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Diversity and spatial distribution of dragonflies (Odonata) at Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

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Abstract. *Suwarno, Saidi AY, Yasmin Y, Siregar Z. 2025. Diversity and spatial distribution of dragonflies (Odonata) at Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia. Biodiversitas 26: 681-689.* Dragonflies (Odonata), a fascinating subject of study, are distributed from the tropics, subtropics to the temperate zones, and the type of habitat strongly influences their presence. This research, conducted from February to May 2021, holds substantial role as it aimed to investigate the dragonfly species in several habitats at the Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia, and analyze their diversity index values. Samples were meticulously collected in the forest, scrub, and river habitats, which collected data from February to March between 9:00 am to 3:00 pm. Three different location points for each habitat were selected with five transect lines, each 200 m long and 5 m wide. The results showed that, dragonflies mostly distributed in the river, while the fewest species were found in the forest habitat. The total in all habitats, Libellulidae dominated both the number of species (39.6%; 19 species) and the number of individuals (30.4%; 129 individuals). In the Zygoptera suborder, the majority of species were from Chorocyphidae and Coenogridae, about 12.5%, meanwhile the number of individuals was in Calopterygidae (18.63%; 79 individuals). The species of dragonflies were found generally belonging to the category of least concern, but one of them is classified as an endangered species called *Rhinocypha orea*. The Shannon-Weiner diversity index (H') value of dragonflies in the three habitats was included in the moderate category, underscoring the importance of our findings.

Keywords: Conservation, diversity, dragonflies, Leuser Ecosystem Area, Soraya Research Station

INTRODUCTION

Dragonflies (Odonata) are a group of insects with a high diversity that are one of Indonesia's most abundant and diverse biodiversity (Virgiawan et al. 2015; Lupiyaningdyah 2020). There are about 900 species of them in Indonesia with around 70% are endemic. Papua island is the most diverse of dragonflies in Indonesia, with 375 species, followed by Kalimantan 291 species, Sumatra 257 species, Java 183 species, Maluku 149 species, Sulawesi 146 species, Lesser Sunda Islands 96 species, and the least is Bali with only 58 species (Lupiyaningdyah 2020). The diversity and population of dragonflies are abundant in tropical areas such as Indonesia because there are various suitable habitats for dragonfly life (Nicolla et al. 2021). The spatial distribution of dragonflies is wide from the tropics to the subtropics, in forests, shrubs, gardens, rice fields, streams, lakes, and others. This is because most adult dragonflies and some damselflies are strong dispersers (Nagy 2019; Veras et al. 2020).

Odonata consists of two suborders based on scientific classification, namely Anisoptera (dragonflies) and Zygoptera (damselflies). A total of 5680 species of odonates has been described worldwide including 2739 species belonging to Zygoptera and the remaining 2941 species belonging to Anisoptera (Kalkman et al. 2008), furthermore according to World Odonata List there are 6429 species found in the world (Paulson et al. 2025). The morphological characteristics can distinguish between them. Anisoptera has a pair of fused compound eyes, a greater front wing size than the hind wings, and a larger body size than Zygoptera. On the other hand, Zygoptera has a separate pair of compound eyes and a relatively smaller body size (Rahadi et al. 2013; Attaullah et al. 2023).

They are beneficial insects, both as nymphs and adults, which play an essential role specifically in pest management (Ilahi et al. 2019). Adult dragonflies have a crucial meaning in agriculture as biological control agents because of their predatory nature in which they can control agricultural pest populations by pressing the growth of insect pests on food crops (Ávila-Júnior et al. 2020; Raut et al. 2023). On the nymph stage, Odonata has the function as predators in aquatic ecosystems which serve as an indicator of the good quality in water habitats because of the eco-physiological adaptations that enable them to settle in different aquatic ecosystems. At all stages of their life cycle, both when they are nymphs and as adults, dragonflies are predatory insects. They can restrict the population of pests, herbivorous insects, insect vector larvae, and their natural populations to maintain the community balance in the ecosystem (May 2019; Daso et al. 2021). Moreover, their presence in an ecosystem can be

an indicator of ecosystem balance as well as their important role for humans (Buczyński 2020).

