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# Species Richness of Odonata in the Agricultural Area of Sultan Naga Dimaporo, Lanao del Norte, Philippines

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**ABSTRACT**
*Odonata is a good biological indicator especially in fresh water ecosystem because it is very responsive to habitat and landscape degradation. This study was conducted to determine the species richness of Odonata in the agricultural areas of Sultan Naga Dimaporo, Lanao del Norte. Eight sampling sites were assessed comprising heavily disturbed and slightly disturbed agricultural areas. Sampling was done by sweep netting. Thirteen species composed of 10 dragonflies (Anisoptera) and three damselflies (Zygoptera) were documented belonging to 10 genera and three families. Only two endemic species were found. Orthetrum sabina sabina, an Oriental species, was the most abundant species found in all areas. The agroforestry sites which are slightly disturbed areas had higher species richness, abundance, endemism, and diversity. Results indicate that agricultural land use has adverse impact on species richness of Odonata.*
***Keywords:*** *damselflies, diversity, dragonflies, endemic, habitat.*

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## INTRODUCTION

Odonata, which consists of two major groups: Anisoptera, the dragonflies and Zygoptera, the damselflies, is a good biological indicator of habitat integrity especially on fluvial environment [1] because of its sensitivity to structural habitat and landscape change [2]. Several species of Odonata are stenotopic and require specialized habitat conditions [3].

The Odonata fauna in the Philippine archipelago is characterized by high percentage of endemic species [4]. Mindanao, the second largest island on 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 and has over a hundred species of Odonata [5]. Approximately 6,000 species and subspecies belonging to 630 genera and 28 families are known all over the world [6]. In the synopsis of the Philippine Odonata reported by Hämäläinen and Müller [7], only 15 families, 91 genera, and 309 species are named of which 203 species (65.7%) are endemic. Of these, Order Zygoptera consisting of 34 genera and 186 species has 85.5% endemism. Order Anisoptera contains 57 genera and 123 species where only 44 species (35.8%) are endemic [8].

In tropical countries like the Philippines, diversity of Odonata is highly dependent on the types of aquatic habitats in different forests. Temperature plays a big role in the increase of diversity from the poles to the equator. The tropics hold higher diversity of Odonata where 12 of the 31 families are restricted mostly to lotic waters within tropical forest habitats. This is the reason why the Philippines is recognized for its high number of endemic Odonata [9].

Recent surveys in the Philippines contributed further to the odonatological data. Thirty-six species were recorded in Zamboanga del Sur [10], 49 species in Lanuza and San Agustin, Surigao del Sur [11] including two new species which are new Mindanao record, and 22 species in Misamis Occidental [12]. New species are still regularly found particularly from poorly explored regions [13]. However, none of these surveys was conducted in Sultan Naga Dimaporo, Lanao del Norte an, agricultural town in the province of Lanao del Norte. The main objective of this study is to determine the species richness of Odonata in agricultural areas in Sultan Naga Dimaporo which will also serve as a baseline record of Odonata species in the area.

## METHODOLOGY

### Study area

The study was conducted in the municipality of Sultan Naga Dimaporo, Lanao del Norte (Figure 1). The geographic coordinates of Sultan Naga Dimaporo are 7° 46' 59'' N, 123° 45' 0'' E. Agricultural farming is one of the main sources of living in the area.

