Dragonfly Species Diversity (Odonata) in Three Telaga on The Highland Freshwater, West Java

S S Wibowo¹, A Basukriadi¹ and N L Winarni²
¹ Department of Biology, Faculty of Mathematics and Natural Sciences, University of Indonesia, Depok, Indonesia
² Research Center for Climate Change, University of Indonesia, Depok, Indonesia

*Corresponding author email: sri.supardi@ui.ac.id

Abstract. Odonata was very selective to the habitat selection. Their sensitivity toward environment makes them be good indicator species. Information of species diversity of Odonata in the highland of tropical freshwater lakes is still rare. The purpose of this research was to compare species diversity of Odonata in Telaga Biru Mount Gede Pangrango National Park, Telaga Warna, Nature Park, and Telaga Saat, West Java. Data of Odonata population were collected using fixed point count method. The results showed that species diversity of Odonata in Telaga Saat is higher than Telaga Warna, Nature Park and Telaga Biru, Mount Gede Pangrango National Park. Species diversity indices of Odonata in the three of lakes ranged between 0.78 – 1.75 and were categorized medium and low diversity. Jaccard index of similarity showed that Telaga Warna and Telaga Saat had the similar communities of Odonata. The high index of species diversity of Odonata in Telaga Saat was probably due to the higher intensity of light, which created the higher air temperature at the lake. Species richness, diversity and Shannon index of Odonata was the highest in Telaga Saat compared two other sites.

1. Introduction
Almost 60% of the world’s species diversity Odonata is clustered in the Neotropical and Indo-Malayan realms. Amongst these, most of the threatened species are resided in the Indo-Malayan realm [1]. The increased human populations have intensified the transformation of natural landscapes into human dominated systems which threatened the Odonata communities [2], especially in aquatic habitat. High and low of aquatic habitat quality can occurrence effect local extinction [3] and determining characteristic of species Odonata certain [4].

Java Island is one of the regions with the highest population density in Indonesia and is rapidly undergo habitat destructions. The typical habitat destructions in Java and Borneo are due to the effects of urbanization, agricultural expansion, deforestation and forest modification [5, 6, 7]. Information of species diversity of Odonata in the highland of tropical freshwater lakes is still rare. Data on Odonata abundance and the influence of land use is virtually unavailable [7].

The Odonata were highly sensitive to changes in physical habitat structure, which make them good bioindicators [8]. Species diversity of tropical Odonata is at least partly explained by the high diversity of aquatic habitats in tropical forests [9], especially in montane areas [10]. The highest species diversity of Odonata was found in flowing waters in tropical rain forest. Mountains not only provide a greater contemporary diversity of habitats, but also a greater potential for survival in regional refugia.
The relative long term stability of forest habitats, which provides opportunities for animals with specialist lifestyle, might also explain the high species diversity of tropical Odonata [11].

Lief tinck [12] suggested that species diversity Odonata in Java were highly exceeded than 150 species. The Indonesia Dragonfly Society (IDS) has updated data species Odonata by compiling many checklists species occurring in Java. There are 177 species in Java. IDS has found 88 species in East, Central and West Java, in which seven species of them are endemic to Java [13]. Because of the limited information on the highland tropical freshwater lakes, the purpose of this study was to evaluate the species diversity of Odonata in highland freshwater habitat of Telaga Biru Mount Gede Pangrango National Park, Telaga Warna, Nature Park, and Telaga Saat, West Java.

2. Method

2.1. Study sites
The study sites were located in Telaga Biru, Mount Gede Pangrango National Park, Cianjur; Telaga Warna, Nature Park and Telaga Saat, Bogor, West Java with altitude of 1,602; 1,477; and 1,443 m asl respectively. Administratively, the three sites were located in the Cianjur, Sukabumi, and Bogor Regencies (Figure 1). The 0.05 ha Telaga Biru has a color characteristic which depend on algae growth, sometimes the lakes water was slimy green-brow and at other times a magical deep blue. Telaga Biru is rich in nutrients and many soluble minerals from volcanic rock and soils to the rich supply of decomposing leaves or other organic water. Telaga Biru is located in the montane zone within the tropical forest of Mt. Gede Pangrango which is surrounded by vegetations such a, Schima wallichii, Dacrycarpus imbricatus, Podocarpus nerifolius [14]. Engelhardtia spicata, Pinanga coronata, Actinodaphne sp., Ardisia sp., Magnolia sp. and Brugmansia suaveolens.