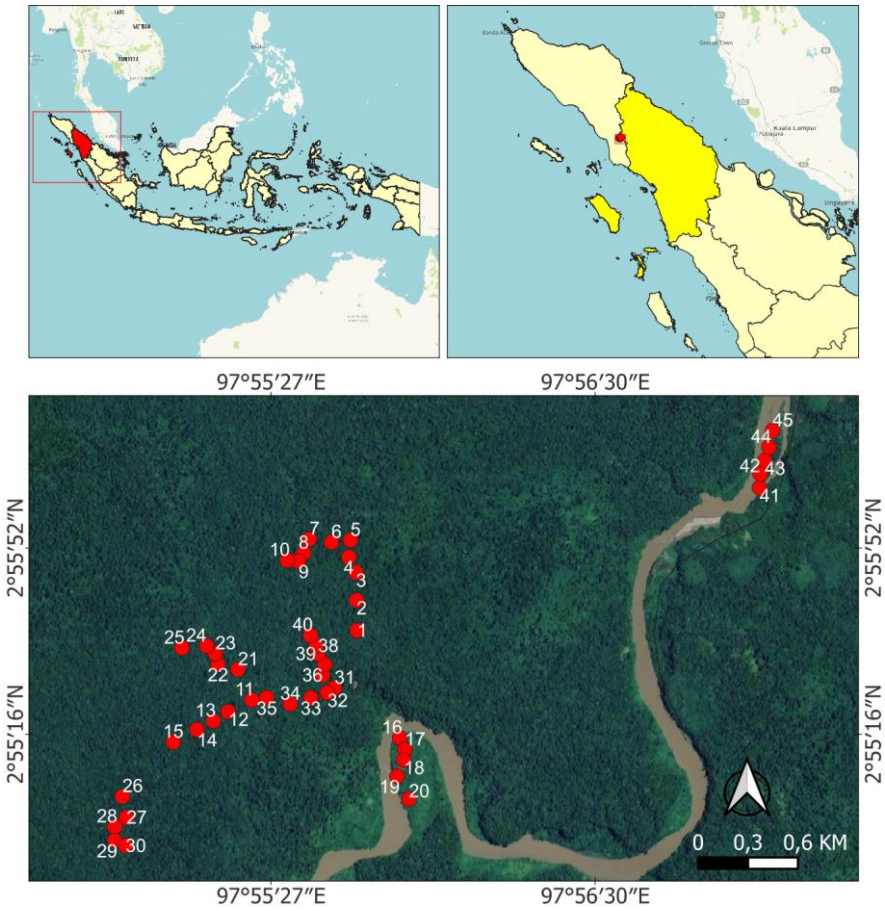
Dragonflies are a fascinating research object for several reasons. They are easy to observe in the field (Indriani and Singkam 2023), have high diversity with regular taxonomic status arrangements (Singh et al. 2017), widespread distribution (Borges et al. 2019), and an essential role in the ecosystem in maintaining the food chain balance (Riyaz 2021). One suitable location for conducting the research is in the Leuser Ecosystem Area (LEA), a tropical forest in Sumatra with a high level of biodiversity (Putra 2015).

Leuser Ecosystem Area has three Research Stations (RS), namely Ketambe, Soraya, and Suaq Balimbing. The Soraya RS has several different types of habitats like forests, scrubs, rivers, and restoration areas. Habitat plays an essential role in supporting the survival of an organism. The existence of variations in habitat types in Soraya RS causes many objects to be studied (Suwarno et al. 2019; Salma et al. 2021; Fautama et al. 2022), and also as dragonflies. Some research about the dragonflies in several locations of Indonesia has been reported, such as Nafisah and Soesilohadi (2021) in Natural Forest and Tourist Sites Petungkriyono Forest, Central Java, Susanto and Bahri (2021) in Mount Sigogor Nature Reserve Area at Ponorogo Regency, Ilhamdi et al. (2021) in the Suranadi Ecotourism Area, Lombok, and others. However, the results of searching many works of literature so far have yet to obtain reports on the dragonfly diversity in LEA.

MATERIALS DAN METHODS

Study area

This research was conducted at the Soraya Research Station, Leuser Ecosystem Area, District of Sultan Daulat, about 580.2 km southeast of Banda Aceh, the capital city of Aceh Province, Indonesia (Figure 1). The sampling of dragonflies (Odonata) was executed from February to March 2021. Further identification of specimens and data processing were carried out at the Zoology Laboratory, Department of Biology, Faculty of Mathematics and Natural Sciences, Universitas Syiah Kuala in Banda Aceh, from April to May 2021.



No.	Habitat	Sample Points	Coordinate	
1	Forest	1	2°55'36.4"N	97°55'44.1"E
2		2	2°55'42.3"N	97°55'44.0"E
3		3	2°55'47.7"N	97°55'43.9"E
4		4	2°55'50.7"N	97°55'42.5"E
5		5	2°55'54.0"N	97°55'42.8"E
6		6	2°55'53.6"N	97°55'39.1"E
7		7	2°55'54.2"N	97°55'34.8"E
8		8	2°55'51.5"N	97°55'33.7"E
9		9	2°55'49.9"N	97°55'32.7"E
10		10	2°55'50.3"N	97°55'30.5"E
11		11	2°55'22.9"N	97°55'23.6"E
12		12	2°55'20.6"N	97°55'19.0"E
13		13	2°55'18.8"N	97°55'16.3"E
14		14	2°55'17.1"N	97°55'14.1"E
15		15	2°55'14.7"N	97°55'08.3"E
16	Scrub	16	2°55'15.7"N	97°55'52.4"E
17		17	2°55'13.2"N	97°55'53.4"E
18		18	2°55'11.2"N	97°55'53.2"E
19		19	2°55'08.0"N	97°55'51.9"E
20		20	2°55'03.6"N	97°55'54.2"E
21		21	2°55'28.8"N	97°55'20.9"E
22		22	2°55'29.8"N	97°55'17.8"E
23		23	2°55'31.9"N	97°55'16.5"E
24		24	2°55'33.6"N	97°55'14.8"E
25		25	2°55'33.0"N	97°55'10.0"E
26		26	2°55'04.1"N	97°54'58.4"E
27		27	2°55'00.0"N	97°54'59.2"E
28		28	2°54'58.2"N	97°54'56.9"E
29		29	2°54'55.0"N	97°54'56.7"E
30		30	2°54'53.5"N	97°54'58.2"E
31	River	31	2°55'25.2"N	97°55'39.7"E
32		32	2°55'24.3"N	97°55'38.3"E
33		33	2°55'23.3"N	97°55'36.1"E
34		34	2°55'22.1"N	97°55'31.8"E
35		35	2°55'23.3"N	97°55'26.3"E
36		36	2°55'27.7"N	97°55'41.4"E
37		37	2°55'29.8"N	97°55'41.8"E
38		38	2°55'31.9"N	97°55'40.5"E
39		39	2°55'33.4"N	97°55'40.1"E
40		40	2°55'35.5"N	97°55'39.0"E
41		41	2°56'04.2"N	97°57'02.5"E
42		42	2°56'06.9"N	97°57'02.6"E
43		43	2°56'09.5"N	97°57'03.5"E
44		44	2°56'12.1"N	97°57'04.3"E
45		45	2°56'15.3"N	97°57'05.0"E