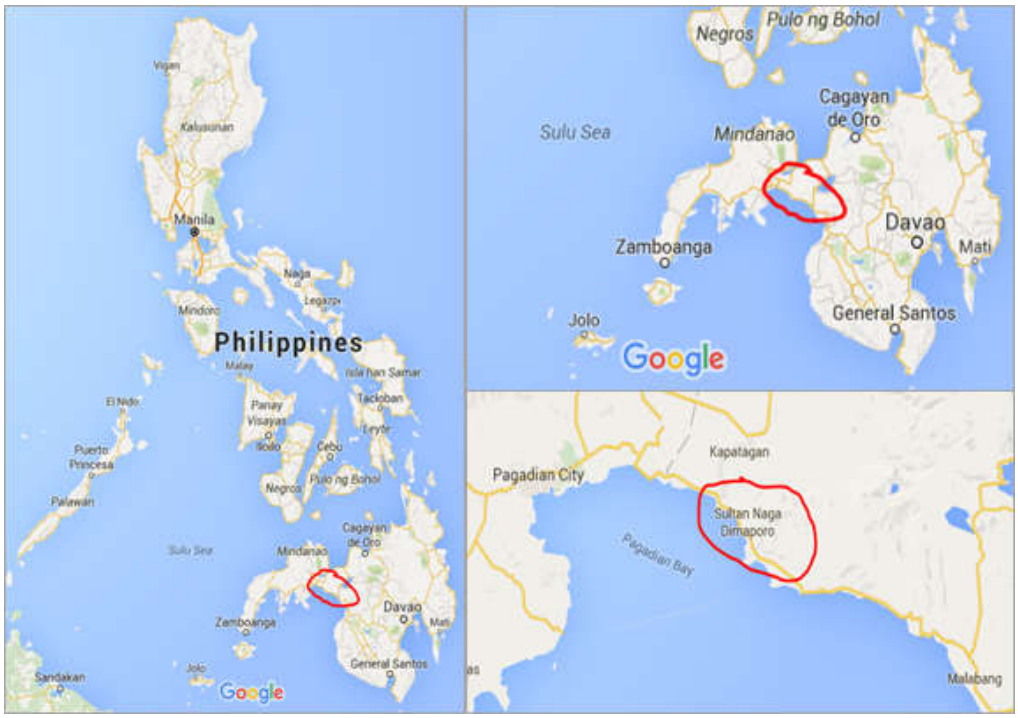


**Figure 1.** Map of the study area, Sultan Naga Dimaporo, Lanao del Norte, Philippines [14].

### Agricultural crop area

Four sampling sites were established in the agricultural crop area**.**

Site 1, Pandanan River with slow-flowing brackish water is located in Barangay Pandanan (7°49'42.2"N 123°38'27.8"E). The site is an open field with vast array of rice (*Oryza sativa*) fields. Soil type is muddy. Coconuts (*Cocos nucifera*), narra (*Pterocarpus indicus*), talisay (*Terminalia catappa*), bamboo (*Bambusoideae*), mahogany (*Swietenia mahagoni*), "caimito" (*Chrysophyllum cainito*) and "santol" (*Sandoricum koetjape*) are present in the area. The ocean is about 400 meters away. Residential houses are present at the opposite side of the field 20 meters across the river.

Site 2, Pikinit stream with slow- flowing water is located in Barangay Pikinit (7°49'36.8"N 123°39'41.2"E). The site is an agricultural area with muddy type of soil with gravel. Rice (*Oryza sativa*) fields are present in the other side of the river but at the opposite side of the river is an empty field. Coconuts (*Cocos nucifera*), narra trees (*Pterocarpus indicus*), rubber trees (*Ficus stipulosa*) and Gemilina (*Gmelina arborea*) provide canopy to the river.

Site 3, Ramain river, lower stream is located in Barangay Ramain (7°47'36.6"N 123°44'13.7"E), an agricultural area. Soil type is silty. Rocks and stones are found at the center and at the side of the river. Trees, carabao grasses, and corn fields are present along the side of the river. Bathing and washing of clothes are some of the common activities in the river. Households are about 5 meters away from the river. Trash and plastics were seen.

Site 4, Pinaring stream with slow-flowing water is located in Barangay Pinaring (7°49'16.3"N 123°41'22.1"E). Rice (*Oryza sativa*) fields are present at both sides of the river. "Hagonoy" (*Chromolaena odorata*), bananas, gmelina (*Gmelina arborea*), coconuts (*Cocos nucifera*), and carabao grasses (*Paspalum conjugatum*) are present.

### Agroforestry areas

Four sampling sites were also established in the agroforestry areas.

Site 5, Ramain river upper stream is located in Barangay Ramain (7°47'30.1"N 123°44'45.2"E) with elevated slope. Sandy soil type and protruding rocks from the river were observed. Carabao grasses (*Paspalum conjugatum*) and various kinds of trees like mahogany (*Swietenia mahagoni*), narra (*Pterocarpus indicus*), rubber trees (*Ficus stipulosa*) and Gemilina (*Gmelina arborea*) are seen. Big trees provide 40% of canopy. Coconuts were also seen.

