

Species richness of Odonata in Lanuza and San Agustin, Surigao del Sur, Philippines

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Abstract. The Odonata spends its time in water and on land during its life cycle making this invertebrate an important link between aquatic and terrestrial ecosystems. To determine the species richness of Odonata in Lanuza and San Agustin, Surigao del Sur, assessment was conducted in 18 sampling sites in August to October 2012. Forty-nine species were documented where 26 species are under the suborder Zygoptera and 23 under suborder Anisoptera. Himatagan River of Lanuza, Surigao del Sur was found to be the most species-rich. Three species which are indicators of environmental disturbance were found to be abundant in eight sampling sites. These are the highly disturbed sites being in the vicinity of agroecosystems such as rice paddies, eggplant farms and root crop fields. Twenty-three Philippine endemic species were documented. Two species are new Mindanao record and one is endemic to the Philippines. More species are expected to be documented with intensive surveys especially in pristine habitats.

Key Words: Anisoptera, indicator, invertebrate, river, Zygoptera.

Introduction. Odonata, an order comprising Anisoptera (dragonflies) and Zygoptera (damselflies) (Arnett 2000), spends its time in water and on land during its life cycle making this order an important link between aquatic and terrestrial ecosystems (Kalkman et al 2008). Sensitivity to changes in the habitats, atmospheric temperature and the weather conditions make Odonata a significant biological indicator of environmental changes (Tiple et al 2008). Biological indicators can be defined as a species or group of species that readily reflect the abiotic or biotic state of an environment, represent the impact of environmental change on a habitat, community or ecosystem or indicative of the diversity of a subset of taxa or the whole diversity within an area (Gerhardt 1995).

The Odonata plays a vital role as prey and predator to maintain the balance of tropic levels of food chain. The Odonata larvae live underwater, preying upon mosquito larva, fresh water invertebrates, and even small tadpoles and fish. But they fall as prey to larger fish, frogs, tadpoles, and parasites. Upon emergence, their diet consists of mosquitoes, gnats, aphids, moths, butterflies, and smaller Odonata, but again, the Odonata larvae are fed upon by parasites, frogs, toads, spiders, and birds. The prey of the adult Odonata consists mostly of the harmful insects of crops, orchards and forest and thus has a regulatory impact on agro-forestry (Das et al 2012).

Patterns of distribution of Odonata primarily relate to the biogeographic zones of the country where climates may differ. Temperature plays a big role in the increase of diversity from the poles to the equator. The tropics hold higher diversity of Odonata where twelve of the 31 families are restricted mostly to lotic waters within tropical forest habitats. In the tropics like the Philippines, diversity of Odonata is highly dependent on the types of aquatic habitats in different forests. This is the reason why the Philippines is recognized for its high number of endemic Odonata fauna, with more than 60% of the named species endemic to the country. Globally, a total of 5,680 species of Odonata are identified and 2,739 of these belong to the sub-order Zygoptera while 2,941 species belong to the sub-order Epiprocta (Anisoptera). Comparing the Odonata biodiversity

within the biogeographical regions, Afrotropical has 33% estimated endemic species; 31% for Oriental; 20% for Palearctic; 12% for Neotropical; 52% for Australasian and 52% for Pacific. These are based on the areas with a high number of endemic dragonflies (Kalkman et al 2008).

The numerous islands in the Philippines have assisted speciation which results to a high number of endemic species in genera such as *Drepanosticta*, *Amphicnemis*, *Teinobasis*, *Risioicnemis* and *Oligoaeschna* (Hämäläinen & Müller 1997). Presently, Philippine species under the genus *Amphicnemis* are transferred to the newly erected genera: *Luzonobasis* Villanueva, 2012, *Pandanobasis* Villanueva, 2012, and *Sangabasis* Villanueva, 2012, or moved to the genus *Pericnemis* (Villanueva 2012). The Philippine archipelago has numerous aquatic ecosystems. Most of these ecosystems are poorly explored including many islands in Mindanao like the marshes located in Agusan and Liguasan, and the lakes in Lanao and Mainit. Several Odonata from lotic environments can be discovered in the island and more endemic Odonata can also be documented. Villanueva (2011) discovered *Hydrobasileus vittatus* in Davao Oriental. There were also two first records of *Tetracanthagyna brunnea* and *Aethriamanta gracilis* from Mindanao Island. Significant endemic species of damselflies (94%) and endemic dragonflies (33.3%) were recorded in Mt. Hamiguitan Wildlife Sanctuary in Davao Oriental (Villanueva & Mohagan 2010).

Despite the many surveys on Odonata in the Philippines there is no Odonatological record in San Agustin and Lanuza, Surigao del Sur. This study assessed the species richness and endemism of adult Odonata in the municipalities of San Agustin and Lanuza, Surigao del Sur.

Material and Method. Reconnaissance was conducted to select the study area and corresponding sampling sites based on accessibility, safety and more importantly on their probabilities as habitats, breeding or feeding sites of Odonata.

The study area selected was Surigao del Sur which is the 56th province of the Philippines located in Mindanao. It is one of the sub-regions of the CARAGA region. It is located on the Northeastern Coast of Mindanao facing the Pacific Ocean and is bounded on the Northwest by the Province of Surigao del Norte, on the Southeast by Davao Oriental, on its Eastern side by the Pacific Ocean, and on the West and Southwest by the Provinces of Agusan del Norte and Agusan del Sur. Eighteen selected locations in the two municipalities, Lanuza and San Agustin, served as the sampling sites. Four rivers, six streams and two swamps were sampled in San Agustin (Figure 1) while in Lanuza three rivers, one waterfall, one lake and one spring were sampled (Figure 2).