Figure 1. The coordinate of sampling point of dragonflies at overall habitats in Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

The collection of dragonflies

The method used in this study is the exploring method, specifically walking through the points of the sampling location to collect data on dragonflies using insect nets (2-m long sticks and 40 cm net diameter). Samples were accumulated in three habitats: forests, scrubs and rivers. Determining the sampling points for each habitat was implemented by using a purposive sampling technique. For each observation point, modified by Daso et al. (2021), a 200-meter-long transect and a 5-meter-wide line were made. Sample collection was carried out at one observation point a day by two collectors in the warm weather, and it was collected at the peak time of activity based on Borges et al. (2019) at 9:00 am to 3:00 pm. This research included 15 points per habitat, and observation was done one time per point. Forest locations are covered by a dense canopy and overgrown with trees of more than 20 cm of stem diameter. The scrubs are located in a relatively open area with plant heights below 2 meters which is a logged area undergoing succession. 10 river locations are in the middle of the forest, while the other 5 points are on the edge of the forest. Furthermore, the coordinate points for the dragonfly sampling locations has been shown in Figure 1.

Measurement of environmental factors

Assessment of environmental conditions at the Soraya research station uses three parameters: temperature, humidity, and light intensity. Oliveira-Junior et al. (2019) explained that environmental conditions such as temperature, humidity, and light can influence the distribution, richness, and composition of the Odonata. The power of the light is sufficient to perform the functions of flight by moving or pumping thoracic muscles and wings. Temperature is measured using a thermohygrometer with an average, based on Indriani and Singkam (2023), at 29-31ºC. Generally, effective temperatures, as stated in Krebs (2014), range from 15ºC for the minimum, 25ºC for the optimum, and 45ºC for the maximum temperature. Moreover, Noviyana et al. (2021) reported that 85-90% is the optimum range of humidity. The light instrument uses a lux meter for measuring purposes because dragonflies are insects that need light for their activity and have a positive response to it. This instrument is placed 1.5 m from the ground in three areas where the sunlight entered.

Specimen preservation

Dragonfly samples that have been collected are injected with Formaldehyde (HCHO), so they are not damaged and rotten before being taken to the laboratory to be used as specimens and identified. This method of preserving specimens refers to Pamela (2019) using the pinning method, where the thorax is pierced using an insect needle, which size adjusted to the size of the dragonflies on styrofoam. The two wings of the dragonfly are extended and arranged so that they are not damaged or broken. Furthermore, specimens are dried in the oven for 3 days at a temperature of 40-45ºC. Next, the dragonflies are ready to be identified.

Identification of specimen

Identification is attempted wherever possible up to the species level, but if not, only up to the genus level. The step was executed by observing the morphology of the organs as a whole, such as the head, thorax, and abdomen. Dragonfly characteristics for identification refer to Orr (2005), Subramanian (2005), Orr and Kalkman (2015), and several other kinds of literature, including the shape and color of the eyes, the shape and color of the thorax, the color of the abdomen and the shape of the venation of the wings. The parameters observed in this study consisted of the main parameters, such as the number of species and individuals, and supporting parameters in the form of measurements of physical environmental factors (temperature, humidity, and light intensity).

Data analysis

Data analysis was carried out descriptively and quantitatively. Descriptive analysis used tables and pictures on the physical environmental and morphometric factors of dragonflies, while quantitative analysis on dragonfly populations used the formulas for the Shannon-Weiner Diversity Index (H'), as follows:

$$H' = -\sum_{i=1}^{n} pi \ln pi$$

Where,
H' : Diversity index
Pi : ni/N
ni : Individuals number of species-i
N : Total number of individuals of all species
Criteria (Southwood 2000):
H'<1 : Low diversity
1<H'<3 : Medium diversity
H'>3 : High diversity

RESULTS AND DISCUSSION

Results

Composition of dragonflies

The species of dragonflies at the Soraya Research Station (RS) are very diverse. Based on the samples that have been collected, as many as 48 species of dragonflies in Soraya have been identified. This is because at the research location are many natural habitats that support the survival of dragonflies. Thoroughly they were found in the three habitat types listed in Table 1.

