, Agusan del Sur. The sampling sites were also compared and other habitat variables were observed.

Materials and methods

Study area

The study was conducted in Bega Watershed of Barangay Mabuhay, Prosperidad, Agusan del Sur (Fig. 1).

Fig. 1. Map of the world and the Philippines showing the location of Prosperidad, Agusan del Sur (www.google.com.ph, 2015).

It is located on the island of Mindanao in the south of the Philippines. Table 1 shows the summary of habitat description of the twelve sampling sites.

Collection and Processing of Samples

Opportunistic sampling was conducted for seven field days from May 8-14, 2014. Sampling sites were randomly selected. A habitat description form was used to describe the sampling sites. Samples were collected by hand-catching and sweep-netting. A long-handled white aerial net was used to capture flying and resting Odonata. Samples were placed in paper triangles as soon as they were captured. Only one Odonata sample was placed in each paper triangle with the exception of mating pairs that were placed together.

The live specimens collected in the paper triangles were placed in a closed plastic container with a cotton ball soaked in ethyl acetate to suffocate them. Suffocation took around 5 to 10 minutes depending on the size of the captured Odonata. The samples were then placed in containers to be soaked with acetone for preservation purposes. Damselflies were submerged for 12 hours and dragonflies were submerged for 24 hours. After the allotted time, the samples were placed on tissue paper and air dried. One to two individuals per species were kept as voucher specimens, the others were released.

Photographs of the specimens were taken in the field or immediately after capture. Initial identification was done through the use of published references. The identification was verified by the third author.

Statistical analysis

Biodiversity Indices, Detrended Correspondence Analysis, and Cluster analysis were done using Paleontological Statistics Software Package version 3.06.

Results and discussion

Species richness, endemism, and abundance

Twenty-seven species of Odonata under 10 families and 20 genera were identified (Table 1).

Table 1. Species richness, relative abundance, and distribution of Odonata in Bega watershed.

Species Name	Sampling Sites in Bega Watershed												Total
	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Site 8	Site 9	Site 10	Site 11	Site 12	
SUB-ORDER ANISOPTERA													
Family Corduliidae													
Heteronaias heterodoxa *	1 (0.59)	--	--	--	--	--	--	1 (0.59)	--	--	--	--	2
*Idionyx philippa**	--	1 (0.59)	--	--	--	--	--	--	--	--	--	--	1
Family Gomphidae													
*Gomphidia kirschii**	2 (1.18)	--	--	--	--	1 (0.59)	--	--	1 (0.59)	--	2 (1.18)	2 (1.18)	8
Family Libellulidae													
Agrionoptera insignis	2 (1.18)	--	--	--	--	--	--	--	1 (0.59)	--	--	--	3
Diplacodes trivialis	--	1 (0.59)	--	--	--	--	--	--	--	--	1 (0.59)	--	2
*Diplacina bolivari**	--	1 (0.59)	1 (0.59)	1 (0.59)	--	--	--	--	1 (0.59)	--	--	3 (1.76)	7
Neurothemis ramburii	3 (1.76)	--	--	--	1 (0.59)	2 (1.18)	--	1 (0.59)	1 (0.59)	1 (0.59)	--	2 (1.18)	11
Orthetrum pruinosum clelia	1 (0.59)	1 (0.59)	1 (0.59)	1 (0.59)	--	--	--	--	--	--	--	--	4
Orthetrum sabina sabina	--	--	--	1 (0.59)	1 (0.59)	--	--	--	--	--	1 (0.59)	--	3
Trithemis aurora	5 (2.94)	--	--	1 (0.59)	--	4 (2.35)	--	--	1 (0.59)	--	--	4 (2.35)	15
Trithemis festiva	2 (1.18)	--	--	2 (1.18)	--	3 (1.76)	--	--	--	--	--	1 (0.59)	8
SUB-ORDER ZYGOPTERA													
Family Calopterygidae													
*Neurobasis anumariae**	3 (1.76)	1 (0.59)	--	1 (0.59)	--	--	--	--	--	--	--	--	5
*Vestalis melania**	--	1 (0.59)	--	--	1 (0.59)	--	--	--	--	--	--	2 (1.18)	4
Family Chlorocyphidae													
Cyrano angustior *	--	1 (0.59)	--	1 (0.59)	4 (2.35)	1 (0.59)	--	1 (0.59)	3 (1.76)	2 (1.18)	--	--	13
*Rhinocypha colorata**	5 (2.94)	5 (2.94)	--	4 (2.35)	1 (0.59)	3 (1.76)	--	--	--	3 (1.76)	--	1 (0.59)	22
*Rhinocypha turconii**	5 (2.94)	1 (0.59)	--	3 (1.76)	1 (0.59)	1 (0.59)	--	--	1 (0.59)	--	--	--	12
Family Coenagrionidae													
Pseudagrion pilidorsum pilidorsum	--	--	--	2 (1.18)	--	1 (0.59)	--	--	--	--	--	--	3
Sangabasis sp. Cf. dentite	--	--	--	--	--	1 (0.59)	--	--	--	--	--	--	1
Family Euphaeidae													
*Euphaea amphicyana**	1 (0.59)	1 (0.59)	--	--	1 (0.59)	--	1 (0.59)	--	--	--	--	--	4
Euphaea cora	--	--	--	--	--	1 (0.59)	--	--	--	--	--	--	1
Family Platycnemididae													
*Coeliccia dinocerus**	--	--	--	4 (2.35)	2 (1.18)	--	--	--	--	--	--	1 (0.59)	7
*Risiocnemis atripes**	2 (1.18)	1 (0.59)	--	1 (0.59)	--	--	--	--	--	--	--	--	4