The sampling started at 08:00 hours and ended at 16:00 hours for a total of 203 man-hours for all the sampling sites. The study was conducted on August 28–31, 2012 for 60 man-hours and October 18–19, 2012 for 33 man-hours for San Agustin. Sampling in the municipality of Lanuza was done from 09:00 hours to 15:00 hours for 10 days, from September 13-15 and October 21-27, 2012 for 110 man-hours.

Assessment of Odonata was done on clear and windless days where dragonflies are most active (Fulan et al 2008). Since adult Odonata are mobile, opportunistic sampling was employed using hand picking and sweep nets with a net opening of at least 18 inches. A wide mesh (but small enough to hold the smallest specimens) was used because this reduces air resistance and allows a faster swing.

The adult dragonflies and damselflies caught were placed in envelopes or paper triangles (preferably wax paper) as temporary storage with wings folded back. While in the field the envelopes containing live adult Odonata were kept as cool as possible, storing them in a non-crushable box. Photographs of live and preserved specimens and their habitats were taken. Photographs are used as reliable way to preserve color in adult Odonata for later reference and identification.

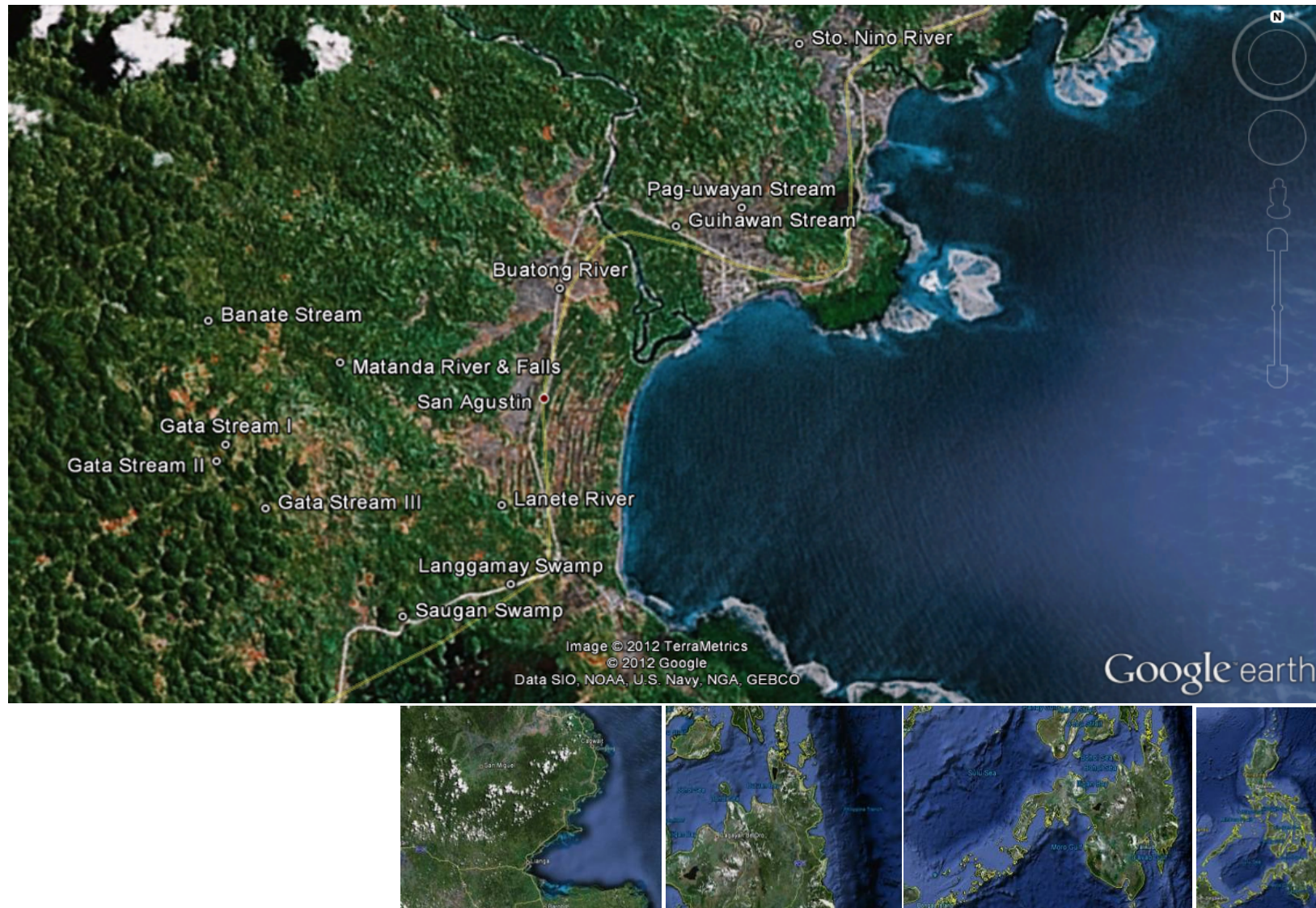


Figure 1. Sampling sites in San Agustin, Surigao del Sur (Google Earth 2012).



Figure 2. Sampling sites in Lanuza, Surigao del Sur (mapsnworld.com; oneocean.org; Google Earth 2013).