The observations at Soraya Research Station discovered 11 families belonging to the four families of the Anisoptera suborder, specifically Libellulidae, Gomphidae, Aeshnidae, and Corduliidae; seven families from the Zygoptera sub-order, such as Platycnemididae, Euphaeidae, Chlorocyphidae, Calopterygidae, Coenagrionidae, Protoneuridae and Isostictidae with a total of 424 individuals (Table 1). River habitat is the most appealing place to settle, as proven by the highest number of dragonflies, including 12 species from Libellulidae and 1 species from the families of Gomphidae, Platycnemididae, and Isostictidae.

Table 1. Dragonfly species in Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

Order	Family, species	Total individuals in all habitats	Habitats			Conservation status
			Forest	Scrub	River	
Anisoptera	**Libellulidae**					
	Agrionoptera insignis (Rambur, 1842)	2	-	2	-	LC
	Cratilla metallica (Brauer, 1878)	2	-	1	1	LC
	Crocothemis servilia (Drury, 1773)	3	1	2	-	LC
	Diplacodes trivialis (Rambur, 1842)	3	-	3	-	LC
	Hadrothemis sp.	2	-	1	1	LC
	Lathrecista asiatica (Fabricius, 1798)	1	1	-	-	LC
	Lyriothemis tricolor (Ris, 1916)	3	3			LC
	Neurothemis fluctuans (Fabricius, 1793)	21	-	20	1	LC
	Neurothemis ramburii (Kaup, 1866)	12	-	9	3	LC
	Neurothemis terminata (Ris, 1911)	6	1	3	2	LC
	Orthetrum chrysis (Selys, 1891)	1	1	-	-	LC
	Orthetrum pruinosum (Burmeister, 1839)	3	-	-	3	LC
	Orthetrum sabina (Drury, 1773)	8	-	5	3	LC
	Orthetrum testaceum (Burmeister, 1839)	2	-	1	1	LC
	Orthetrum villosovittatum (Brauer, 1868)	2	1	1	-	LC
	Pantala flavescens (Fabricius, 1798)	51	-	46	5	LC
	Rhodothemis nigripes (Lohmann, 1984)	1	-	-	1	LC
	Rhyothemis phyllis (Sulzer, 1776)	1	-	-	1	LC
	Trithemis aurora (Burmeister, 1839)	5	-	4	1	LC
	Gomphidae					
	Ictinogomphus decoratus (Selys, 1854)	1	-	-	1	LC
	Aeshnidae					
	Indaeschna grubaueri (Förster, 1904)	1	1	-	-	LC
	Corduliidae					
	Hemicordulia tenera (Lieftinck, 1930)	1	-	-	1	LC
	Idionyx yolanda (Selys, 1871)	1	-	-	1	LC
Zygoptera	**Platycnemididae**					
	Calicnemia sinensis (Lieftinck, 1984)	1	1	-	-	LC
	Coeliccia magrostigma (Laidlaw, 1918)	1	1	-	-	Unknown
	Copera marginipes (Rambur, 1842)	3	1	-	2	LC
	Elattoneura analis (Selys, 1860)	2	-	2	-	LC
	Euphaeidae					
	Dysphaea dimidiata (Selys, 1853)	15	-	-	15	LC
	Euphaea impar (Selys, 1859)	1	-	-	1	LC
	Euphaea variegata (Rambur, 1842)	29	-	-	29	LC
	Chlorocyphidae					
	Heliocypha fenestrata (Burmeister, 1839)	49	3	3	43	LC
	Libellago aurantiaca (Selys, 1859)	3	-	-	3	LC
	Libellago hyalina (Selys, 1859)	3	2	1	-	LC
	Libellago lineata (Burmeister, 1839)	4	-	2	2	LC
	Melanocypha snellemanni (Albarda, 1879)	1	-	-	1	DD
	Rhinocypha orea (Hämäläinen & Karube, 2001)	1	-	1	-	EN
	Calopterygidae					
	Neurobasis chinensis (Linnaeus, 1758)	5	-	-	5	LC
	Vestalis amoena (Hagen, 1853)	58	10	13	35	LC
	Vestalis gracilis (Rambur, 1842)	16	8	7	1	LC
	Coenagrionidae					
	Amphicnemis gracilis (Krüger, 1898)	2	2	-	-	LC
	Archibasis incisura (Lieftinck, 1949)	4	-	-	4	LC
	Archibasis viola (Lieftinck, 1949)	2	-	-	2	LC
	Onychargia atrocyana (Selys, 1865)	10	-	-	10	LC
	Pseudagrion pruinosum (Burmeister, 1839)	40	6	15	19	Unknown
	Teinobasis stigmatizans (Lieftinck, 1938)	9	-	9	-	DD
	Protoneuridae					
	Prodasineura interrupta (Selys, 1860)	28	1	27	-	LC
	Prodasineura notostigma (Selys, 1860)	3	3	-	-	LC
	Isostictidae					
	Cnemisticta angustilobata (Donnelly, 1993)	1	-	-	1	DD
	Species number	**48**	**18**	**23**	**31**	
	Individual total (N)	**424**	**47**	**178**	**199**	