The 5 ha area of the Telaga Warna is surrounded by a steep cliff and cottage in other side as it is located in the middle of the Nature Recreational Park (Taman Wisata Alam) [15]. Some local and foreign tourists come to Telaga Warna for fishing, outdoor activity and ecotourism. Telaga Warna having broad 0.71 ha, the mud alluvial with sediment into the middle reaches 15 m and 1-2 m at edge side. Vegetations around the Telaga Warna inhabited by Altingia excelsa, Turpinia sphaerocarpa, Lithocarpus sp., Litsea sp., Breynia sp., Schefflera sp., Cordyline sp. Caryota mitis, and Brugmansia suaveolens.

The 5.8 ha Telaga Saat is mostly surrounded by tea plantation and only some vegetations such as Agathis dammara, Schima wallichii, Altingia excelsa, Musa sp., and Coffea sp. which occupying riparian area. The mid sediment become shallow due to rapidly growth of vegetation Ludwigia peruviana (Onagraceae). Telaga Saat commonly used as a tourist attraction and fishing for local people in Tugu village.

2.2. Sampling
The study was conducted in May – June 2019. We used fixed point count to sample the adults of Odonata [16]. The sampling was started from 08:00 until 16:00. Adult Odonata observed at each point was photograph using digital camera Nikon Coolpix P900. Spesies and number of individuals were recorded at each point. Species identification was used identification book dragonfly such as Orr [17], Orr et al. [18], Sigit et al. [19] and Orr & Kalkman [20].

2.3. Data analysis
Data were then analyzed to determine individual rarefaction, species abundance model, species diversity using Shannon-Wiener index [21], and Jaccard similarity index with hierarchical clustering classical UPGMA. All analyses were performed using PAST ver. 3.02 [22,23].
3. Results and Discussion

In total we surveyed 59 points from 3 locations. We recorded 157 individuals of adults Odonata which belong to 11 species, 5 families and 2 sub order identified from three study sites. Dragonfly Suborder Anisoptera composed of two dominant species based on relative abundance species: *Orthetrum pruinosum* (20.38%) and *Anax guttatus* (5.09%), while damselflies suborder Zygoptera composed of five species: *Agriocnemis rubescens* (33.12%), *Agriocnemis pygmaea* (14.64%), *Agriocnemis femina* (8.28%), *Ischnura senegalensis* (7.64%) and *Coeliccia membranipes* (5.09%) (Table 1).

Table 1. Numbers of individual and species among three study site.

| Family and Species       | Individuals | Location       |
|--------------------------|-------------|----------------|
|                          |             | Telaga Saat    | Telaga Warna | Telaga Biru |
| Anisoptera               |             |                |              |              |
| Aeshnidae                |             |                |              |              |
| *Anax guttatus* [24]     | 8           | X              | X            | X            |
| Libellulidae             |             |                |              |              |
| *Orthetrum pruinosum* [25]| 32         | X              | X            | X            |
| *Orthetrum sabina* [26]  | 5           | X              | X            | *            |
| *Pantala flavescens* [27]| 2           | X              | *            | *            |
| Zygoptera                |             |                |              |              |
| Coenagrionidae           |             |                |              |              |
| *Agriocnemis femina* [28]| 13          | X              | *            | *            |
| *Agriocnemis pygmaea* [29]| 23          | X              | *            | *            |
| *Agriocnemis rubescens* [30]| 52      | X              | X            | X            |
| *Ischnura senegalensis* [29]| 12          | X              | X            | *            |
| Platycnemididae          |             |                |              |              |
| *Coeliccia membranipes* [29]| 8            | *              | *            | X            |
| *Coptera marginipes* [29]| 1           | X              | *            | *            |
| Calopterygidae           |             |                |              |              |
| *Vestalis luctuosa* [24] | 1           | *              | X            | *            |
| Total Individu           | 157         |                |              |              |

