

Dragonflies in the City: Diversity of Odonates in Urban Davao, Philippines

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Abstract: Dragonflies are well-known group of insects because of their biological and ecological importance in a community, that is, they indicate the environmental health of an ecosystem. However, in an urban ecosystem, there are many threats that can affect the assemblages of dragonfly species such as the intensification of urbanization which contributes biodiversity loss of most dragonfly species. This study aimed to identify dragonfly species and determine the species richness, relative abundance, species diversity, evenness and effective number of dragonflies in selected areas in Davao City. Opportunistic sampling using sweep net and photo documentation were used during the study. The sampling lasted for three months from June 2017 to August 2017. A total of 962 individuals of dragonflies were observed and recorded comprising of six species of dragonflies from six different genera of one family. *Orthethrum sabina* was the most abundant among the six species recorded in all sampling sites. The species richness was six. Low species diversity was obtained in all sampling which shows that the sites were not evenly distributed and indicating that the study sites were not diverse in terms of the number of species and highly disturbed.

Key words: Dragonfly, urban, biodiversity, biological, ecological, species diversity.

1. Introduction

Dragonflies (Odonata: Anisoptera) are a well-studied group of insects because of their increasing conservation acknowledgement around the world. In a context of Simaika [1], this reality is reflected in dragonflies being the groups of insects which have been globally assessed by the International Union for Conservation of Nature (IUCN). As a group of freshwater invertebrates, dragonflies are considered indicators of environmental health and quality of habitat for freshwater ecosystems. There were studies conducted showing that adult dragonfly is sensitive to conditions at the breeding site and surrounding terrestrial area, and thus reacts rapidly to changes in environmental quality via active dispersal [2]. In the Philippine archipelago, Odonata fauna is portrayed by the high rate of endemic species [3]. Currently, the Philippine has nearly 300 species of Odonata and 40

new species waiting to be described. Mindanao is the second biggest island in the Philippine archipelago which has a list of fascinating flora and fauna [4].

In an urban ecosystem, the major threat to most dragonfly species is the intensification of modern urbanization, thereby contributing to biodiversity loss including habitat alteration, rivalry from presented species, human interest for specific species, and fast ecological changes (e.g., climatic change) [5]. These factors explain the changes between urban areas or within urban areas with various histories and diverse social standards and heritages, which can affect the impact of usual processes within urban areas [6]. However, in spite of various studies on Philippine dragonflies, there have been no studies conducted yet in urban ecosystem and does not have any data about dragonfly specifically in Davao City. Moreover, Davao City is poorly studied for the diversity of dragonflies. This study was conducted to provide data and document species of dragonfly that are present in the area of Davao City, Philippines.

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2. Materials and Methods

2.1 Description and Location of the Study Area

The study was conducted in Davao City specifically in downtown area and Catalunan Grande, Davao City—a highly urbanized city on Mindanao Island with an overall land area of 2,444 km² [7]. Two areas were selected during the collection: one at the downtown area centered at geographic coordinates 7°05'04.99" North latitude and 125°36'44.33" East longitude, and the other one at Catalunan Grande lying along 7°04'31.87" North latitude and 125°32'46.81" East longitude. The area is estimated about 11 km road distance North West from the terminal. Fig. 1 shows the location of the study area.

2.1.1 Sampling Area

The study was conducted in a highly urban area which was in the downtown area and the semi-urban area in Catalunan Grande, Davao City. The sampling was conducted from June 2017 to August 2017 during weekend in such a way that there were at least two visits to each site in a week in four selected sampling sites of the two areas in Davao City. The area was divided into four sites namely: the Barrio Obrero (site I lies along 07°5'19.05" North latitude and 125°37'3.67" East longitude), Dacudao Avenue (site II lies along 07°5'27.79" North latitude and 125°37'4.5" East longitude), Skyline Village (site III lies along 07°4'45.76" North latitude and 125°32'40.83" East longitude) and Southvilla Heights (site IV lies along 07°4'33.37" North latitude and 125°32'46.87" East longitude).

2.1.2 Description of Sampling Sites

Site I was located at Barrio Obrero, Davao City (07°5'19.05" North, 125°37'3.67" East). Schools, malls, hotels, apartments and residential houses were present in this area. Thereby, anthropogenic disturbances like canal modification, clogged drainage and pollution were observed in the area. There was also canal located in Veloso st. that serves as drainage in nearby residential houses that were connected to

Dacudao Avenue canal, where water ran slowly.