*Risiocnemis flammea**	--	2 (1.18)	--	4 (2.35)	1 (0.59)	1 (0.59)	1 (0.59)	--	10 (5.88)	1 (0.59)	--	--	20
*Risiocnemis appendiculata**	--	1 (0.59)	--	--	--	--	--	--	--	--	--	--	1
Family Platysticitidae													
Drepanosticta krios *	--	--	--	--	1 (0.59)	--	--	--	--	--	--	--	1
Drepanosticta leonardi *	--	--	--	--	--	--	--	--	1 (0.59)	1 (0.59)	--	--	2
Family Protoneuridae													
Prodasineura integra *	--	1 (0.59)	--	2 (1.18)	1 (0.59)	1 (0.59)	--	1 (0.59)	--	--	--	--	6
Total Number of individuals	32 (18.82)	19 (11.18)	2 (1.18)	28 (16.47)	15 (8.82)	20 (11.76)	2 (1.18)	4 (2.35)	20 (11.76)	8 (4.71)	4 (2.35)	16 (9.41)	
Total Number of species	12	14	2	14	11	12	2	4	9	5	3	8	27
Total Number of Endemic Species	7	10	1	9	9	6	2	2	6	4	1	5	17

Legend: * - Philippine Endemic, ( ) - Relative Abundance in Percentage.

A total of 170 individuals were collected. There were eleven Anisopteran species recorded belonging to three families: Corduliidae, Gomphidae and Libellulidae. Sixteen Zygopteran species from seven families, namely, Calopterygidae, Chlorocyphidae, Euphaeidae, Coenagrionidae, Platycnemididae, Platysticitidae, and Protoneuridae were also documented. However, the result is relatively lower than the recorded number of Odonata species by Cayasan *et al.* (2013) in Zamboanga del Sur, Quisil *et al.* (2013) in Surigao del Sur, Jomoc *et al.* (2013) in Cagayan de Oro and Bukidnon, and Villanueva and Gill (2011) in Catanduanes Island. But compared to the study conducted by Mapi-ot *et al.* (2013) in Misamis Occidental and Dimapinto *et al.* (2015) in Lanao del Sur the result is relatively higher. The same number of Odonata species was also recorded by Ebrahimi *et al.* (2009) in the freshwaters of South-Eastern Iran and by McMurray and Schuster (2009) in Kentucky, USA.

Table 2. Biodiversity indices of the twelve sampling sites in Bega watershed.