The specimens were left inside their envelopes for a while so that they can void their intestinal contents and later killed using ethyl acetate. The abdomen was straightened and the legs arranged in place for each specimen. The collected adult Odonata was submerged in acetone in a tightly closed plastic container for 16–24 hours (12 hours for small Odonata and 24 hours for large Odonata). Each specimen was removed from acetone and placed in the open for 5-6 hours to let the acetone evaporate. The samples were stored in new envelopes and kept in a sturdy plastic container that is able to withstand crushing. The envelopes were stored vertically, like a card file, and without packing them tightly.

The samples collected were transported to the Wildlife Laboratory of MSU-Iligan Institute of Technology (MSU-IIT) in Iligan City, Philippines. Identification was done with the help of the fourth author.

Description of sampling sites. *Site 1.* Matanda River and Falls, located at Barangay Buatong, San Agustin, Surigao del Sur (8° 44' 6.96" N 126° 10' 55.89" E). The site has a mountainous slope with a secondary vegetation type. The site is dominated by a slow pacing current. Leaf litters were found prominent at the edges of the river. Exposed rocks dominate the land. Fallen twigs and branches were found in the area decomposing naturally without any logs being spotted. The vegetation on the site was diverse as less human-induced disturbances were present. About 30 meters from the site was a hut with surrounding corn field and ongoing agricultural expansions using the slash - and - burn method.

Site 2. Banate Stream, located at Barangay Gata, San Agustin, Surigao del Sur (8° 44' 21.31" N 126° 10' 7.69" E). The site has a mountainous slope with a disturbed vegetation. Logs cut down for agricultural expansion and commercial purposes were observed while logs without any economic significance were left to be burned or to rot. A mini-dam was made around the stream to secure the water source for the crops. About 20 meters from the stream was an eggplant farm. Human-induced disturbances like the slash - and - burn method and more logging down the stream were noted. About 30 meters away from the stream logs being pulled up were also found.

Site 3. Pag-uwayan Stream, located at Barangay Otieza, San Agustin, Surigao del Sur (8° 45' 6.49" N 126° 13' 23.79" E). The site has a flat slope with a disturbed vegetation. The site is an open field with gusts of wind causing the plants to lean in the area. The stream is near a hill and rice paddies. Coconuts and bananas were commonly seen. Grasses and sedges covered most of the landscape. About 10 meters from the stream is a dirtclay road used by the local people in going to the mountain. The stream is flowing in a slow current. About 40 meters from the stream there is a house.

Site 4. Guihawan Stream, located at Barangay Kauswagan, San Agustin, Surigao del Sur (8° 44' 58.12" N 126° 12' 59.62" E). The site has a flat slope with a disturbed vegetation type. The site is an open field near a forested hill. Strong gusts of wind dominate the area. Around the stream are unused rice paddies. Grasses and sedges cover the landscape. Grazing animals such as water buffaloes were around the site. About 50 meters from the stream is a public cemetery. Constructions of a new road to the cemetery and the expansion of the public cemetery itself are the developments near the site. A clay road used by the locals in going to the mountain was observed about 10 meters away from the stream.

Site 5. Buatong River, located at Barangay Buatong, San Agustin, Surigao del Sur (8° 44' 35.11" N 126° 12' 16.18" E). The site has a flat slope with a disturbed vegetation. The landscape is dominated by the river's slow moving currents. On each of the sides, open fields of rice paddies were observed. Coconut palms, a mango tree and a Javelina tree were observed. Grasses and sedges were abundant around the edges of the river. Near the river, pigs and water buffaloes were present. About 20 meters from the site are irrigation canals; about 30 meters away are houses, while 50 meters away a highway bridge. Construction of irrigation canals is ongoing.

Site 6. Gata Stream I, located at Barangay Gata, San Agustin, Surigao del Sur (8° 43' 35.79" N 126° 10' 14.28" E). The site has mountainous slope with a disturbed vegetation.

The stream is small and flowing from inside the hill. The site has a clay type of soil with less exposed rocks on the landscape. The main source of the water is a built tank with tubers or pipes that run downtown. Falcata trees were found in the site. The site is drastically changing as agricultural expansions are occurring using slash - and - burn method of clearing. About 20 meters from the streams were root crops and vegetable farms. Huge logs left to rot were found near the stream.

Site 7. Gata Stream II, located at Barangay Gata, San Agustin, Surigao del Sur (8° 43' 29.11" N 126° 10' 10.74" E). The site has a mountainous slope with a disturbed vegetation. The stream is in between a semi-open field and a forest hill. The site is fully covered with grasses and sedges that even the slow flowing stream looks small for it is shadowed by grasses and sedges. Exceptions to this are the rubber trees planted and maintained, as grasses and sedges are being cleared out. Small tuber and ferns are around the edges of the stream. Leaf litter on site is low and the soil type is clay. Vines are dominant in the area. About 40 meters from the site is a rocky-dirt road used by the local people to carry logs from the forest.

Site 8. Gata Stream III, located at Barangay Gata, San Agustin, Surigao del Sur (8° 43' 11.35" N 126° 10' 29.65" E). The site has a mountainous slope with a disturbed vegetation. The local inhabitants wash their clothes in this stream. About 30 meters from the stream, a hut is present. Grasses are slowly taking over the site but less on the corn farm as farmers maintained the fields. About three meters from the site is a rock-dirt road used mainly as transportation road for the local people hauling logs from the forest using motor bikes. Near the site are evidences of the slash - and - burn method of clearing and ongoing agricultural expansions.