Site II was located at Dacudao Avenue, Davao City (07°5'27.79" North, 125°37'4.5" East). There is a canal present between the two lanes that served as the main drainage to nearby districts and barangays in Davao City. The canal has a moderate flow of water and was surrounded by trees. The presence of dragonflies was noticed. The starting point of the canal starts from Bajada flyover and ends in Agdao proper.

Site III was located at Skyline Village, Catalunan Grande, Davao City (07°4'33.37" North, 125°32'46.87" East). The site was semi-urbanized and some parts were not yet fully developed. The site was inhabited by various types of organisms such as spiders, damselflies and butterflies. It was 20 m distance away from the site where a small stream surrounded by the houses of indigenous people was located. Therefore, dragonflies were present in the stream.

Site IV was located at Southvilla Heights (07°4'33.37" North, 125°32'46.87" East). The site was open and partly covered with trees. An estimate of 10 m away from the site was an agricultural ecosystem. Dragonflies were seen on the site.

2.2 Sampling Method

2.2.1 Sweep Netting Method

Light weight gauze net was used to capture dragonflies while in flight or perching on vegetation. This method involved moderate sweeping by using back and forth sweeps at least 1 m in the distance while walking at a constant speed in the vegetation [8]. The captured dragonflies were removed from the net by holding both wings to ensure the safeness of the specimen [9] and were recorded in a global positioning system (GPS) tracker. The date, location and habitat were noted using field notebook to document the detailed information of the collected specimens [10].