Sampling Sites	Biodiversity Indices		
	Species Richness	Shannon's Diversity (H')	Evenness (E)
S1	12	2.33	0.19
S2	14	2.45	0.18
S3	2	0.69	0.35
S4	14	2.47	0.18
S5	11	2.25	0.2
S6	12	2.32	0.19
S7	2	0.69	0.35
S8	4	1.39	0.35
S9	9	1.7	0.19
S10	5	1.5	0.3
S11	3	1.04	0.35
S12	8	1.96	0.25
Total	27	2.94	0.69

Most of the Odonata species recorded came from family Libellulidae (Fig. 2). According to Kaize and Kalkman (2009), Libellulidae is one of the two largest families worldwide that dominates fauna of standing water in every continent. Bechly and Sach (2002)) reported that it ranks among the most diverse and widespread subgroups of dragonflies. The study of Aspacio *et al.* (2013), Dimapinto *et al.* (2015), Jomoc *et al.* (2013), Tiple and Koparde (2015), and Seyab *et al.* (2015) also recorded a higher number of species that belong to the family Libellulidae. Furthermore, most of the species (S=8) from Suborder Anisoptera

came from family Libellulidae. This result is in agreement with the findings of Jomoc *et al.* (2013), Mapi-ot *et al.* (2013), Fleck *et al.* (2008) and Quisil *et al.* (2014) that family Libellulidae contains higher number of Anisopteran species. Libellulidae is the most diverse and most numerous group of Odonata (Subramanian, 2005) with over 1000 species in approximately 140 genera (Pilgrim and Dohlen, 2008) that breed primarily in still water or lentic habitats (*Kiany* and *Minaei, 2009*). Most damselfly species in this study belong to Family Platycnemididae, (S=4). Platycnemididae has a distribution confined to Europe, Asia, and Africa. Most of the species of Platycnemididae live along rivers although there are species that breed in standing water (Danish Dragonflies, 2015), however, they are often encountered in slow-flowing streams (Dudgeon, 1999).

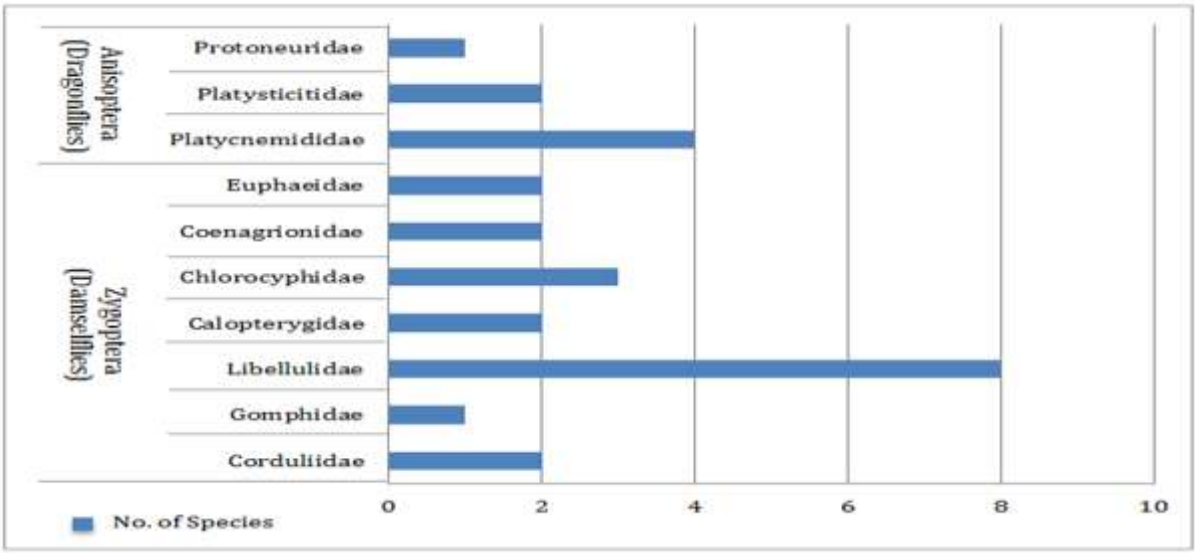

Fig. 2. Species richness per family.

In terms of sampling sites, the highest species richness was recorded in Sites 2 and 4 (S=14). This could be due to the large body of water and the dense vegetation in these sampling sites. Odonata is found to have a preference for dense forests with undisturbed vegetation, optimum temperature, and the presence of an aquatic habitat (Villanueva and Mohagan, 2010). This result concurs with the findings of Mabry and Dettman (2010) that dense and diverse vegetation provides a rich array of Odonata, particularly damselfly species which is the case of sites 2 and 4 where damselflies dominate over dragonflies. Both Sites 2 and 4 are relatively undisturbed riparian areas next to waterfalls.