Site 9. Sto. Niño River, located at Sto. Niño, San Agustin, Surigao del Sur (8° 46' 9.19" N 126° 13' 45.94" E). The site has a flat slope with a disturbed vegetation. The landscape of the site is dominated by grasses and sedges. The river is between unused rice paddies and a disturbed forest. As an open field, the site is subject to frequent strong gusts of wind. The soil type is sandy and moist. Grazing animals like water buffaloes were found resting in the river. Logs were present but trees fell not due to logging but natural causes like the continuous expansion of the river which bares the roots of trees and eventually uproot them. Dredging for commercial purposes was seen near the site. About 30 meters from the site is a dirt road.

Site 10. Lanete River, located at Barangay Salvacion, San Agustin, Surigao del Sur (8° 43' 12.79" N 126° 11' 54.54" E). The site has a flat slope with a disturbed vegetation. Flowing streams are near the river, cut-off by local farmers to make a dam to be used for watering the crops. About six meters from the river is a sweet potato farm. The river is also used to float logged trees from the mountain. Some locals use water buffaloes in hauling Falacata timber to the town. About 100 meters from the river, a highway is present. A dirt path going to the river is also present. The soil type is sandy clay with little exposed rocks around the river. Near the river human-induced disturbances mainly logging activities up top can be seen.

Site 11. Langgamay Swamp, located at Barangay Salvacion, San Agustin, Surigao del Sur (8° 42' 42.48" N 126° 11' 57.95" E). The site has flat slope with a secondary vegetation. The site is dominated by pandan and tuber plant species. Grasses and sedges are abundant around the swamp. Coconuts and vines were seen in the area. Water pockets zigzag the swamp. Leaf litters were common around the swamp and soil type is loam and moist. About 10 meters from the swamp is a highway. On the site of human-induced disturbances were evidences of human litter such as plastics, cans and plastic bags found near the entrance of the swamp.

Site 12. Saugan Swamp, located at Barangay Gata, San Agustin, Surigao del Sur (8° 42' 30.46" N 126° 11' 18.63" E). The site has a mountainous slope with a disturbed vegetation. The site is dominated with pandan, banana and tuber plant species. Ficus tree species are common in the swamp. Coconut palms are present. Mosses were moderate and

leaf litters were common around the swamp. The soil type is clay and moist and fallen logs were present. About 50 meters from the swamp is a highway and 10 meters nearby is a hut. Human-induced disturbances were observed such as the use of slash - and - burn method and cutting of Falcata trees.

Site 13. Lambonao river at 25-30 meters above sea level (masl) located in Zone III, Lanuza, Surigao del Sur. The area is a lowland forest and is characterized by loamy soil and muddy water. The water was brownish in color and the substrate accumulates in the sand. Logs are transported via the river. The sand is also excavated to be used for building infrastructures like houses and bridges. Butterflies were observed to be flying around during sampling. *Musa sp.* was present along the river banks. Canopy vines are rare; canopy trees are dominant in the area. Fallen logs were also present which were undergoing decomposition already through leaching by water. Exposed rocks were also observed to be common in the area.

Site 14. A stream at 60-65 masl at Sitio Panawilan, Zone III, Lanuza, Surigao del Sur. A tribal settlement was near the area. The area is undulating in slope. The vegetation type is secondary since some trees were replanted to conserve the forest. Emergent trees were present with canopy trees becoming sparsely distributed. Canopy vines were commonly seen hanging on trees. *Musa sp.* is also abundant as well as understory plants like rattan. Some plants near the river banks were observed to be bent, perhaps due to a flood. The streams were also abundant with fallen branches, twigs and leaves. Some logs have decayed already and the soil is muddy and fine. Trails and on-site disturbances caused by fallen trees due to heavy rains and slash - and - burn were observed.

Site 15. Silop Spring, Barangay Aksam, Lanuza, Surigao del Sur at 60-65 masl. The area is used as a tourist attraction by the nearby residents. Ferns are common and canopy trees were observed. *Musa sp.*, coconuts and grasses were also abundant. Exposed rocks are big in size and were common in the area.

Site 16. Magkawas Falls, Barangay Sibahay, Lanuza, Surigao del Sur at 237 masl. The area is also used as a tourist spot for the municipality. The vegetation type is secondary. The river banks were constructed with riprap. Cottages are built near the area for the tourists. However, the head water of this waterfall is rarely visited, but during the sampling it was observed that some plants were replanted. Emergent and canopy trees were present with canopy epiphytes attached around trees. Ferns and grasses were common as well as rattan and coconuts.

Site 17. Himatagan river (449 masl), Km. 7, Barangay Aksam, Lanuza, Surigao del Sur. The area is a primary dipterocarp forest. Ferns, especially tree ferns and rattan were visibly abundant with wild berries present along trails. Grasses were rare, but canopy epiphytes were abundant as well as canopy vines that almost covered some trees. Soil is moist, rocks were moderately exposed and water is very clear. Some birds that feed on fishes and insects were observed to be diving into the river. Fallen trees were present caused maybe by heavy rains or a typhoon.

Site 18. Himatagan Lake (437 masl), Km.7, Barangay Aksam, Lanuza, Surigao del Sur. Nearby is a slash - and - burn patch about 10-15 meters wide. The area is flat and surrounded by ferns. Canopy and emergent trees were present with canopy vines and epiphytes that commonly cling into trees. Wild berries as well as tree ferns are common. A small-scale logging area is near the lake. Soil is muddy and water is cloudy. Fallen logs were also observed in the area.