2.2.2 Opportunistic Sampling Method

Sampling was conducted for a three-hour time

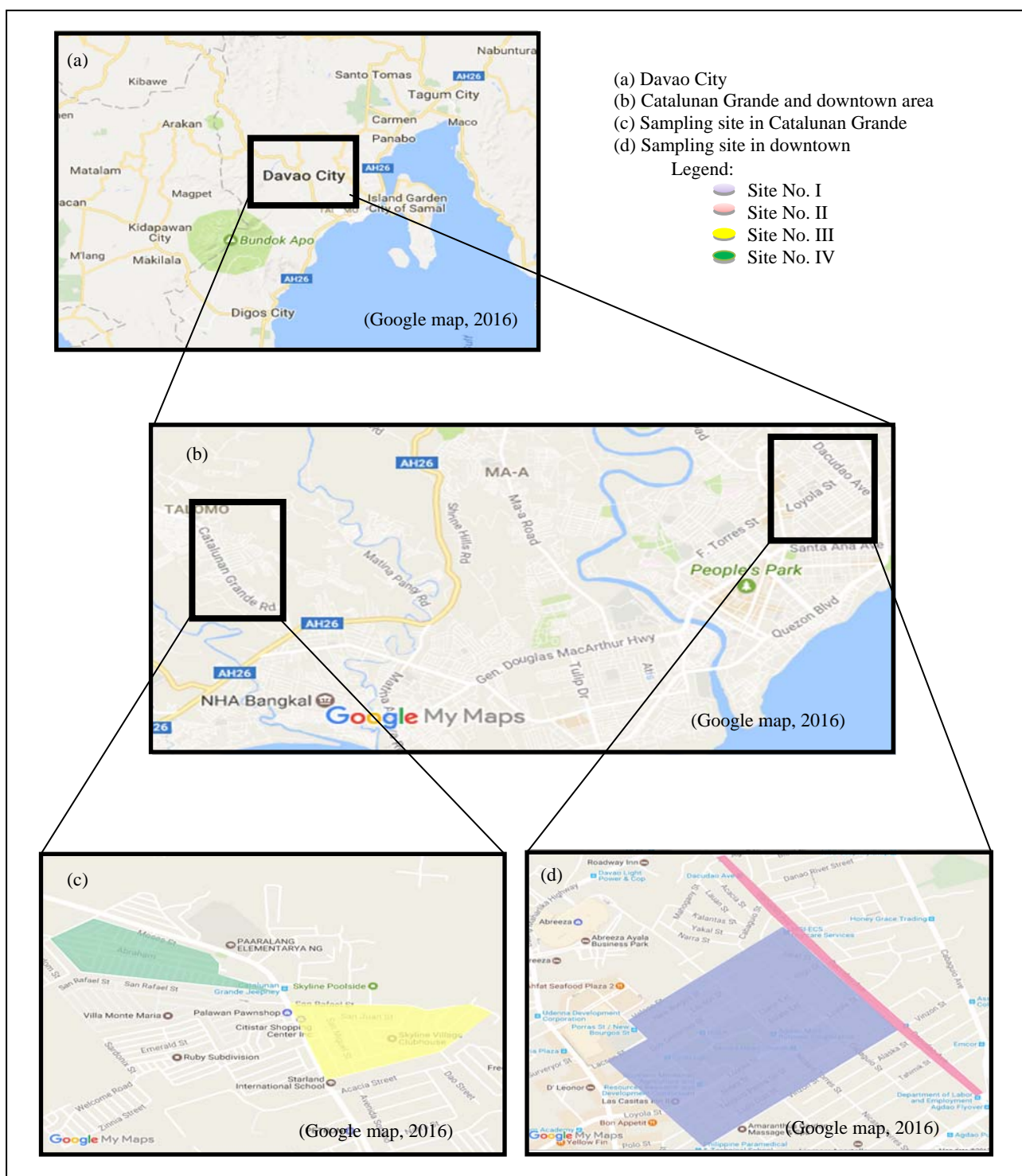


Fig. 1 Map of the sampling area [11].

walking, starting from 7:00 AM to 10:00 AM and was used as allotted time in each sampling site for every two days.

2.3 Processing and Identification of Dragonfly Species

The gathered specimens were stored in a glassine paper. Only one representative per species was kept in each glassine paper to avoid damage. The specimens were immersed in the container filled with acetone [4] for about 24 h. After immersing the sample overnight, glassine papers were removed from the container and allowed to dry totally for 30-60 min. The specimens were then removed carefully from the glassine papers by using soft forceps and placed on the petri dish [9]. The dried-stored specimen was labeled with information as to the date and location where it was collected [10].

The initial identification of species in the study area was done using the published articles on Philippine Odonata of Villanueva and colleagues [12]. Important characteristics used in species identification included the color pattern of the thorax specifically the synthorax, patterns of wing venation, abdomen specifically the segment 10 and the epiproct, the sizes, shapes, and even their flight behaviors [9]. The initial identification was verified by Dr. Reagan Joseph T. Villanueva of Southern Philippines Medical Center, Davao City, Philippines, and Dr. Milton Norman D. Medina and Dr. Analyn A. Cabras of University of Mindanao, Davao City, Philippines.

2.4 Biodiversity Indices

The species diversity, evenness, and an effective number of species were determined and calculated using Shannon-Weiner index. This was used as species diversity index to compare between different sampling sites [13]. It was computed using the formula:

$$H' = \sum \frac{n_i}{N} \times \ln \frac{N}{n_i} \quad (1)$$

where H' is the value of species diversity index while

n was equal to the total number of individuals belonging to a single species (i) and N is the total number of the individuals regardless of the species that were collected.

On the other hand, species richness (S) was done by counting the number of species found in the sampling sites. The relative abundance of the species was done by counting the total number of individuals per species [14]. All collected individuals were counted to determine the total relative abundance (RA). It was computed using the formula:

$$RA = \frac{N_i}{N} \times 100 \quad (2)$$

where N_i was equal to the total number of individuals belonging to a single species while N was the total number of the individuals regardless of the species that were collected.

2.4.1 Pielou's Evenness Index

Pielou's evenness index was used to calculate and determine the evenness of species [15]. It was computed using the formula:

$$J = \frac{H'}{\ln S} \quad (3)$$

where J was the Pielou's evenness index, H' is the species diversity index, S was equal to the total number of species in the sample and \ln was the natural logarithm.

2.4.2 Effective Number of the Species

Effective number of the species was considered to identify the number of equally abundant species found in a given area that are needed to give the same value of the true diversity measure [16]. It was computed using the formula:

$$ES = \exp(H') \quad (4)$$

where ES was the effective number of species found in the sampling sites and H' was the value of the diversity index which was the Shannon-Weiner function.