The study of Jomoc *et al.* (2013) and Quisil *et al.* (2015) found that undisturbed sites or semi-pristine environments have higher species richness than the disturbed sites. Site 1 had the highest abundance (32) and relative abundance (18. 82%) of Odonata species. It is a semi-open habitat with waterfalls that is surrounded with dense vegetation and large canopy. The heat of the sun can directly hit the area; however, there are areas in this site that are shaded due to the presence of large trees. This factor could contribute to the abundance of Odonata species especially the Anisoptera which dominated the area due to its preference to an open habitat. Zygopteran species, however, were also present due to the presence of dense vegetation and shaded areas. This finding is in agreement with the observation of Cayasan *et al.* (2013) that Anisopteran species often inhabit open and sunny environments. Jomoc *et al.* (2013) also found that the presence of Zygopteran species is probably due to the large canopy cover that provided shady areas in the site. Sites 3 and 7 had the least species richness (S=2). Baptista *et al.* (2001) noted that Odonata has a higher preference for areas of low

water flow.

In terms of species abundance, the most abundant and widespread species were *Rhinocypha colorata* (12.94%) and *Risiocnemis flammea* (11.76%), both Philippine endemic species and are present in seven out of the 12 sampled sites. According to Villanueva (2012) *R. colorata* can be found even in areas with significant human activity and it can tolerate streams that have agricultural and domestic runoffs. Moreover, Mapi-ot *et al.* (2013) and Quisil *et al.* (2014) observed that *R. colorata* can adapt and tolerate disturbed habitats. Thus, this adaptable characteristic of *R. colorata* could be the factor for its abundance and being widespread in the study area. Furthermore, Aspacio *et al.* (2013) also found *R. colorata* to be the most abundant Odonata species in selected areas of Iligan City and Tubod while *R. flammea* was usually found in dense vegetated areas. Some individuals of this species were perching on leaves at the edge of water body. The study of Villanueva (2011a) in Bucas Grande Island, Cayasan *et al.* (2013) in Zamboanga del Sur, Jomoc *et al.* (2013) in Cagayan de oro and Bukidnon and Malawani *et al.* (2014) in Lanao del Sur showed that *R. flammea* is not a very abundant species and widespread unlike the recorded data in this study.

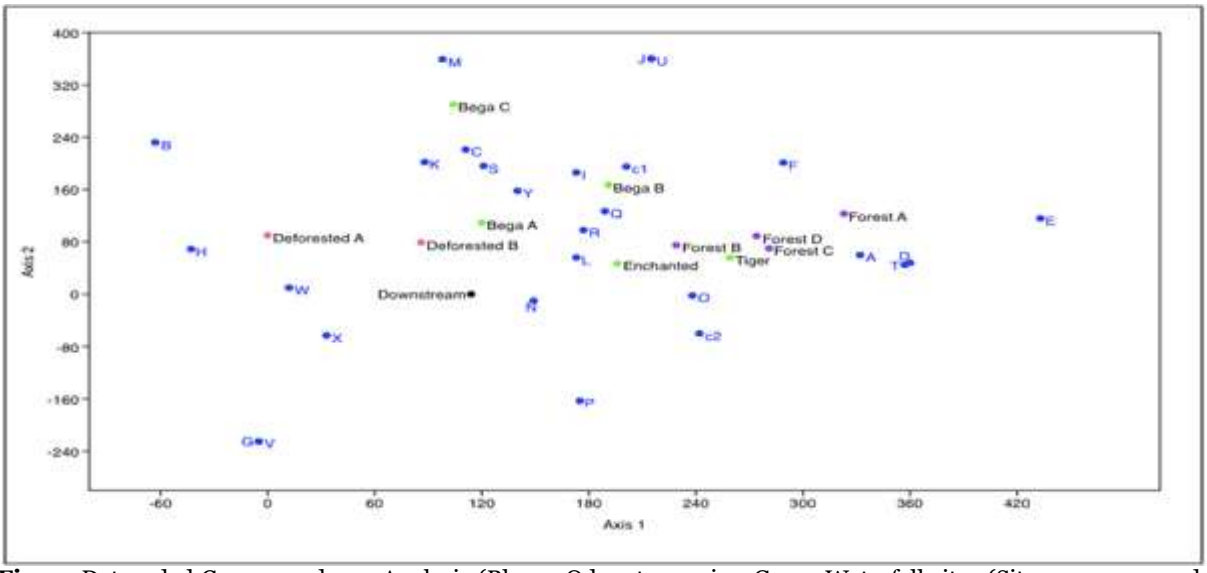

Fig. 3. Detrended Correspondence Analysis (Blue – Odonata species, Green Waterfall sites (Sites 1, 2, 3, 4, and 5), Black – Downstream (Site 6), Violet – Forested Sites (Sites 7, 8, 9, 10), Pink – Deforested Sites (Sites 11 and 12)).