Site 6, Kirapan stream is located in Barangay Kirapan, Sultan Naga Dimaporo (7°49'48.5"N 123°42'49.7"E). The stream is slow- flowing and almost empty due to dry season. Mahogany (*Swietenia mahagoni*), narra trees (*Pterocarpus indicus*), bananas, "kanding-kanding" (*Lantana camara*), Gemilina (*Gmelina arborea*), and cogon grass (*Imperata cylindrica*) are present.

Site 7, Dangolaan stream with slow-flowing water is located in Barangay Dangolaan (7°49'48.1"N 123°41'08.6"E). Carabao grasses (*Paspalum conjugatum*), "ipil-ipil" (*Leucaena leucocephala*), "hagunoy" (*Chromolaena odorata*), coconuts (*Cocos nucifera*), rubber trees (*Ficus stipulosa*), and logs were seen. Soil type is muddy and the stream has protruding big rocks.

Site 8, Mag-abin stream with slow-flowing water is located in Barangay Pikinit, Sultan Naga Dimaporo (7°49'57.9"N 123°39'55.3"E). The site has protruding rocks, gravel, muddy soil type, and flat slope. The river is surrounded by various kinds of trees like rubber trees (*Ficus stipulosa*), "mahogany" (*Swietenia mahagoni*), "narra" trees (*Pterocarpus indicus*), and mango (*Mangifera indica*).

**Collection of Samples, Processing, and Identification**

Field sampling was conducted on December 22-24, 2014, April 20-24, 2015, and November 22 to 27, 2015 for a total of 84 man -hours. Specimens were collected from Ramain River (upper and lower streams), Pandanan River, Pikinit River, Dangolaan River, Pinaring River, Mag-abin stream, and Kirapan stream.

An opportunistic method was followed in sample collection using sweep nets. Each of the live Odonata collected sample was put in paper triangle to avoid damage [12]. Samples identified to be voucher specimens were treated with ethyl acetate [12] after which they were soaked with acetone to preserve the specimen [10]. Specimens then were air dried and dried specimens were stored again in paper triangle with label. After labelling the specimen they were put in a sealed container with naphthalene balls to keep the specimen from ants [12].

Initial Identification of species was based on pictorial keys and verified by the second author.

**Data Analysis**

Biodiversity indices were calculated and seriation analysis was done using Paleontological Statistics software (PAST) package version 2.17c [15].

## RESULTS AND DISCUSSION

**Species richness, Relative abundance, and Endemism**

Thirteen Odonata species belonging to three families with a total of 250 individuals were documented in the eight sampling sites of Sultan Naga Dimaporo. Ten dragonfly species (Anisoptera) belonging to one family (Libellulidae) and three damselfly species belonging to two families: Coenagrionidae and Platycnemididae (Table 1) were collected. Two species are Philippine endemic (*Coeliccia dinocerus* and *Diplacina bolivari*). The species richness documented in this study is relatively lower compared to the species richness of Odonata in Surigao del Sur [16], Misamis Occidental [12], and Zamboanga del Sur [10].

Endemic species (15%) were found only in the agroforestry area. No endemic species was present in the agricultural crop area. This may be due to the high level of disturbance in the agricultural crop area. This observation concurs with the study of Cayasan *et al.* [10] who found low endemism of Odonata in disturbed habitats and the species composition characterized predominantly by Oriental species. Quisil *et al.* [11] also recorded low endemism (47%) in San Agustin, Surigao del Sur due to the unsustainable and rapid agricultural expansion that was observed as the main threat to the habitats of Odonata. Quisil *et al.* [16] documented low endemism due to mining activities. Low endemism of Odonata is attributed to anthropogenic disturbances [17].

Kalkman *et al.* [9] also reported that low endemism of Odonata could be due to the slow detrimental effects of human activities, habitat destruction, eutrophication, acidification, and pollution of aquatic habitats in general, and the canalization of streams and rivers. Species that are dependent on closed canopy may tolerate habitat modification by moving upstream into shadier sections of the watercourse. Opening the canopy along the creeks may benefit species that are naturally limited by availability of sunny areas along creeks [18].