Note: DD: Data Deficient, EN: Endangered, LC: Least Concern

The composition of the greatest number of dragonflies in the scrub habitat was obtained from the Libellulidae families, totaling 13 species, and the least from the Protoneuridae and Platycnemididae families, with 1 species (Figure 4). The largest number of dragonfly families found in forest habitats is the Libellulidae, covering 6 species. Meanwhile, the least number of dragonflies is from the Aeshnidae family, with 1 species (Figure 5).

Index diversity of dragonflies

There were five discovered dragonflies in three habitats at the Soraya research station, including *Neurothemis terminata, Heliocypha fenestrata, Vestalis amoena, V. gracilis* and *Pseudagrion pruinosum*. Diversity in all locations is included in the high category, H': 3.033, and the diversity index in each habitat type shows the medium category, H': 2.479-2.583 (Table 3).

Conservation value

All dragonfly species found in the research location, which are shown in Table 1, do not contain the protected species in Indonesia based on tracking conservation status, which refers to the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number P.106/MENLHK/SETJEN/KUM.1/12/2018. Other conservation status searches are referred to internationally on The International Union for Conservation of Nature (IUCN) Red List. According to IUCN (2024), research results in river habitats in the Soraya Research Station area found dragonflies with a threatened conservation status (EN), specifically *Rhinocypha orea*, which is at high risk of extinction in the wild. Moreover, *Melanocypha snellemanni*, *Teinobasis stigmatizans*, and *Cnemisticta angustilobata* are included in the Data Deficient (DD) category; *Coeliccia magrostigma* and *P. pruinosum* are included in unknown, and other species that belongs to families Libellulidae, Gomphidae, Aeshnidae, Corduliidae, Platycnemididae, Euphaeidae, Calopterygidae, Protoneuridae, and the majority of Coenagrionidae and Chlorocyphidae have the Least Concern (LC) conservation status (Table 1).

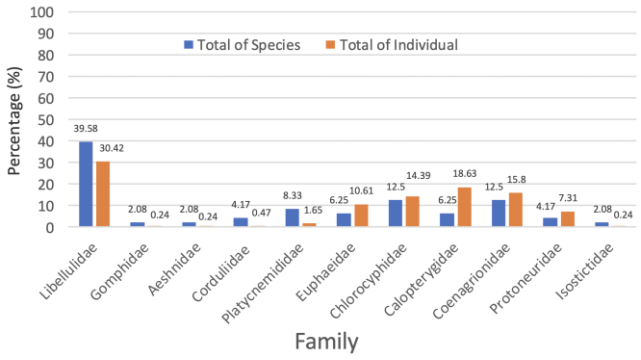


Figure 2. Composition total of species and individual dragonflies in three habitats of the Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

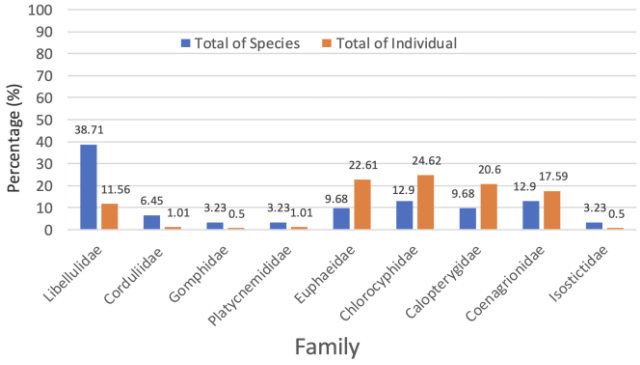


Figure 3. Composition of species and individual dragonflies at the river in the Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

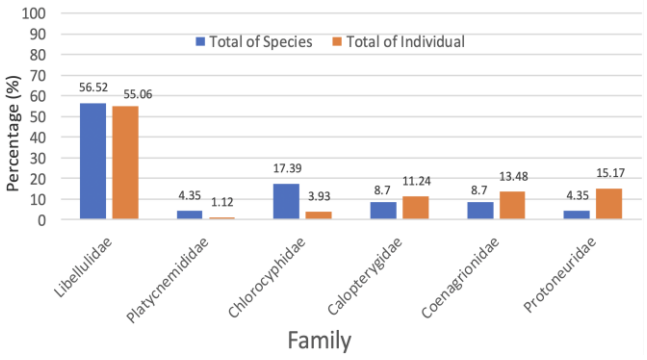


Figure 4. Composition of species and individual dragonflies at the scrub in the Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