The Philippine endemic Anisopteran species *Idionyx philippa* was the least abundant. This species was observed perching on dried twigs near the water in Site 2. This observation is in agreement with the findings of Villanueva (2009a) that *I. philippa* is frequently encountered hovering or perching on twigs, sometimes in group, in shaded montane forest near or at some distance of the water. The Zygopteran species, *Sangabasis sp. Cf. dentite, Euphaea cora,* and two Philippine endemic, *Risiocnemis appendiculata* and *Drepanosticta krios* were also least abundant with only one individual each.

Seventeen Philippine endemic Odonata (62.96% endemism) consisting of four Anisopteran and 13 Zygopteran species were recorded in Bega Watershed. The highest number of endemic species (10) was found in Site 2. According to Malawani *et al.* (2014) endemic Odonata species prefer forested and seemingly undisturbed areas which are characteristics of site 2. The same trend of having a higher number of endemic species in Suborder Zygoptera was noted by Malawani *et al.* (2014) in Lanao del Sur, Cayasan *et al.* (2013) in Zamboanga del Sur, and Quisil *et al.*

(2013) in Lanuza and San Agustin. In addition, the studies of Villanueva and Mohagan (2010) and Kalkman *et al.* (2008) in the Philippines also reveal that there are more endemic damselflies than dragonflies. There is a high number of endemic Odonata fauna from the Philippines, around 60% of named species (Kalkman *et al.*, 2008). Moreover, the presence of more Zygopteran species than Anisopteran could be due to the presence of more shaded areas or forest cover in the sampling sites because as Arulprakash and Gunathilagaraj (2010) reported, the presence of shade cover and aquatic vegetation favors Zygopteran population more than Anisoptera. This result is also in agreement with the findings of Jomoc *et al.* (2013) that high number of damselfly species is due to the large canopy cover that provided shady areas in the site. The high level of endemism indicates that Bega Watershed is a relatively healthy ecosystem and is of high conservation importance. However, low endemism was recorded in sites 3 and 11 since site 3 is a semi-open habitat having only two species which are both Anisopteran while site 11 is a disturbed site which could not be a favorable habitat to some endemic Odonata species. Mapi-ot *et al.* (2013) reported that a forested area with a lesser degree of disturbance could harbor mostly Philippine endemic species while an already disturbed area like site 11 consists mostly of oriental and common species. Furthermore, low endemism of Odonata is attributed to anthropogenic disturbances (Aspacio *et al.,* 2013).