3. Results and Discussion

Six species of dragonflies from six different genera

of one family were identified and recorded throughout the duration of the sampling period. There were 962 dragonflies observed and recorded in selected areas of Davao City, which include Barrio Obrero, Dacudao Avenue, Skyline Village and Southvilla Heights.

3.1 Species Richness, Relative Abundance and Species Diversity

In this study, the highest species richness was exhibited in site III ($S = 6$) (Table 1). Site III is a less disturbed site that is highly dominated by dragonflies. The semi-urban areas ($S = 6$) obtained higher species richness of dragonflies compared to highly urban areas ($S = 5$). The *Trithemis aurora* was the only species that is not present in highly urban areas because they are commonly found in standing and slow flowing streams in the lowland of semi-urban areas. Mapiot and Enguito [4] found that anthropogenic disturbances have a negative impact on the species richness of the Odonata fauna and may lead to the low species diversity and endemism of Odonata.

Of the six species identified, all of them belonged to family Libellulidae. Kalkman *et al.* [17] considered family Libellulidae as one of the largest families of Anisoptera and one of the two leading families in Odonata fauna distributed worldwide. The latest studies conducted in Mindanao showed that most of the species gathered belong to the family Libellulidae [4]. Recently, this family ranks as the most diverse and widespread suborder of dragonflies [18].

Throughout the duration of sampling, it was observed that *Orthethrum sabina* had the highest representation of relative abundance among the six species collected having 689 (71.62%) individuals, which is considered the most abundant species recorded and found in all sampling sites. The *O. sabina* are species that are tolerant to various types of anthropogenic disturbances. It means they can adapt both highly disturbed and undisturbed habitats [19]. In the study conducted by Villanueva *et al.* [20] in Northern Sierra Madre Natural Park, Isabela, Luzon who also obtained that *O. sabina* is one of the species with the highest relative abundance; meanwhile, in this study, the *Diplacodes trivialis*, *Pantala flavescens*, *Neurothemis ramburii*, *Tholymis tillarga* and *T. aurora* have the lowest number of individual count or relative abundance. Table 1 shows the species richness and relative abundance of dragonfly species in the sampling sites.

3.2 Biodiversity Index

The Shannon-Weiner diversity index for each site was calculated and obtained. The areas were distributed into four sampling sites. Fig. 2 shows that the Shannon-Wiener diversity index was lowest in Southvilla Heights and the highest diversity occurred in Barrio Obrero. However, all sampling sites attained low diversity as shown in the graph (Fig. 2). This means that the sampling sites are relatively disturbed considering the fact that dragonflies are highly dependent on the habitat characteristics, especially that most of

Table 1 Species richness and relative abundance of dragonflies in selected areas in Davao City.

Species name	Site I	Site II	Site III	Site IV	Total	RA (%)
<i>Orthethrum sabina</i> (Drury, 1773)	57	36	145	451	689	71.62
<i>Diplacodes trivialis</i> (Rambur, 1842)	42	30	48	44	164	17.05
<i>Pantala flavescens</i> (Fabricius, 1798)	37	8	14	21	80	8.32
<i>Neurothemis ramburii</i> (Brauer, 1866)	4	2	5	5	16	1.66
<i>Tholymis tillarga</i> (Fabricius, 1798)	1	1	5	1	8	0.83
<i>Trithemis aurora</i> (Burmeister, 1839)	0	0	5	0	5	0.52
Total number of individuals	141	77	222	522	962	
Total number of species	5	5	6	5		

Site I: Barrio Obrero, Site II: Dacudao Avenue, Site III: Skyline Village, Site IV: Southvilla Heights.