Noted. (X) Present & (*) Absent
Other species as *Orthetrum sabina* (3.18%), *Pantala flavescens* (1.27%), *Copera marginipes* (0.63%) and *Vestalis lactuosa* (0.63%) were species with low relative abundance in three sites. Only three species occupy in all three Telaga i.e., *Anax guttatus*, *Orthetrum pruinoseum* and *Agriocnemis rubescens*. Those species shared similar habitats and become species specialized in freshwater highland habitat. Families of Coenagrionidae were mostly abundant and easily found in Telaga Saat and Telaga Warna. In overall, suborder damselflies were more abundant than dragonflies. *Agriocnemis rubescens* was very abundance in Telaga Warna. Almost each point they were presence and the activity more settle down in foliage than fly. *A. rubescens* (Zygoptera) naturally not much stronger fliers than dragonflies [31]. *Orthetrum pruinoseum* and *Ischnura senegalensis* were easy founded in edge Telaga Saat and rather abundance from other species. Meanwhile, species *Coeliccia membranipes* was abundance in Telaga Biru and suggested be specialized species in there. Base on criteria selection to indicator species, one of criteria from abundance or richness [32]. Those species can chosen and used as indicator species in three different Telaga with biomonitoring design explicit.

### 3.1. Individual rarefaction and species abundance model

Species richness in three location is depicted in Figure 2. Telaga Saat has the highest species richness compare to Telaga Warna and Telaga Biru. In all of the three lakes, the curves were almost reached an asymptote, suggesting that only rare species may still be unrecorded.

![Image](https://example.com/image.png)

**Figure 2.** Species richness in three study sites

By looking at species abundance models, both Telaga Saat and Telaga Biru communities were categorized as log-normal series. Both have similar patterns while in the community in Telaga Warna was more likely following log series model (Figure 3). in Telaga Warna, only one species *Agriocnemis rubescens* occur as dominant species. Log series in Telaga Warna explained that distribution of individuals amongst species which described the relationship between total number of species, total number individuals, and α (the log series diversity index). The log-normal series showed that species abundance decreased after the fourth species with the rest of the species were considered rare.

### 3.2. Shannon diversity index, evenness and similarities index

Shannon diversity index (H) from the three sites ranged between 0.78 – 1.75, with the Telaga Saat showing the highest diversity (1.75) and the Telaga Warna has the lowest diversity (0.78) (Figure 4). The value of the Shannon index obtained from empirical data usually falls between 1.5 and 3.5 and rarely surpasses 4 [33]. Shannon diversity index in Telaga Saat and Telaga Biru were categorized as medium diversity [21]. These were contrasted with Telaga Warna which was categorized as low diversity (Figure 4). The high index of species diversity of Odonata in Telaga Saat was probably due to the higher intensity of light, which created higher air temperature at the Telaga. Dragonglfy species rapidly increases with allowed increasing freshwater width and more light penetrating tree canopy.
The higher intensity of light, air temperature and relative humidity regulate by presence of riparian vegetation which provides microclimatic in the Telaga [35]. Area Telaga which surrounding riparian vegetation be one of the factor which associated the persistence of adults Odonata in freshwater habitats of terrestrial landscape [36].

Evenness index describes the variability in species abundances and each community in which all species which have approximately equal numbers of individuals or similar biomasses would be rated as extremely even [21]. Our results suggested that the highest evenness (0.83) was in Telaga Biru, suggesting an assemblage in which most species present are equally abundant. The low evenness (0.36) occurred in Telaga Warna and the medium evenness (0.64) occurred in Telaga Saat (Figure 4).