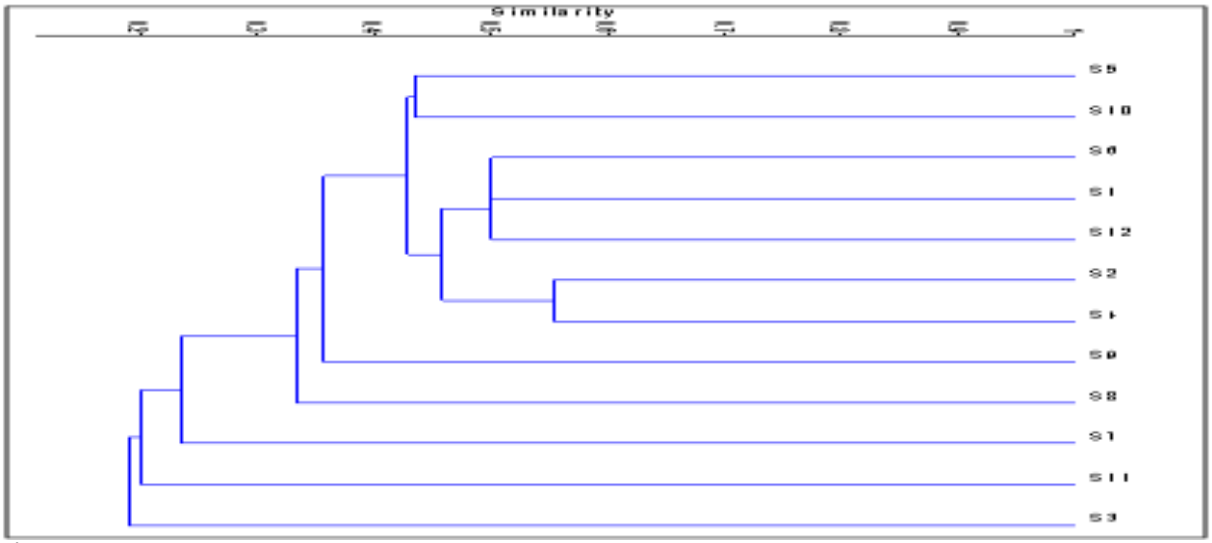

Fig. 4. Cluster analysis (Bray-Curtis: Single Link) of Odonata in the twelve sampling sites of Bega Watershed. (site 1, site 2, site 3, site 4, site 5, site 6, site 7, site 8, site 9, site 10, site 11, site 12).

Biodiversity Indices

The biodiversity indices are shown in Table 2. In interpreting Shannon's Diversity index, the higher the number means a greater diversity. High species diversity (>2.0) was observed in Sites 1, 2, 4, 5 and 6. Moderate species diversity (1.0<2.0) was observed in sites 8, 9, 10, 11 and 12. Low species diversity (<1.0) (H'=0.69) was documented in sites 3 and 7. High species diversity was observed to be associated with undisturbed secondary forest and filtered forest with dense vegetation and waterfalls or stream on site while moderate diversity was seen in areas with primary-secondary forest associated with water system, Low diversity was observed in slash-and-burn forest without aquatic habitat. Jomoc *et al.* (2013) also found high species diversity in habitats associated with mixed primary-secondary forest while low diversity in disturbed areas. Odonata as a group has preference for dense forest, undisturbed vegetation, optimum temperature, and presence of aquatic habitat Villanueva and Mohagan (2010). Dolny *et al.* (2011) stated that habitat type is an

important factor for the composition of dragonfly assemblages. Among the sampled sites, Site 4 had the highest species diversity (H'=2.47) although most of the sampling sites had a moderate to high diversity. Site 4 also had the highest number of species present. Overall, Bega Watershed has high species diversity with an uneven distribution of species in all the sampled sites. The uneven distribution of species could be due to the presence of two dominant species, *Rhinocypha colorata* and *Risiocnemis flammea* which were present in seven out of the 12 sampled sites. According to Malawani *et al.* (2014) the evenness value is influenced by the competition of species for food and territory within an area. Moreover, tolerance of species to habitat disturbance could also be the factor for the presence of dominant species in the sampling sites.

Detrended Correspondence Analysis

Fig. 3 shows the trend of the distribution of Odonata in the sampling sites. More Odonata species preferred riparian habitats than deforested habitat or forest. Only few Odonata species are present in deforested habitats or the forests. *Orthetrum pruinosum clelia, Neurobasis anumariae, Pseudagrion pilidorsum pilidorsum, Sangabasis sp. Cf. dentite, Euphaea cora, Risiocnemis atripes, Risiocnemis appendiculata* and *Drepanosticta krios* are the species that were only recorded in riparian areas. The damselfly species *Drepanosticta leonardi* was only found in the forested habitat of sites 9 and 10 where a creek and small pools are present. *Idionyx philippa, Agrionoptera insignis, Cyrano angustior, Rhinocypha turconii, Euphaea amphicyana, Risiocnemis flammea,* and *Prodasineura integra* are species that were found both in riparian areas and forested habitat while the species that were found both in riparian and deforested habitats are *Diplacodes trivialis, Orthetrum sabina sabina, Trithemis festiva, Vestalis melania,* and *Coeliccia dinocerus*. Cayasan *et al.* (2013) reported that the presence and richness of Odonata species are greatly affected by the characteristics of freshwater system and its surroundings. Thus, the characteristics of habitats in the sampled areas could influence the presence of species. Moreover, it was found that some of the Odonata species were not only associated or found in one or two sites but were present in the three habitats: riparian , forested, and deforested habitats like the widespread species *Gomphidia kirschii, Diplacina bolivari, Neurothemis ramburii, Trithemis aurora,* and *Rhinocypha colorata*. However, there were no exclusive species found in deforested habitat. Remsburg (2007) stated that diversity and abundance are correlated positively with local abundance of vegetation. It was observed that most of the endemic Odonata species prefer to inhabit undisturbed riparian areas and forested habitat where water system is present while widespread species can also be found in deforested habitat or forest in the presence or absence of water. This result is in agreement with the findings of Quisil *et al.* (2013) that endemic species of Odonata prefer forested and undisturbed areas while Aspacio *et al.* (2013) and Cayasan *et al.* (2013) found that widespread Odonata species can tolerate habitat disturbance and are able to survive in human settlements and are therefore indicators of degraded environments.