Results and Discussion. Forty-nine species were recorded out of 488 specimens of Odonata collected in the 18 sampling sites. Twenty-six species are under the sub-order Zygoptera and 23 species under sub-order Anisoptera (Table 1). Two species are recorded for the first time on the island of Mindanao. Twenty-three endemic species (47% endemism) were recorded. Site 14 (83%) and site 6 (80%) had the highest endemism out of the 18 sampling sites. It must be noted that in the two sites, four to five species are endemic species out of five to six species captured resulting to such high endemism. Site 14 has a stream which is fully covered with weeds and has a spring used by locals. Site 6 has streams rarely visited by locals but are used for transferring logs to town and tribal settlements are near in the site. Site 1 has an endemism of 68%. The high endemism is attributed to the location of site 1 as it was not easily accessible and human-induced disturbances were lesser. No endemic species was found on sites 3, 4, 5, 9, 10, 13 and 16. This may be the result of human disturbances on these sites. The Philippines has a high number of endemics (more than 60% of the named species) sharing elements with both the Sunda and the Australasian fauna (Kalkman et al 2008).

The endemism of sub-order Zygoptera is 88% far greater than Anisoptera having only 2%. This result is in agreement with the findings of Villanueva & Mohagan (2010) that most endemics are damselflies (94%) than dragonflies (33.3%) and Kalkman et al (2008) where the endemism for Anisopterans in the Philippines is 31% and 86% for Zygopterans.

There were 11 families recorded. The most represented family is Libellulidae with 20 species (Figure 3) which concurs with the statement of Pilgrim & Dohlen (2008) that Libellulidae is by far the largest, with over 1000 species in approximately 140 genera. Coenagrionidae has 10 species occurring in a wide range of habitats from pristine forest to urban open drains. The strong tolerance of some species to pollution and habitat disturbance makes the group so widely distributed that it forms the main damselfly fauna on some of the islands in the Philippines (Villanueva 2012). The same number of families (12) of Odonata were recorded by Villanueva & Cahilog (2013) in Talaingod in Davao del Norte and Jumawan et al (2012) in Mainit hot spring in Compostela valley.

Figure 4 shows that the oriental species *Orthetrum sabina sabina*, *Neurothemis terminata* and *N. ramburii* under Anisoptera were the species with high abundance and are widely distributed (Villanueva et al 2009). These species are Oriental species and they are tolerant of disturbed sites. Abundant species under Zygoptera were *Rhinocypha colorata*, a bluish damselfly that is tolerant of human disturbances (Villanueva et al 2012). *Vestalis melania* and *Risicnemis appendiculata* were observed to be abundant. Villanueva (2010a) observed that *V. melania* is absent during dry weather condition which correlates with the abundance of this species among the 49 species recorded in the two municipalities due to wet weather condition during the time of sampling. *R. appendiculata* was also observed to be the most widely distributed member of its genus in Greater Mindanao bio-geographic region (Villanueva 2011).

Table 1

Species Richness of Odonata in San Agustin and Lanuza, Surigao del Sur

Family	Species	Sampling sites in San Agustin											Sampling sites in Lanuza							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Suborder Zygoptera																				
1. Amphipterygidae	<i>Devadatta podolestoides basilanensis</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
2. Calopterygidae	<i>Neurobasis anumariae</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
	<i>Vestalis melania</i> *	9	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	8	6	
3. Chlorocyphidae	<i>Rhinocypha colorata</i> *	16	15	0	0	0	0	0	6	0	1	0	0	0	7	0	0	17	18	
	<i>Rhinocypha turconii</i> *	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	
4. Coenagrionidae	<i>Agriocnemis femina</i>	0	0	2	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	
	<i>Agriocnemis rubescens intermedia</i>	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	2	
	<i>Amphicnemis cantuga</i>	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	
	<i>Amphicnemis furcata</i> *	0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	
	<i>Ceriagrion lieftincki</i> *	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	1	
	<i>Psuedagrion pilidorsum pilidorsum</i>	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	
	<i>Sangabasis dentifer</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	
	<i>Teinobasis annamajae</i> *	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	
	<i>Teinobasis filamentum</i> *	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	2	
	<i>Teinobasis olivacea</i> *	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	
	5. Euphaeidae	<i>Euphaea amphicyana</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
		<i>Euphaea cora</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0
6. Megapodagrionidae	<i>Rhinagrion reinhardi</i> *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
7. Platycnemididae	<i>Coelicia dinocerus</i> *	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
	<i>Risiocnemis appediculata</i> *	3	2	0	0	0	11	4	2	0	0	0	1	0	0	0	0	1	0	
	<i>Risiocnemis atripes</i> *	6	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	
	<i>Risiocnemis erythrura</i> *	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
	<i>Risiocnemis flammae</i> *	2	0	0	0	0	2	0	1	0	0	0	0	0	0	0	0	2	0	
8. Platystictidae	<i>Drepanosticta centrosaurus</i> *	8	0	0	0	0	0	0	0	0	0	5	0	0	2	2	0	0	0	
	<i>Drepanosticta leonardi</i> *	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
9. Protoneuridae	<i>Prodasineura integra</i> *	1	2	0	0	0	5	2	6	0	0	0	2	0	0	0	0	3	0	
Suborder Anisoptera																				
10. Cordulidae	<i>Epopthalmia vitigerra vitigerra</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	