Figure 3. Species abundance model in three study sites

Figure 4. The histogram of Shannon diversity index and evenness in three study sites

Figure 5. The cluster analysis of similarity of species and sites by Jaccard similarity index.
The analysis of similarity index was conducted by Clustering Classical UPGMA using Jaccard similarity index. The results of the cluster showed that Telaga Warna and Telaga Saat have the similarities communities species Odonata than Telaga Biru. The communities of the three sites were clustered into four groups. Group 1 consisted of Copera marginipes; Agriocnemis pygmaea; Agriocnemis femina; and Pantala flavescens. Group 2 consisted of Ischnura senegalensis; Orthetrum sabina; Agriocnemis rubescens; Anax guttatus; and Orthetrum pruinosum. Group 3 and 4 consisted of Vestalis luctuosa and Coeliccia membranipes. Communities in group 1 and 2 had distance similarity relative close than group 3 and 4 which. Because some species in group 2 as Ischnura senegalensis; Orthetrum sabina; Agriocnemis rubescens; Anax guttatus which occupying in Telaga Warna, also can founded in Telaga Saat. The estimated was maked that maybe occur shared species in Telaga Saat and Telaga Warna. Vestalis luctuosa was separate in from group 2, whereas this species occupy in Telaga Warna. Coeliccia membranipes is in separate cluster because this species being species specialist in Telaga Biru (Figure 5).

This study showed that species diversity in freshwater highland, especially in three Telaga site had similar communities. Some species can occupy all sites with different freshwater habitat types. Species like a Orthetrum sabina and Pantala flavescens were considered as common species [7]. Pantala flavescens has high dispersal ability up to New Zealand and this species reported as dominant species in Pune City, India [37]. Those species can mostly be found in the variety of habitat types but usually they are more abundant in the lowland habitat. Anax guttatus, Orthetrum pruinosum and Agriocnemis rubescens were found in three sites as well as O. pruinosum which only found in high altitude habitat with good water quality [7].

Mostly species which founded in three sites from families Coenagrionidae and Libellulidae. Both, the two largest families are believed to be relativley recent [38] and have widespread in global [11]. Species are usually widesspread and can be found in almost all species assemblages of their distribution range because they able to opportunistic. Many species successful reproduce in a wide variety of habitat, such Ischnura senegalensis are also widespread opportunists in the Paleotropics [39]. O. pruinosum, O. sabina P. flavescens can survived in the highland over 1,400 m asl. One of reason why the Libellulidae have wide range distribution was associated with the body size of the species of family Libellulidae which commonly large and bulky which increases alertness [40]. Agriocnemis rubescens was very abundance in Telaga Warna with total number individuals 49. The Coenagrionidae was the most abundant Zygoptera family in Telaga Warna. This result is similar to the general pattern of that studied in eastern Amazon [41]. Constrasted with Coeliccia membranipes which dominant in Telaga Biru although only 8 individuals. We expected those species can used as species indicator for monitoring and assessment from environmental quality.

The community of Odonata in Telaga Biru was found at low species richness with only four species. However, we found some eksoskeleton of larvae in foliage of Brugminansia suavelons. The vegetation cover such B. suavelons was important on the Odonata species distribution [42]. Vegetation cover can provide structure for thermoregulation, foraging, territory defense, protection for adults, contribute to the input of branches and leaves that provide place for refure and larval development [43]. Other research in Pindari forest of Western Himalaya, India which situated altitudinal between 2,100 until 3,500 m asl showed that nine species of Odonata were recorded [44]. The diversity of Shannon index explain thats the diversity in three location study were medium and low diversity, especially in the Telaga Warna. Study of Novelo-Gutiérrez & Gómez-Anaya [45] that the alpha diversity Odonata vary following altitudinal gradient was recorded 92 species (10-500 m asl), 61 species (501-1,000 m asl) and 63 species (1,001-1,130 m asl) in the sierra de Coalcoman Mountains, Mexico. Compared from this results, showed diverge diversity. This study emphasizes how the theory of variation in species diversity along gradient of elevation that the number of species decrease progressively with higher elevation [46, 47].