The Philippine endemic species, *Rhinocypha colorata* which was found in sites 1,2 4, 5, 6, 10 and 12, and *Risiocnemis flammea* found in sites 2, 4, 5, 6, 7, 9 and 10 are the two most widespread species. It was observed that *R. flammea* was only found in riparian areas and forested habitat while *R. colorata* can be found in three habitats (riparian, forested and deforested) thus indicating that it can tolerate site disturbance. The only anisopteran species *Idionyx philippa* was only found in site 2 while three Zygopteran species, *Sangabasis sp., Cf. dentite,* and *Euphaea cora* were found in site 6. The Philippine endemic and the near-threatened species, *Drepanosticta krios* was only found in the shady area adjacent to a small flow of water from the waterfalls of site 5. This concurs with the findings of Villanueva (2009b) that *D. krios* is usually encountered in shaded forest trickles and rivulets or in a trickles adjacent to waterfalls.

Similarity of Sites

Fig. 4 shows the similarity of the 12 sampling sites. Sampling sites 2 and 4 formed the first clade with the highest similarity percentage of 55% which means that these sites shared most Odonata species and habitat characteristics. This concurs with the findings of Tubelis and Cavalcanti (2001) that sites having a high similarity percentage might have a similar type of habitat and has a tendency of having similar species composition. Sites 2 and 4 have the same habitat type which is a secondary forest with presence of waterfalls. Presence of shaded areas and absence of site disturbance were also observed in the area which favored the damselfly species making them abundant in these two sites. Ten Odonata with two Anisopteran species, *Diplacina bolivari* and *Orthetrum pruinosum clelia* and eight Zygopteran species, *Neurobasis anumariae, Cyrano angustior, Rhinocypha colorata, Rhinocypha turconii, Risiocnemis atripes, Risiocnemis flammea* and *Prodasineura integra* were also shared by these two sites. The second clade was formed by sites 1, 6, and 12 having a similarity percentage of 50% due to the presence of the shared species, *Gomphidia kirschii, Neurothemis ramburii, Trithemis aurora, Trithemis festiva* and *Rhinocypha colorata* which are widespread species that can tolerate disturbed areas. The third clade is composed of sites 5 and 10 with a similarity percentage of 43% due to the presence of shared species *Neurothemis ramburii, Cyrano angustior, Rhinocypha colorata* and *Risiocnemis flammea* and the absence of on-site disturbance. Moreover, sites 5 and 10 were clustered to sites 2 and 4 and sites 1, 6, and 12 due to the presence of *R. colorata* with 45% similarity percentage. *R. colorata* is a widespread species (Renema, 2007) that prefers open flowing waterways where it perches on exposed twigs adjacent to the water and can tolerate moderate habitat disturbance (Villanueva *et al.,* 2012). Thus, these factors could explain for the presence of species in the seven sampling sites. The study of Quisil *et al.* (2014) also showed that *R. colorata,* is the most abundant and widespread species found in seven out of the eight sampling sites in Surigao del Sur indicating that this species can adapt to sites with mine tailings.

Conclusion

Bega Watershed has high species diversity of Odonata with high percentage of endemism (62.96%). The twelve sampled sites had uneven distribution of species. Sites 2 and 4 had the highest species richness (S=14) with site 2 had the most number of endemic species. The Philippine endemic species *Rhinocypha colorata* is the most abundant and widespread species. Results indicate that an undisturbed forest-riparian area is the favored habitat of the Odonata. The high level of endemism and the moderate to high diversity in most of the sites further indicate that Bega Watershed is a relatively healthy ecosystem and is of high conservation importance.

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