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Community Structure of Libellulidae (Insecta: Odonata) Across Four Habitat Types in Jambi Province, Indonesia

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Abstract. This study aims to analyze the community structure of Libellulid dragonflies at four habitats, i.e., settlement, forest, oil palm, and rubber plantations located in Jambi Province, Indonesia. A survey was conducted from August 2017 to February 2018 in the settlement area and at 12 plot pairs of 50×50 m in the other three habitats, using a visual survey method with a photographic approach. Community structure was analyzed using Shannon–Wiener diversity index (H′), Simpson dominance index (D), evenness index (E), and Sorensen similarity index (S). The survey recorded 36 Libellulidae species across 24 genera, with the most records at the rubber plantation (23 species) and the fewest at the settlement (11 species). The highest diversity was observed at the rubber plantation (H'=2.853), followed by the oil-palm plantation (H'=2.536), the forest (H'=2.377), and the settlement (H'=1.988). The settlement was observed to have the highest disturbances (D=0.202), while the rubber plantation was presumably the stable one (D=0.070). The Libellulid individuals were most evenly distributed at the rubber plantation (E=0.910) and the forest (E=0.901). Oil palm and rubber plantations had the most similar Libellulid community (S=0.711), whereas forest and rubber plantations had the least similar community (S=0.270). In this study, settlement had no typical species. This study suggests that differences in vegetation complexity and disturbance levels may influence the community structure of Libellulidae.

Key words: diversity index; forest; oil-palm plantation; rubber plantation; settlement

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INTRODUCTION

Dragonflies and damselflies are vernacular names for Odonata species. This group of insects is known for its attractive body morphology, diverse body colors, and agile flight, and it also acts as a predator of various other insects in both adult and nymphal stages (Lorenzo-Carballa & Koroiva, 2024). The ecological roles of dragonflies are not limited to predation but also include serving as environmental bioindicators, because community structure and the presence of certain species are greatly influenced by the conditions of the aquatic habitat where their life cycle takes place (Ali et al., 2025).

Most Odonata have an amphibious life cycle, in which the nymphal phase develops in aquatic habitats, while adults use the terrestrial habitats surrounding water bodies for feeding, breeding, and dispersal. Therefore, dragonflies can be found in a variety of habitat types, from natural water bodies to landscapes altered by human activity, as long as there are water sources that support nymphal development and suitable microhabitat conditions for their survival (Vilenica & Mihaljević, 2022). The presence of riparian vegetation and vegetation structure around aquatic bodies plays a crucial role in providing perching sites, food sources, and reproductive sites for adult dragonflies. Microhabitat variations resulting from differences in vegetation cover and microclimatic conditions have been shown to influence the distribution and abundance of Odonata in a water body (Susanto & Zulaikha, 2021).

Although habitat requirements vary among dragonfly species, the presence of a species in a given location is largely determined by physiological and morphological limitations during the nymphal phase. Environmental factors influencing dragonfly community structure include the quality and quantity of aquatic habitat, vegetation structure around the water body, hydrological characteristics, and sunlight intensity (Thomas et al., 2016). Several studies in Indonesian freshwater systems have shown that physicochemical parameters such as water temperature, pH, and turbidity correlate with the diversity and abundance of Odonata; thus, changes in aquatic environmental conditions can directly impact community structure (Khoiriyah et al., 2023; Zunnikah et al., 2025). Adult dragonflies utilize visual cues from their environment to assess habitat suitability, so changes or disturbances to habitat can directly impact the composition of dragonfly communities, both in the larval and adult phases (Luke et al., 2017).

Libellulidae is a family in the suborder Anisoptera, which includes the dragonfly group, and is one of the largest families, with approximately 1035 species across 144 genera distributed worldwide. This family shows high morphological diversity and adaptability across various aquatic habitats and is classified as cosmopolitan, with many species commonly found in natural and degraded habitats (Walia & Singh, 2022). Some Libellulidae species are generalists and can survive in habitats modified by humans, such as irrigation canals, artificial ponds, and urban riparian areas (Khoiriyah et al., 2023). Thus, Libellulidae, like other Odonata, are excellent indicators of environmental conditions.

Dragonfly research within Jambi Province is still limited to species inventory (Rembold & Schroter, 2017; Yudiawati & Oktavia, 2020; Primanda, 2025). The province has been experiencing rapid changes due to development activities that impact environmental conditions and the living organisms within it. This includes the reduction in forest area and the conversion of land to anthropogenic uses, such as plantations, housing, and other uses (Mubin, 2025; BPS Jambi, 2026). Monitoring environmental conditions using natural parameters, such as bioindicators derived from living organisms, is essential. Although various studies have reported the diversity of Odonata in specific habitats, studies that specifically compare the community structure of Libellulidae across four main habitat types in the Jambi landscape, forests, rubber plantations, oil palm plantations, and settlements remain very limited. This gap hinders the understanding of the response of the family Libellulidae to gradients of habitat modification. This study aims to examine the community structure of Libellulidae across several common habitat types in Jambi Province, with the expectation that this work will serve as an initial step toward using Odonata as bioindicators of environmental conditions.