*Diplacodes trivialis* (20.4%) and *Orthetrum sabina sabina* (22.4%), both oriental species under sub-order Anisoptera are the two most abundant and dominant Odonata in the agricultural crop area while *T. festiva* was found abundant and dominant in the agroforestry area. These Oriental species appear to be agriculture-tolerant species since they flourish in agricultural disturbances. It was also observed that Anisopteran species were abundant in most of the water bodies sampled. This might be due to their high dispersal ability [19, 20, 21, 22] and their adaptability to a wide range of habitats [23, 24, 25].

The Family Libellulidae is the most abundant family that comprised the majority (S=10) of the collected species and is the only family that is represented in every site. This result concurs with the findings of Norma-Rashid *et al.* [26] that Family Libellulidae is extensively distributed worldwide and in local areas. Kalkman *et al.* [9] reported that Family Libellulidae is the largest family of Anisoptera. In addition, the family Libellulidae is also one of the two largest families worldwide and dominates the dragonfly fauna of standing water in every continent. A high percentage of the species under this family has large distributional range [27]. Presently, this family ranks among the most diverse and widespread subgroups of dragonflies [28].

*Orthetrum s. sabina* under family Libellulidae was the most abundant having 61 individuals which are present in all the sampled sites. This indicates that *Orthetrum s. sabina* can thrive in disturbed and undisturbed sites. The same observation was obtained by Mitra [29] that *Orthetrum s. sabina* is a very common species over much of its huge range and very tolerant of high salt contents and habitat disturbance. The study of Villanueva *et al.* [30] also found that *Orthetrum s. sabina* is one of the species with high abundance and wide distribution that can tolerate disturbed sites.

**Table 1:** Species Richness, Endemism, and Relative Abundance of Odonata in Agricultural Areas of Sultan Naga Dimaporo.

Legend: Numbers in parentheses correspond to the % relative abundance.

| | | Agricultural crop area | | | | | Agroforestry area | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Species Name** | **Distribution Status** | **1 Pandanan river** | **2 Pikinit river (lower stream)** | **3 Ramain river(lower stream)** | **4 Pinaring stream** | **5 Ramain river (upper stream)** | **6 Kirapan river** | **7 Dangolaan stream** | **8 Mag-abin stream** | **Total** |
| **SUB-0RDER ANISOPTERA** | | | | | | | | | | |
| **Libellulidae** | | | | | | | | | | |
| *Diplacina bolivari* | Philippine endemic | 0 | 0 | 0 | 0 | 1 (2) | 0 | 0 | 0 | 1 (0.40) |
| *Diplacodes trivialis* | Oriental species | 8 (26.67) | 10 (26.32) | 9 (28.13) | 7 (23.33) | 0 | 3 (10.71) | 8 (40.0) | 6 (27.27) | 51 (20.4) |
| *Macrodiplax cora* | Circumtropical | 8 (26.67) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 (3.20) |
| *Neurothemis ramburii* | Oriental species | 5 (16.67) | 9 (23.68) | 9 (28.13) | 7 (23.33) | 4 (8) | 0 | 6 (30.0) | 4 (18.18) | 44 (17.6) |
| *Neurothemis sp.* | | 0 | 0 | 0 | 0 | 4 (8) | 0 | 2 (10.0) | 0 | 6 (2.4) |
| *Neurothemis terminata* | Oriental species | 0 | 6 (15.79) | 5 (15.63) | 6 (20.0) | 3 (6) | 0 | 0 | 0 | 20 (8.00) |
| *Orthetrum sabina sabina* | Oriental species | 9 (30) | 11 (28.95) | 9 (28.13) | 5 (16.67) | 9 (18) | 8 (28.57) | 4 (20.0) | 6 (27.27) | 61 (24.4) |
| *Pantala flavescens* | Circumtropical | 0 | 0 | 0 | 0 | 6 (12) | 0 | 0 | 0 | 6 (2.4) |
| *Trithemis aurora* | Oriental species | 0 | 2 (5.26) | 0 | 5 (16.67) | 3 (6) | 5 (17.86) | 0 | 0 | 15 (6.00) |
| *Trithemis festiva* | Oriental species | 0 | 0 | 0 | 0 | 8 (16) | 4 (14.29) | 0 | 6 (27.27) | 18 (7.2) |
| **SUB-ORDER ZYGOPTERA** | | | | | | | | | | |
| **Coenagrionidae** | | | | | | | | | | |
| *Agriocnemis sp.* | | 0 | 0 | 0 | 0 | 0 | 4 (14.29) | 0 | 0 | 4 (1.60) |
| *Pseudagrion pilidorsum pilidorsum* | Oriental species | 0 | 0 | 0 | 0 | 7 (14) | 4 (14.29) | 0 | 0 | 11 (4.40) |
| **Platycnemididae** | | | | | | | | | | |
| *Coeliccia dinocerus* | Philippine endemic | 0 | 0 | 0 | 0 | 5 (10) | 0 | 0 | 0 | 5 (2.00) |
| **Total # of individuals** | | 30 | 38 | 32 | 30 | 50 | 28 | 20 | 22 | 250 |
| **Total # of species** | **13** | 4 | 5 | 4 | 5 | 10 | 6 | 4 | 4 | |
| **Philippine endemic** | **2(15%)** | 0 | 0 | 0 | 0 | 2 (15%) | 0 | 0 | 0 | |