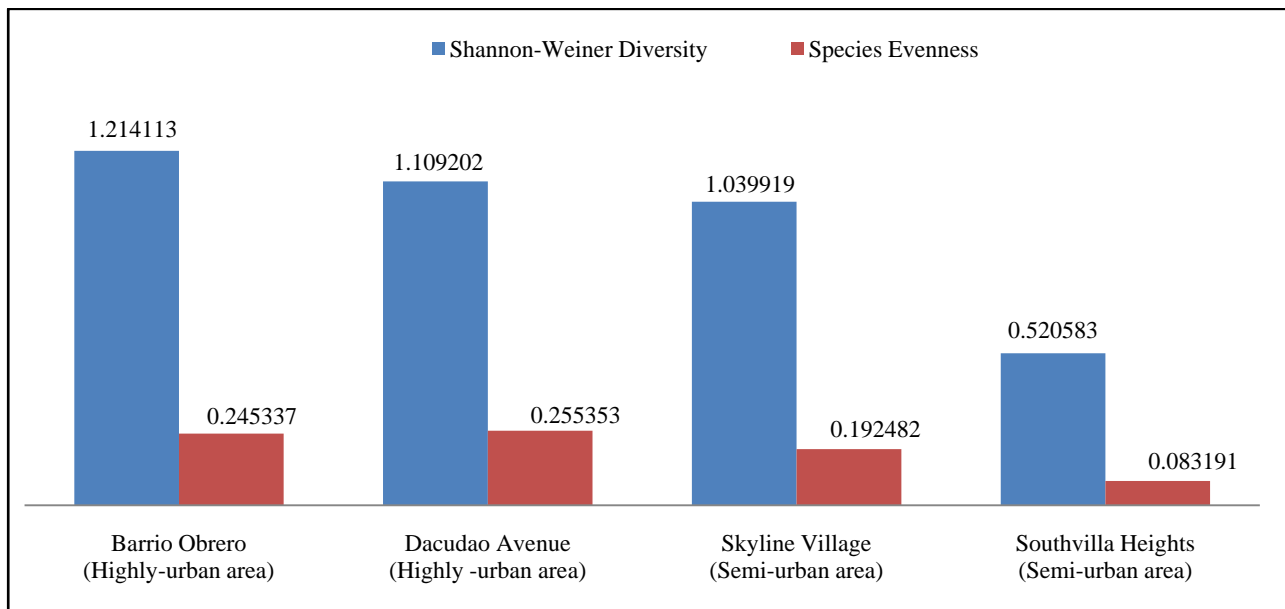


Fig. 2 Shannon-Weiner diversity index and evenness of dragonflies in selected areas in Davao City, Philippines.

the dragonflies rely on vegetation that plays an important role throughout their life cycle. However, their life cycle can also be determined on what kinds of environments they can be able to adapt [21].

According to Bibi and Ali [13], the indication value of Shannon-Weiner diversity index commonly falls between 1.5 and 3.5 and it is rare to exceed 4.5. If the value is near to 4.6 it indicates that the numbers of the individuals in a certain area are evenly distributed among all the species. In this study, the value of the Shannon-Weiner diversity index of dragonflies in Barrio Obrero, Dacudao Avenue, Skyline Village and Southvilla Heights were 1.214113, 1.109202, 1.039919 and 0.520583, respectively (Fig. 2). It shows that all sampling sites were not evenly distributed and indicate that the sampling sites were not diverse in terms of the number of species.

The low species diversity of dragonflies were affected by anthropogenic impact in selected areas in Davao City such as habitat heterogeneity, habitat fragmentation, habitat disturbance, fast growing agricultural expansion, pollution, canalization of streams and rivers and potential interaction that cause substantial decrease of dragonflies assemblages and that led to the virtual extirpation of insect life. On the

other hand, there is no doubt that human civilizations have caused a negative impact on the biodiversity of dragonflies and have clearly been detrimental to the biodiversity [22].

For the evenness, according to Cerda *et al.* [23] if the value of evenness is nearer to 1 it means there is even distribution whereas the distribution nearer to 0 means that there is a dominant distribution of species in a given area. Meanwhile, the value attained between highly urban and semi-urban areas in all sites has more or less the same evenness closer to 0 (Fig. 2); therefore, the sites appeared to have a dominant distribution of species indicating that there is competition among the species and none of the single species are dominant in one site. According to Malawani *et al.* [24], the greater competition among species leads to decrease in evenness because the value of evenness also affects the competition of species between food and territory within an area.