11. Libullidae	<i>Hemicordulia mindana mindana</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	<i>Idionyx philippa*</i>	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Agrioptera insignis</i>	0	0	0	0	0	0	0	0	0	0	1	12	0	0	0	0	0
	<i>Cratilla lineata assidua</i>	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Diplacina bolivari</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	1
	<i>Diplacina braueri</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	<i>Diplacina trivalis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
	<i>Lathrecista asiastica</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	<i>Nannophya pygmaea</i>	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	5
	<i>Neurothemis ramburii</i>	0	0	7	5	4	1	0	0	1	2	6	1	0	0	0	0	0
	<i>Neurothemis ramburii ramburii</i>	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	0	4
	<i>Neurothemis terminata</i>	1	0	15	6	14	5	3	9	3	7	0	0	0	0	0	0	0
	<i>Orthetrum pruinosumclelia</i>	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0	3
	<i>Orthetrum sabina sabina</i>	0	0	10	6	15	2	6	2	16	6	1	0	0	0	0	0	0
	<i>Orthetrum testaceum testaceum</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	5
	<i>Pantala flavescens</i>	0	0	1	0	2	0	0	0	0	0	0	0	0	0	0	0	0
	<i>Potamarcha congener</i>	0	0	3	0	8	0	0	0	1	1	0	0	0	0	0	0	1
	<i>Raphismia bispina</i>	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
	<i>Ryothemis resplendens</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
	<i>Tetrathemis irregularis</i>	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0
	<i>Tetrathemis irregularis irregularis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	1	0
	<i>Trithemis festiva</i>	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	2
	Total Number of Individuals: 488 (San Agustin - 350; Lanuza - 138).	69	19	38	17	43	37	17	21	21	23	16	29	3	22	5	4	71
	Species richness: 49	16	3	6	3	5	5	6	6	4	7	6	11	1	6	3	3	22
	Total Number of Endemics: 23	11	2	0	0	0	4	2	3	0	0	3	3	0	5	1	0	12
	Endemicity: 47%	68	67	0	0	0	80	33	50	0	0	50	27	0	83	33	0	55

* Philippine Endemics; Sites: **San Agustin** - (1) Matanda River and Falls, (2) Banate Stream, (3) Pag-uwayan Stream, (4) Guihawan Stream, (5) Buatong River, (6) Gata Stream I, (7) Gata Stream II, (8) Gata Stream III, (9) Sto. Nino River, (10) Lanete River, (11) Langgamay Swamp, (12) Saugan Swamp; **Lanuza** - (13) Lambonao River, (14) Panawilan River, (15) Magkawass Falls, (16) Silop Spring, (17) Himatagan River, (18) Himatayan Lake.