High species richness was found in site 5 (S=10) which is a slightly disturbed habitat having 40% of canopy cover with clean waterways. Most of the species recorded are oriental under order Anisoptera comprising five species while there was only one oriental Zygopteran species. The result implies that oriental dragonfly species recorded in this study are adapted to disturbed and undisturbed sites. The Philippine endemic species (*Diplacina bolivari* and *Coeliccia dinocerus*) were documented only in site 5 indicating that endemic species are more likely to be found in habitats with less disturbance.

Agroforestry sites had higher species richness of odonata (S=12) than agricultural crop sites (S=6). Agroforestry sites are composed of a variety of trees and tall grasses which provide canopy to the rivers/streams making the sites more suitable as habitats of Odonata. The agricultural crop area has rice and corn crops as prominent vegetation. Only those species that can tolerate high degree of habitat disturbance can thrive in the agricultural crop area. Mabry and Dettman [31] reported that habitat with dense and diverse vegetation provides a rich site for Odonata. The less disturbance in the agroforestry sites appear to be the main factor in the higher number of species in the agroforestry compared to the agricultural crop area. Mapi-ot *et al.* [12] found in their study that high presence of on-site disturbances could contribute to low species diversity and endemicity of Odonata. Jomoc *et al.* [32] also observed less number of species in areas with existing anthropogenic disturbances.

**Biodiversity Indices**

Table 2 shows that site 5, Ramain river upper stream, is the only site with high diversity. The higher species diversity in site 5 is credited to clean waterways and the percent canopy cover of the river. In addition, site 5 is less disturbed being far from human settlements and other disturbances. The presence of many rocks which could serve as perching sites to some Odonata species was also observed in site 5. Other sites showed moderate diversity and this could be due to agricultural vegetation in the area and degree of disturbance. Moreover, factors like percentage cover of macrophytes and tree cover which could provide shade in an area are the most important environmental variables for Anisoptera and Zygoptera [33].

Agricultural crop and agroforestry sites have more or less the same evenness indicating that no single species dominates in one site. Evenness may influence the richness effect by controlling the variation of species. It is known to have a positive impact on productivity by increasing the representation of each species' functional traits allowing a greater complementary effect [34].

**Table 2:** Species Richness, Diversity, and Evenness of Odonata.

| | **Agricultural crop area** | | | | **Agroforestry area** | | | |
|---|---|---|---|---|---|---|---|---|
| | **Site 1 Pandanan river** | **Site 2 Pikinit river (lower stream)** | **Site 3 Ramain river (lower stream)** | **Site 4 Pinaring stream** | **Site 5 Ramain river (upper stream)** | **Site 6 Kirapan river** | **Site 7 Dangolaan stream** | **Site 8 Mag-abin stream** |
| Species richness | 4 | 5 | 4 | 5 | 10 | 6 | 4 | 4 |
| Shannon-Weiner (H') | 1.36 | 1.50 | 1.36 | 1.60 | 2.18 | 1.74 | 1.28 | 1.37 |
| Evenness (E') | 0.98 | 0.93 | 0.98 | 0.99 | 0.95 | 0.97 | 0.93 | 0.99 |