3.3 Effective Number of Species

The effective number of species for each site was also calculated and obtained. The values for effective number of species in Barrio Obrero, Dacudao Avenue, Skyline Village and Southvilla Heights were 3.367307,

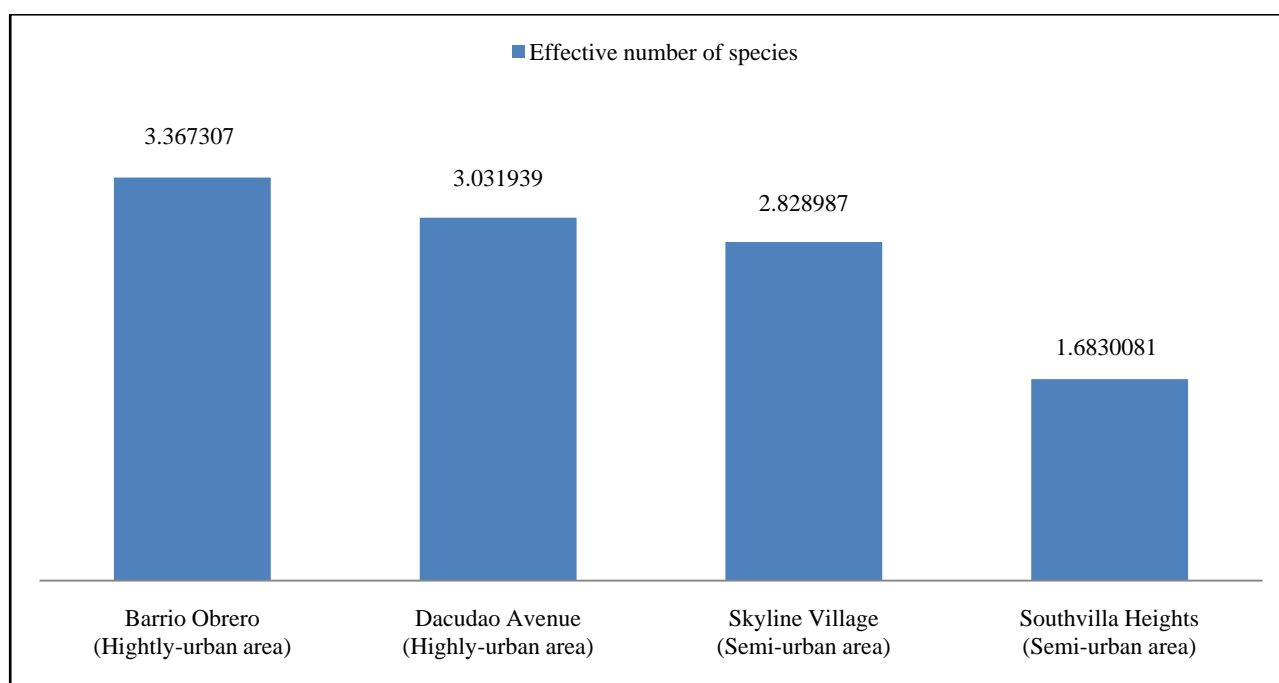


Fig. 3 Effective number of dragonflies species in selected areas in Davao City.

3.031939, 2.828987 and 1.6830081, respectively (Fig. 3). This means that all of the six species recorded in all sampling sites were equally abundant.

According to Jost [25], diversity values must be converted into effective numbers of species so that the quantity of similarly abundant species is expected to create the observed value of diversity. Furthermore, the effective numbers were applied so that rate changes and proportion relationship of diversity value are significant [26].

4. Conclusions and Recommendation

Of the 962 dragonflies, a total of six species under family Libellulidae were identified in the sampling sites. The dragonflies found in the sampling sites were *O. sabina*, *D. trivialis*, *P. flavescens*, *T. tillarga*, *N. ramburii* and *T. aurora*. None of these species were threatened, however, based on observations, the status and conditions of dragonflies in selected areas in Davao City showed that their habitats might be in danger as the main bodies of water and environment within the sampling sites are being threatened by anthropogenic activities and disturbances. There were 962 individuals

recorded in this study. The *O. sabina* was the most abundant in terms of individual count among the six species under family Libellulidae. The Shannon-Weiner diversity index value of the dragonfly species was low in all sampling sites. Therefore, the diversity index of dragonflies in selected areas indicates that Davao City, Philippines had minimal diversity of dragonfly species with very low endemism.

It is recommended to have an additional research and monitoring of the dragonflies about the effects of anthropogenic disturbances and other factors that affect their diversity. It also needs further assessment (such as monitoring aquatic and terrestrial habitats, condition and status of dragonfly communities) to be conducted in the other areas to add more to the initial odonatological record of diversity in urban biodiversity in Davao City.

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