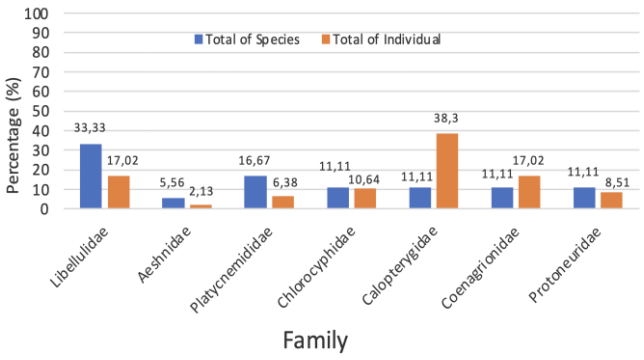


Figure 5. Composition of species and individual dragonflies at the forest in the Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

Table 2. Physical environmental factors at Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

Type of habitat	Environmental and physical factors		
	Temperature (°C)	Humidity (%)	Light intensity (10^3 lux)
River	26-41	67-98	66-130
Scrub	26-37	70-95	86-131
Forest	25-35	86-99	50-90

Table 3. Diversity index of dragonflies in Soraya Research Station, Leuser Ecosystem Area, Northern Sumatra, Indonesia

Habitat	H'
Forest	2.508
Scrub	2.479
River	2.583
Overall	3.033

Discussion

Several dragonflies were successfully observed such as *V. amoena* and *Pantala flavescens* more numerous than the others at 58 and 51 individuals, respectively. Another two species are *H. fenestrata* (49 individuals) and *P. pruinosum* (40 individuals). *Pantala flavescens* is commonly located in open areas, particularly scrubs migrating in groups with 2-5 meters flying height above the ground. According to Susanto and Bahri (2021), they have high-flying activity and are often seen perching on scrubs which are dominated by herbaceous plants with many trees.

Heliocypha fenestrata and *P. pruinosum* were seen in abundance in streams and rivers, resting on tree branches and plants around the waters. Both really prefer a damp place with a lack of light; unsurprisingly, they appeared in many river habitats. According to Sugiman et al. (2020), *H. fenestrata* is one of the damselflies (Zygoptera) that has the highest abundance among other needle dragonflies, and Rahadi et al. (2013) showed that *P. pruinosum* is commonly found around water and often perches on plants near the water. *Vestalis amoena* (Calopterygidae) mostly occupies in shadow area of the forests and can be seen appearing frequently in the morning. This dragonfly flies less aggressively and often rests on the leaves of plants in the forest, which are protected from direct sunlight. Five species of dragonflies can be found in three habitats, called *N. terminata* (Libelluidae), *H. fenestrata* (Chlorocyphidae), *V. amoena*, *V. gracilis*, (Calopterygidae) and *P. pruinosum* (Coenagrionidae), because of a high tolerance range for environmental conditions which are suitable for their life. According to previous research from Sugiman et al. (2020), the genus *Neurothemis* and several species of dragonflies, such as *P. flavescens* and *P. pruinosum*, are dragonflies that are frequently discovered in various habitats such as waters, land use, and urban areas.

The Libellulidae has the highest figure for species and individuals (Figure 2), including 19 species (39.58%) and 129 individuals (30.42%) due to the fact that this family is the largest in the Anisoptera suborder. Vatandoost (2021) defined that Libellulidae has 140 genera and 962 species. In addition, members of them are capable of living and adapting to various locations. Hence, they exist as cosmopolitan animals that live in polluted or non-polluted environments with available food sources in the form of small insects. Most individuals are from the families of Calopterygidae, Coenagrionidae, Chlorocyphidae, Euphaeidae, and Protoneuridae. Based on Orr (2005), they are widely distributed on the islands of Sumatra, Kalimantan, Java, and the Malaysian peninsula. This phenomenon occurred due to the large distribution of their populations in Soraya Research Station, and they like rivers and inundated areas with water. Dragonflies very favor water ecosystems because their life phase requires water as a place to lay eggs where nymphs live (pre-adult stage).

On the other hand, the few individuals of Soraya dragonflies are Gomphidae, Aeshnidae, Corduliidae, Platycnemididae, and Isostictidae. Two factors cause this experience: narrow living areas and the needed specific habitats. The distributed Gomphidae and Corduliidae were only found in the river, while Ashnidae were in the forest. In line with the statement from Kalkman and Orr (2013) reported that most dragonflies from the Aeshnidae family breed in water, and the Gomphidae family is discovered in river habitats same as the members of the Corduliidae in rivers and streams, specifically in the forest with a narrow distribution zone for three families. Kalkman and Orr (2013) elaborated that all dragonflies from the Isostictidae are detected in streams, whose distribution is limited to the Maluku, Australia, Papua New Guinea, and surrounding islands, while the distribution of dragonflies from the Platycnemididae family is in Australia, Papua New Guinea, and the tropics.