In addition, environmental variables associated with the Telaga microclimate like a light intensity and humidity were correlated to the different time of the day. Those variables play an important role in species richness, abundance and composition of species diversity of Odonata [48]. The presence riparian vegetation influenced the light intensity and humidity which contributed to the microclimatic
regulation of the Telaga. The peak of species richness and abundance of Odonata around at 12:00 am, coincide with changes in air temperature and light intensity [35, 44]. The sites at the lowest altitude and the sites with the longest rainy seasons tend to have the highest Shannon-Wiener diversity index [44]. Leksono et al. [7] suggested that to study the highest diversity of Odonata should be conducted at elevation between 400-1,200 m asl [7].

4. Conclusion
Species richness was the highest in Telaga Saat than two other sites. Species diversity of Odonata in Telaga Saat was higher than Telaga Warna, Nature Park and Telaga Biru, Mount Gede Pangrango National Park. Shannon index showed that diversity index in Telaga Saat was the highest among three locations. Agriocnemis rubescens and Coeliccia membranipes were species potential for used as species indicator for indicate good water quality in Telaga Warna, Telaga Biru from modification habitat and anthropogenic. Species diversity Odonata in Telaga Warna and Telaga Saat was more similar than Telaga Biru.

Acknowledgements
We thanks to Dicky Larisdo Sihombing, Sapta Imam Santoso, Fakih Mahendra, Citra Fatmala, Riskhey Nuradiliyanti and Tresna Puspa Herdani have been assistant research for author. Ade Yusuf was Bogor Botanic Garden’s staff who help to create the research map. BKSDA Region 1, Bogor, West Java and Mount Gede Pangrango National Park for permission to enter the conservation area. We also thank to Sri Lestari who always giving support greatly during the manuscript preparation.

References
[1] Clausnitzer V, Kalkman V J, Ram M, Collen B, Baillie J E M, Bedjanić M, Darwall W R T, Dijkstra K-D B, Dow R, Hawking J, Karube H, Malikova E, Paulson D, Schutte K, Suhling F, Villanueva R J, von Ellenrieder N and Wilson K 2009 J. Bio. Conserv. 142 8
[2] Steffen W, Grinevald J, Cruczen P and McNeill J 2011 J. Philos. Trans. 369
[3] Suhonen J, Hilli-Lukkarinen M, Korkeamäki E, Kuitunen M, Kullas J, Penttinen J and Salmela J 2010 J. Conserv. Bio. 24 4
[4] Agus M, Pujiaustuti Y and Windusari Y 2017 J. Sci and Techno Indo 2 4
[5] Prasetyo L B, Kartodihardjo H, Adiwibowo S, Okarda B and Setiawan Y 2009 J. Integra. Fiel. Sci 6
[6] Dolný A, Báta D, Lhota S, Rusdianto R and Drozd P 2011 J. Tropic. Zool. 24
[7] Leksono A S, Feriwbisono B, Arifanto T and Pratama A F 2017 J. Ento. Res. 47 4
[8] Kietzka G J, Pryke J S and Samways M J 2018 J. Bas. Appli. Eco. 33
[9] Orr A G 2006 Odonata in Bornean tropical rain forest formations: diversity, endemcic and implications for conservation management In Cordero Rivera A (Ed.) Forest and Dragonflies Fourth WDA International Symposium of Odonatology Sofia-Moscow Pensoft Publishers pp 51–78
[10] Oppel S 2005 Inter. J. Odonata 8 2
[11] Kalkman V J, Clausnitzer V, Dijkstra K-D B, Orr A G, Paulson D R and Van Tol J 2008 J. Hydro. 595 1
[12] Liefínck M A 1934 J. Tre. 14
[13] Setiyono J 2014 J. Agr. 18 2
[14] Supriatna J 2014 Toured of Nature in National Park Jakarta Yayasan Obor Indonesia pp xxviii–469
[15] Nila S, Suryobroto B and Widayati K A 2014 J. Bios. 21 1
[16] Smallshire D, Beynon T and British Dragonfly Society Conservation Group 2010 Dragonfly monitoring scheme manual British Dragonfly Society p 8
[17] Orr A G 2005 A Pocket Guide: Dragonflies of Peninsular Malaysia and Singapore Malaysia Sabah Kota Kinabalu Natural History Publication (Borneo) pp vi–127
[18] Orr A G, Butler S G, Hämäläinen M and Kemp R G 2012 Insect: Odonata In Yule C M and Hoi
S Y Freshwater Invertebrates of The Malaysian Region pp 409–442