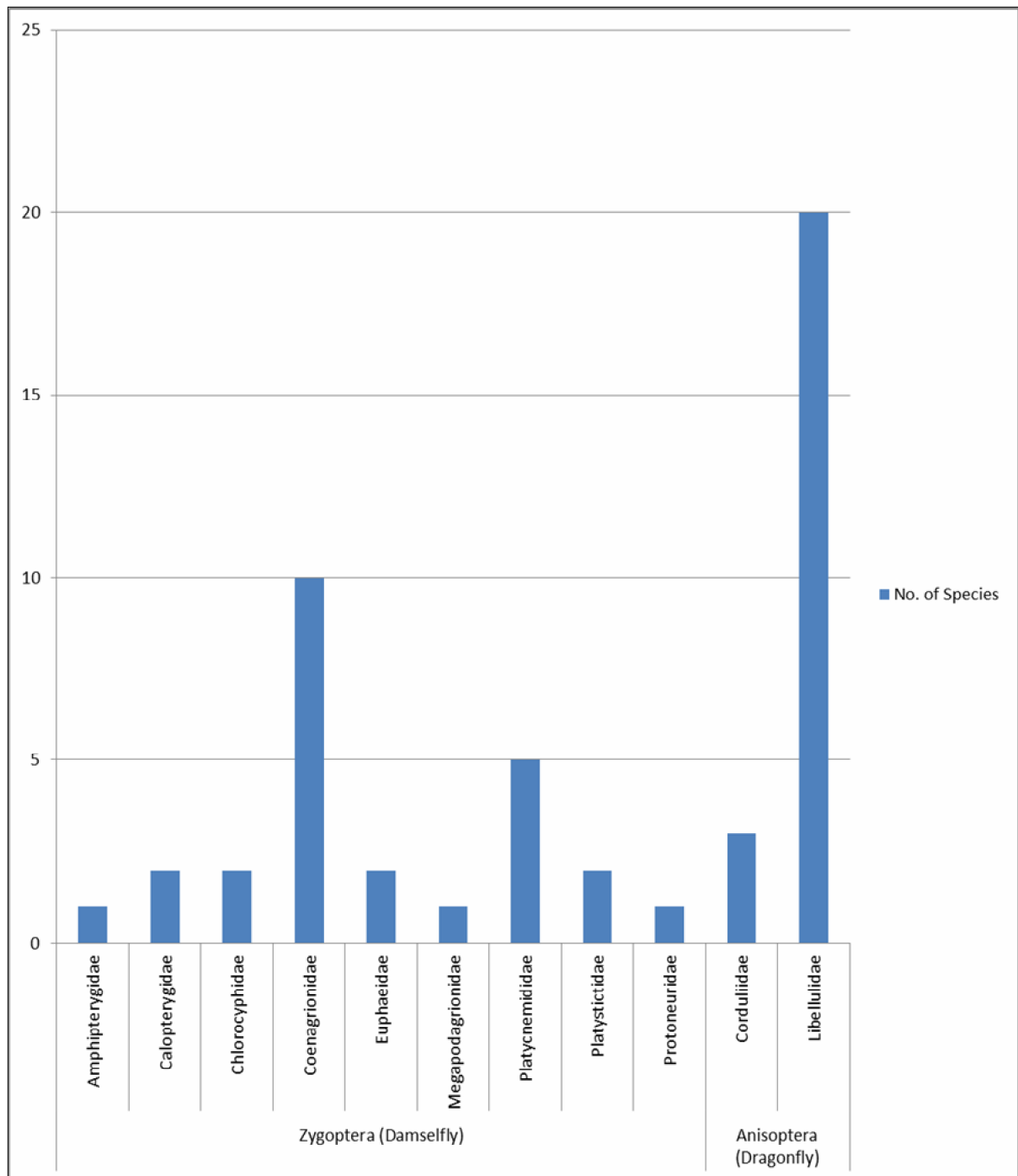


Figure 3. Species richness per family.

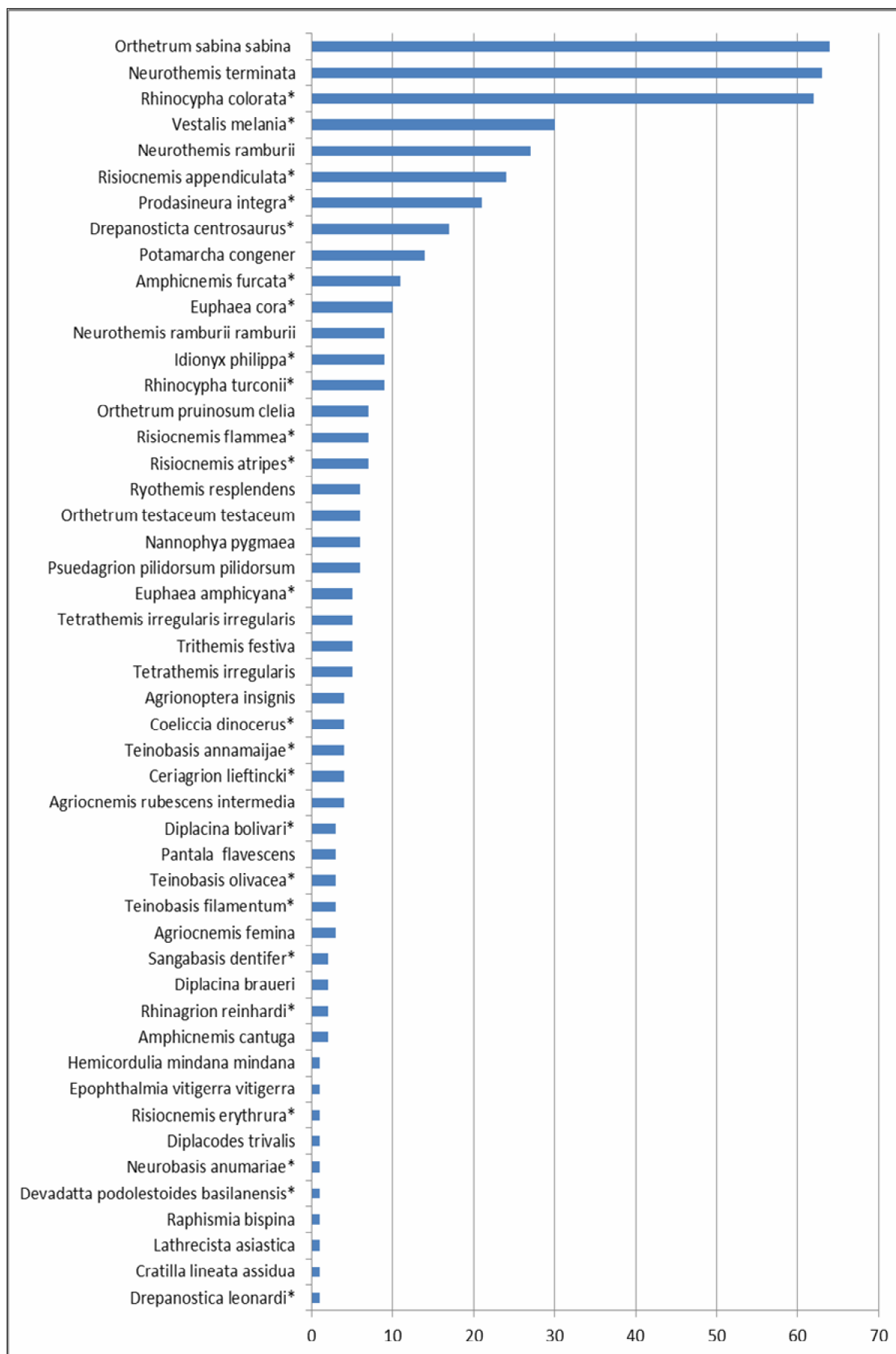


Figure 4. Species abundance.