The highest number of species and the number of individual dragonflies were located in river habitats (31 species, 199 individuals), followed by scrub habitats (23 species, 178 individuals), and the least in forest habitats (18 species, 47 individuals) (Table 1). These facts were founding the huge figure for species and individuals in the river because the life and breeding of dragonflies are highly dependent on rivers or streams. The nymphs live and develop in water and as adults, will fly in areas where there is much food, for instance, small insects. Dragonflies from the Zygoptera suborder, which are known for their delicate, slender bodies and wings that are similar in size and shape, prefer to live in river habitats, inside the forest where sunlight enters. Meanwhile, adults from the Anisoptera suborder really like areas that are open and have strong light intensity, so this group is more generally found in scrub habitats. However, some of these species are also found in the river. The difference in distribution (the species and individual numbers) of dragonflies in each habitat is strongly influenced by environmental conditions, which are one of the important factors that greatly influence the survival of dragonflies. Soraya has a relatively stable temperature, humidity and light intensity to support dragonfly life. The temperature, humidity, and light intensity in this area are still within the tolerance range that can support dragonfly life (Table 2).

The average value of environmental conditions in the three habitats does not seem much different. According to Indriani and Singkam (2023), the temperature, humidity, and light intensity at Soraya Research Station are still within the tolerance range for dragonflies to live, at 29-31ºC. The highest temperature is in the river habitat, followed by scrub and forest, with the highest humidity in the forest habitat. The high temperature is due to the intensity of sunlight entering the research location. As a result, the humidity is quite low.

Furthermore, Figure 3 shows that the individual of families Chlorocyphidae, Euphaeidae, and Coenagrionidae and most Calopterygidae from Zygoptera are more frequent in river habitats than Anisoptera, specifically from the families Libellulidae, Corduliidae, and Gomphidae. Some of them cannot be found in other habitats except in rivers (Table 1). It is in line with the findings of Koneri et al. (2022) that the greatest abundance of Zygoptera is frequently found in waterfalls and forests with moderate light intensity or under tree shades in undisturbed environmental conditions.

The intensity of light in the river in the Soraya area is 66-130 (10^3 lux). Rahadi et al. (2013) showed that the habitat of the needle dragonfly is among the thickets of aquatic plants near the waters with fairly low light intensity. Although the highest figure for species is in the Libellulidae, the highest number of individuals is from the Chlorocyphidae (Zygoptera). Hamalainen and Karube (2001) explained that this group tends to breed in flowing water, such as forest grooves and shady rivers. *Euphaea variegata* (Euphaeidae) and *Neurobasis chinensis* (Calopterygidae) were seen alighted on plants and rocks near the river, and *Libellago aurantiaca* (Chlorocyphidae) was seen flying near the river. The activity of Zygoptera and Anisoptera dragonflies is around puddles and grooves to lay their eggs, which can be found alighting on tree branches around water. In addition, the plants in the river, like *Pandanus* sp. and several species of Poaceae, lived there. The environmental temperature in river sites ranges from 26-41ºC which is the ideal condition that can support dragonfly life. Corbet (1999) explained that dragonflies exist in open places not far from aquatic environments with sufficient light intensity and warm temperatures around 25-33ºC. River humidity in Soraya is 67-98%, and it is in a tolerance range for species, in the minimum range of humidity based on Noviyana et al. (2021), about 70%. According to Hasanah et al. (2021), the presence of families Chlorocyphidae, Calopterygidae, and Platycnemididae illustrates ecosystems of clean water quality.

Figure 4 illustrates the highest figure for species and individuals of Libellulidae from the suborder Anisoptera. They are abundant in scrubs because it has open areas and a wide distribution, causing the abundance of this species which was discovered in every type of habitat in Soraya. This is consistent with the finding of Koneri et al. (2022), stating that Libellulidae is the largest family in the suborder Anisoptera, which was discovered in nearly all habitats because of its high adaptability and distribution pattern. Furthermore, the scrub site has a temperature of 26-37ºC, in which the vegetation is not excessive - the opening areas with more light intensity entering. This ecosystem is filled with plants such as ferns (*Dicranopteris linearis*), *Mimosa* sp., *Melastoma malabatricum*, *Eupathorium odoratum*, *Lantana camara*, *Urena lobata*, and saplings of plenty of species like *Dillenia indica*, *Shorea* sp., *Macaranga* sp., *Litsea* sp. and others with sloping topography. The data from Agustin et al. (2023) revealed that the favorable condition for them is in the open canopy with the presence of trees and scrubs: *Mimosa* sp., *Impatiens* sp., *Chromolaena* sp., and ferns, where sunlight could enter. The light intensity on shrubs in Soraya ranges from 86-131 (10^3) lux - a favorable circumstance as Kalkman and Orr (2013) stated that Anisoptera dragonflies frequently appear in open areas: grass fields, roadsides, and forests to catch insects for food. Susanto and Zulaikha (2021) reported that the presence of dragonflies is dependent on the composition and the structure of vegetation in a habitat and physical environmental factors, one of which is humidity. Humidity in scrub habitats is 70-95% and the species of *Prodasineura interrupta* was seen much perching on ferns in scrub habitats and frequently appears during the late afternoon. Moreover, humidity in this type of habitat is 70-95%, in which the range is still suitable for insect life.