[19] Sigit W, Feriwbisono B, Nugrahani M P, Bernadeta P I D and Makitan T 2013 Dragon fly Wendit: Diversity of Dragonfly in Wendit Aquatic Malang Java Timur Indonesia Dragonfly Society pp xii–164

[20] Orr A G and Kalkman V 2015 Field Guide to The Dragonflies of New Guinea Brachytron Nederlandse Vereniging voor Libellenstudie and Libellenverenigin Vlaanderen pp ii–155

[21] Magurran A E 2004 Measuring Biological Diversity (Blackwell Science) Oxford United Kingdom pp viii–256.

[22] Hammer Ø, Harper D A T and Ryan P D 2001 J. Paleon. Electr. 4 1

[23] Hammer Ø and Harper D A T 2006 Paleontological Data Analysis United Kingdom (Blackwell Publishing) pp xi–345

[24] Burmesiter F 1839 Handbuch der Entomologie 2 2

[25] Forster F 1904 Odonaten von Hocmalaka und Sikkim. Insektenbörse 21

[26] Drury D 1770 Illustration of Natural History

[27] Fabricius I 1798 J. Ent. Syst. Suppl.

[28] Brauer F 1868 J. Zool. Bot. Ges. 18

[29] Rambur M P 1842 Historie naturelle des Insectes. Névroptères

[30] Selys L E De 1877 Synopsis des Agrionines Légion. Agrion

[31] Sanchez-Herrera M and Ware J L 2012 Biogeography of Dragonflies and Damselflies: Highly Mobile Predators In: Global Advances in Biogeography Steven L (ed) pp 291–306

[32] Siddig A A H, Ellison A M, Ochs A, Villar-Leeman C and Lau M K 2016 J. Ecol. Indic. 60

[33] Margalef R 1972 J. Trans. Connect. Acad. Arts Sci. 44

[34] Clausnitzer V 2003 J. Bio. Conserv. 12

[35] Dolný A, Harabis F and Mizicová H 2014 J. Plos One 9

[36] Saha P D and Gaikwad S M 2015 J. Ento. Zool. Stud. 3

[37] Calvâno L B, Juen L, de Oliviera Junior J M B, Batista J D and Júnior P D M 2018 J. Insect. Conserv. 22

[38] Rehn A C 2003 J. Sys. Ento. 28

[39] Suhling F, Sahlén G, Gorb S, Kalkman V J, Dijkstra K-D B and Van Tol J 2015. Throp and Coviach’s Freshwater Invertebrates Order Odonata Fourth ed Academic Press Chapter 35 p 919

[40] Dalzochio M S, Costa J M and Uchôa M A 2011 J. Rev. Bras. Ento. 55

[41] Oliveira-Junior J M B, Shimano Y, Gardner T A, Hughhes R M, Júnior P D M and Juen L 2015 J. Austral. Ecol 40

[42] Remsburg A J and Turner M G 2009 J. Nort. Amer. Bethmol. Socie 28 1

[43] Souza A M, Fogaca F N O, Cunico A M and Higuti J 2015 Braz. J. Biol. 25 3

[44] Joshi P D, Kumar K and Arya M 2008 J. Asia-Pasific Ento. 11

[45] Novelo-Gutiérrez R and Gómez-Anaya J A 2009 J. Bio. Conserv. 18

[46] Brown J H and Lomolino M V 1998 Biogeography Second ed (Sinauer Associates Sunderland) p 463

[47] Cox C B and Moore P D 2010 Biogeography: An Ecological and Evolutionary Approach Eighth ed (John Wiley & Sons) United States of Amerika pp xiv–498

[48] De Marco P Jr, Batista J D and Cabette H S R 2015 J. PLoS ONE 10

[49] Corbet P S 1979 J. Odonato. 8