The two new species record on Mindanao were *Rhyothemis resplendens* (Figure 5) and *Drepanosticta leonardi* (Figure 6). *D. leonardi* captured in Matanda River and Falls which is a slightly disturbed vegetation and *Rhyothemis resplendens* in Himatagan lake was the most interesting record in this study since these two species are new records in Mindanao. The discovery of *D. leonardi* in San Agustin indicates that new unrecorded species can be found in Mindanao especially in the province of Surigao. *D. leonardi* was first found perching on high on a shady cliff in Mt. Pangasugan in the central part of Leyte Island, in Visayas, Philippines. It belongs to *Drepanosticta belyshevi* group and differs from its congeners based on the combination of characters on its posterior lobe of prothorax and cerci (Villanueva et al 2011). Six individuals of *R. resplendens* (Figure 5) were recorded with two individuals in site 5 (Himatagan river) and four individuals in site 6 (Himatagan lake). This species was recorded in Papua New Guinea and northern Australia and is currently recorded in Isabela Provinces in Luzon Island and also in Polillo Island which provides additional Papuan species extension in the archipelago (Villanueva 2010b, 2010c; Villanueva et al 2012).



Figure 5. Shown on the left is *Rhyothemis resplendens* in its actual environment and on the right is a lateral view.

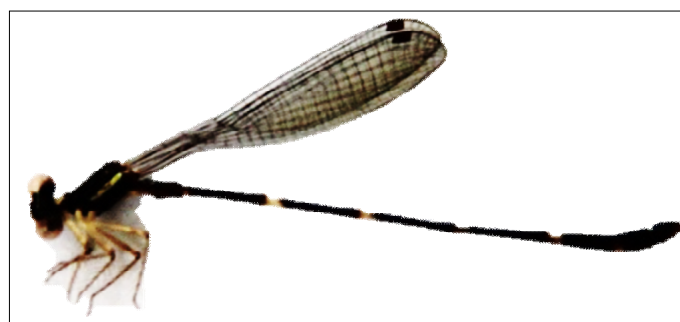


Figure 6. Lateral view of *Drepanosticta leonardi*.

High diversity ($H' = 3.4352$) was recorded in site 17. Moderate diversity was recorded in sites 1, 6, 12 and 18. A more or less even distribution was recorded in these sites. Other sites had low diversity indices (Table 2).

Difference in evenness is a result of variation in communities with geographical and physical factors such as resources present (productivity) which may result to further competition of the species, or light and temperature variation which could limit a species dispersal (Bryant 2002). Site 17 appears to be a complex habitat that can support a wide variety of Odonata species and had the most favorable physical habitat for the different Odonata species recorded in the area. Sites 5 and 16 having the least evenness value have high human-induced disturbances in the area and less water bodies for the

Odonata. Disturbances around the sites could have affected Odonata diversity in other sites. It was also observed that site 13 showed a zero result for both on diversity and evenness as the site only yielded only one species. This is likely due to heavy rains during sampling, which is also similar to the study of Villanueva et al (2012) where the species *Neurobasis luzionensis* is found to experience demise in population because of floods brought by a series of typhoons and tropical depressions which lowered the species habitats.

Table 2

Species diversity and evenness

Site	Species diversity (H)	Evenness (E)
Site 1. Matanda River and Falls	2.5395	0.9140
Site 2. Banate Stream	0.2228	0.2028
Site 3. Pag-uwayan Stream	0.6701	0.3740
Site 4. Guihawan Stream	0.2228	0.2028
Site 5. Buatong River	0.5057	0.3142
Site 6. Gata Stream I	1.2165	0.5537
Site 7. Gata Stream II	0.6701	0.3740
Site 8. Gata Stream III	0.6701	0.3740
Site 9. Sto. Nino River	0.3553	0.2563
Site 10. Lanete River	0.8451	0.4343
Site 11. Langgamay Swamp	0.6701	0.3740
Site 12. Saugan Swamp	1.6022	0.6682
Site 13. Lambonao River	0	0
Site 14. Panawilan River	0.6701	0.3740
Site 15. Magkawass Falls	0.2228	0.2028
Site 16. Silop Spring	0.2228	0.2028
Site 17. Himatagan River	3.4352	0.9845
Site 18. Himatayan Lake	1.9875	0.7749
San Agustin, Surigao del Sur	0.8492	0.4203
Lanuza, Surigao del Sur	1.0897	0.4443

Overall Lanuza has a moderate diversity ($H = 1.0897$) and San Agustin has a low diversity ($H = 0.8492$). However, the discovery of new recorded species in Mindanao indicates that more species of Odonata awaits discovery despite moderate diversity recorded in the area.

Conclusions and Recommendations. San Agustin, Surigao del Sur is species- rich (34 species) but has low endemicity (47%). Oriental species mostly dominate the landscape of the 12 sampling sites indicating disturbed vegetation. The unsustainable and rapid agricultural expansion was observed as the main threat to the habitats of Odonata. Lanuza, Surigao del Sur is species-rich (32 species) with high endemism (50%). The discovery of two new recorded species in Mindanao implies that there could be more species in Lanuza and San Agustin and even in the whole province of Surigao del Sur awaiting discovery. The higher species richness in the dipterocarp forests than in modified habitats and agro ecosystem indicates that Odonata prefer forested and undisturbed areas.

The presence of endemic and rare species suggests that Lanuza is of conservation importance. To have a comprehensive database of Odonata species in the Philippines especially on Mindanao, it is recommended that the remaining freshwater habitats of San Agustin and Lanuza especially areas that are still lush with vegetation and other potential habitats of Odonata in Mindanao be assessed. It is also recommended that additional field work be made for proper evaluation of Odonata, like comparative morphometrics with Odonata collected in other areas in the Philippines. More research needs to be done in understanding the behavior of Odonata and the environmental factors that affect their distribution.

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