Figure 5 depicts that in the forest habitat, the greatest figure for individuals from the Calopterygidae family (38.30%; 18 individuals) and the least of the family Aeshnidae (2.13%; 1 individual). The results of research conducted by Nafisah and Soesilohadi (2021) found that dragonflies from the family Calopterygidae have a great number of species, while Susanto and Arianti (2021) discovered that the family of Calopterygidae was the second-fewest number with 4 individuals. The variations in numbers and results are contradictory, presumably due to the different composition of the habitat constituents of each location. This contradiction prompts us to consider the potential impact of habitat composition on species diversity, a thought-provoking area for further research. Furthermore, the individual numbers for each species of dragonfly found in the forest habitat in Soraya were relatively the same, except for *V. amoena* (10 individuals) and *V. gracilis* (8 individuals) from the Calopterygidae family. Corbet (1999) stated that those dragonflies commonly perch around egg-laying sites and fly actively in the morning. In fact, this species is also found in locations with low temperatures. In addition, appropriate physical environmental factors also greatly affect the survival of dragonflies.

The temperature in the forest is relatively stable for dragonfly life, around 25-35ºC. Generally, effective temperatures, according to Krebs (2014), range from 15ºC for the minimum, 25ºC for the optimum, and 45ºC for the maximum temperature. Humidity in the forest ranges from 86-99%; each study location has different humidity levels depending on the vegetation that is composed and the amount of light that enters it. The intensity of light in the forest at Soraya ranges from 44-90 (10^3 lux). Dragonflies are keen on open areas, which can be seen in forest habitats where there are several canopy gaps. As stated by Agustin et al. (2023), the openness of a place could generate a high

intensity of incoming light for dragonfly activities. The forest habitat is filled with plants of various species: *Mallotus phillipensis*, *D. indica*, *Artocarpus* sp., *Shorea* sp., *Macaranga* sp., *Litsea* sp., and others. The forest floor is generally covered with dry leaf litter and puddles at several points in the forest, with the topography in the form of hills with varying slopes, and some are steep, playing a crucial role in providing suitable breeding and feeding grounds for dragonflies.

Some of the behaviors that were observed during the research were the activity of dragonflies laying eggs in rivers and streams in the forest, resting by alighting on branches, plants around the waters, tree trunks in the forest, and rocks around the river. According to Agustin et al. (2023), a suitable habitat for many dragonflies is the opened canopy, where they hunt for food and perch on the riverbank, which is dominated by scrubs, trees, and herbaceous plants, including bamboo grass. Watson and O'Farrell (1996) also reported that dragonflies that always perch are Zygoptera dragonflies and some Anisoptera from the families Libellulidae, Gomphidae, and Petaluridae as well as dragonflies belonging to excellent flyers with a vertical position when resting, specifically from the families Aeshnidae, Corduliidae and several of the Libellulidae. The position of the Zygoptera wings, when resting, looks closed upwards, while the Anisoptera dragonfly with an open wing position. Observations in the scrub habitat type showed *P. flavescens* flying in the air in groups.

The diversity in overall Soraya sites includes the high level (Table 2), which relates to Southwood (2000) described that the value of H' was divided into three categories: low (H'<1), medium (1<H'<3), and high (H'>3). The higher its H' value, the higher the diversity of organisms in a habitat. The high or low value of the diversity index is not only determined by a large number of species but also specified by the influence of the individual number of each species. Although the number of dragonfly species in the river habitat is more than in the forest habitat, the diversity index values are in the same category. This is due to the variation in the number of individuals in each species. According to Southwood (2000), ecologically moderate diversity of organisms illustrates that an ecosystem has fairly balanced conditions and productivity, and low ecological pressure. *Vestalis amoena* and *V. gracilis* are most often caught and appear in the morning in several habitat types with a medium light intensity. The high or low similarity of species is due to the different conditions of the habitat, which has open land so that sunlight enters optimally, allowing dragonflies to do more activities. This causes the similarity of the two region types to have a greater value.

The research also considered the conservation value of many dragonflies. Surprisingly, one of them is *R. orea*, with endangered status. The value of conservation for *R. orea* is just a few due to housing construction, logging, human disturbance, and the presence of recreational activities. Hamalainen and Karube (2001) discovered this species as the newest to be found in Vietnam. Furthermore, three different species, *M. snellemanni*, *T. stigmatizans*, and *C. angustilobata*, are classified in DD status, which means that there is insufficient species information to make data on the risk of extinction from the pattern of population distribution. The other researched dragonfly is in the LC category, which means the risk of extinction is low. Their status has been evaluated this is aimed at species that are not categorized as threatened.

The conclusion from the study results was that the Libellulidae family was found in the three types of habitats with the highest number of species and number of individuals. On the other hand, the families with the fewest number of species were the Gomphidae, Aeshnidae, and Isostictidae families. Furthermore, dragonflies belonging to the Anisoptera sub-order are found mostly in forests and scrubs, while the Zygoptera sub-order is in rivers. The conservation status of most dragonflies is included in the Least Concern (LC) category, three species of dragonflies, including Data Deficient (DD), and one species of endangered dragonfly (EN). The diversity index values of dragonfly species in the three habitats are in the same category.

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