Table 3 shows the species distribution in the sampling sites. *Orthetrum s. sabina* an oriental species was the most widely distributed which was found in eight sampling sites indicating that this species can adapt to sites with high disturbance. *M. cora,* a salt-tolerant circumtropical species was found only in site 1, a disturbed agricultural area which has brackish water. This is probably because *M. cora* which belongs to order Anisoptera (dragonfly) prefers areas with an open habitat which is characterized by site 1. According to Jomoc *et al.* [32] dragonfly species thrive in exposed areas while damselfly species prefer closed canopy areas. In addition, this species is mainly recorded from coastal lagoons, mangroves, estuaries, riverine pools, permanent and temporary ponds and swamps, except during nomadism and migration where it can be found anywhere [35].

**Table 3:** Species distribution of Odonata in the eight sampling sites.

| | Sampling Sites | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Species Name** | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 |
| *Macrodiplax cora* | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| *Neurothemis terminata* | | | | | | 0 | 0 | 0 |
| *Trithemis aurora* | 0 | | 0 | | | | 0 | 0 |
| *Neurothemis ramburii* | | | | | | 0 | | |
| *Diplacodes trivialis* | | | | | 0 | | | |
| *Orthetrum sabina sabina* | | | | | | | | |
| *Coeliccia dinocerus* | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| *Pantala flavescens* | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| *Diplacina bolivari* | 0 | 0 | 0 | 0 | | 0 | 0 | 0 |
| *Pseudagrion pilidorsum pilidorsum* | 0 | 0 | 0 | 0 | | | 0 | 0 |
| *Agriocnemis sp.* | 0 | 0 | 0 | 0 | 0 | | 0 | 0 |
| *Neurothemis sp.* | 0 | 0 | 0 | 0 | | 0 | | 0 |
| *Trithemis festiva* | 0 | 0 | 0 | 0 | | | 0 | |

Legend: Site1 (Pandanan river), site 2 Pikinit river), site 3 (Ramain river-lower), site 4 (Pinaring stream), site 5 (Ramain river-upper), site 6 (kirapan river), site 7 (Dangolaan stream), site 8 (Mag-abin stream).

*Neurothemis sp.* under family Libellulidae was found only in sites 5 and 7 which are both agroforestry sites with less disturbance than agricultural crop sites. *Agriocnemis* sp. under family Coenagrionidae was found only in site 6 which has clear waterways and shade from the trees present around the river. Fraser [36] and Subramanian [37] reported that shade and aquatic vegetation could favor Zygoptera more than Anisoptera.

The two endemic species, *Coeliccia dinocerus* and *Diplacina bolivari* and the circumtropical species *Pantala flavescens* were only found in site 5. Site 5 is a slightly disturbed site which could be the reason why endemic species were found in this site. The slightly open canopy where the heat and rays of the sun are visible could also be the factor for the presence of dragonfly species like *Pantala flavescens.* The presence of vegetation tree cover in site 5 could also be one of the factors for the presence of the damselfly species *Coeliccia dinocerus* because most damselflies prefer shady areas. In addition, the ground vegetation cover and the big rocks in the site serve as perching sites of Odonata.

Sites 2 and 4 which are in the agricultural crop area have the same number of species which could be due to the similarity of habitat components like the water quality in the river and the presence of rice fields at the opposite side of the river. Sites 1 and 3 which are located in agricultural area had the lowest number of species which is attributed to an open habitat and presence of human disturbances while sites 7 and 8 had the lowest number of species in the agroforestry area.

Both agricultural crop and agroforestry areas had low species richness since both areas are not pristine and are not suitable as habitats of Odonata especially the endemic species. This indicates that the habitats are disturbed or modified for human use. Habitat disturbance even for small-scale subsistence farming has tremendous impact on Odonata diversity [18].

## CONCLUSION

The municipality of Sultan Naga Dimaporo, Lanao del Norte is species-poor with very low endemism of 15%. Sites in the agroforestry area with slightly disturbed habitats have higher species richness, endemism, abundance, and species diversity. Only two endemic species, *Coeliccia dinocerus* and *Diplacina bolivari* were found. Agriculture appears to have adverse effect on the species richness of Odonata

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