METHODS

Location and Research Design

The study was conducted in four habitat types: residential areas, forests, rubber plantations, and oil palm plantations. Observations were conducted in 12 pairs of observation plots (wet and dry), each measuring 50 x 50 m. All plot pairs were evenly divided among three main habitat types, with 4 pairs of plots each in forest, rubber plantation, and oil palm plantation habitats (Figure 1). Meanwhile, surveys in residential habitats (not shown in Figure 1) were conducted over approximately 1,000 m of the residential area of Bungku Village, Bajubang District, Batang Hari Regency, Jambi. Each pair of plots or research area was visited for two consecutive days between August 2017 and February 2018. Observations were conducted during the day, between 08.00–15.00 WIB, when dragonfly activity was relatively high.

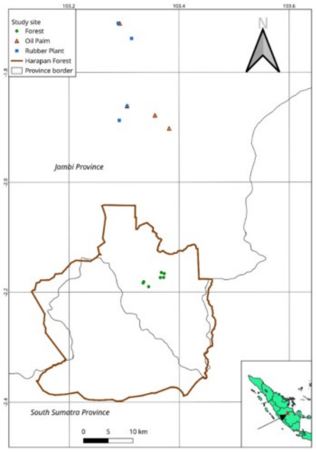

Figure 1. Map of Research Locations in Jambi Province, Indonesia

Observations were carried out at several locations representing four types of research habitats, namely forests, rubber plantations, oil palm plantations, and settlements in Jambi Province, as detailed in Table 1 below.

Table 1. GPS Coordinates of Each Plot Pair and Research Area

Habitat	Latitude	Longitude	Elevation (m)
Forest 1	2°09′52.06″ LS	103°22′03.27″ BT	34.86
Forest 2	2°10′24.62″ LS	103°21′56.29″ BT	24.37
Forest 3	2°10′52.01″ LS	103°20′07.70″ BT	25.68
Forest 4	2°11′24.22″ LS	103°20′39.70″ BT	34.41
Rubber 1	1°44′18.27″ LS	103°18′50.06″ BT	57.88
Rubber 2	1°53′14.67″ LS	103°17′29.39″ BT	29.39
Rubber 3	1°51′42.47″ LS	103°18′20.55″ BT	37.03
Rubber 4	1°42′37.48″ LS	103°17′21.88″ BT	68.09
Oil-palm 1	1°54′07.95″ LS	103°22′54.69″ BT	59.98
Oil-palm 2	1°52′40.92″ LS	103°21′22.27″ BT	61.87
Oil-palm 3	1°51′40.25″ LS	103°18′19.84″ BT	58.12
Oil-palm 4	1°42′38.95″ LS	103°17′32.63″ BT	55.58
Settlement	1°52′08.81″ LS - 1°52'08.8" LS	103°15′20.05″ BT -103°15'20.1" BT	56.56

Odonata Survey and Species Identification

Observations of Libellulid dragonflies were conducted using a photographic approach (Janra, 2018), given the lack of permits for collecting physical specimens during the study, in addition to considerations for maintaining dragonfly populations in the survey area. Observers walked through the observation plot area, then documented each species encountered.

Each observed dragonfly was documented using a Nikon Coolpix P900 camera in macro mode (Normal Close-up Single Shot) and high image quality (4608 × 3456-pixel resolution), with a shooting distance of 0.5–10 m from the observed object. Individual counts were conducted directly in the field and verified using a sequence of individual photos stored in the camera's memory, assuming that two separate photos of the same species represent two different individuals. Most Libellulidae are territorial (Silsby, 2001) so that, within a certain distance, two individuals photographed can be considered distinct. Species identification was carried out based on relevant dragonfly identification guidelines (Dan & Dolný, 2013; Rembold &

Schroter, 2017; Setiyono et al., 2017) and was supported by online sources on Southeast Asian dragonflies.

Data Analysis

The structure of the dragonfly community was analyzed using several ecological indices. The species diversity index was calculated using the Shannon‑Wiener index (H′), while the dominance index used the Simpson index (D) formula. The formulas used are as follows:

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

$$pi = \mathrm{ni/N}$$

$$\mathrm{D} = \sum(\mathrm{ni/N})^2$$

Where H′ represents the diversity index, n_i represents the number of individuals of the i-th species, N represents the total number of individuals recorded, and D is the dominance index (Magurran, 2021).

The Sorensen Similarity Index (SSI) is calculated by comparing the number of similar species recorded at two observation locations with the total number of species found at both locations (Kucuk et al., 2017). The Sorensen similarity index is calculated using the following formula:

$$SSI = \frac{2C}{A + B}$$

A is the number of species recorded in habitat A, B is the number of species recorded in habitat B, and C is the number of species found in both habitats.

The evenness index (E) is calculated by dividing the Shannon‑Wiener diversity index (H′) by the maximum diversity value based on the number of species (S) (Yelastri et al., 2023). The similarity index is calculated using the following formula:

$$E = \frac{H'}{\ln(S)}$$

Where S is the number of species recorded in a given area. An ecosystem or community is considered uneven, or has a low level of similarity, if the E value is <0.20; if the E value is >0.21, it is categorized as having a high level of similarity.

RESULTS AND DISCUSSION

Species Diversity of Libellulidae (Odonata)

Based on observations, some species of Libellulidae dragonflies were recorded from four habitat types. Data on the number of individuals of each species in each habitat is presented in the following table.

Table 2. The diversity of Libellulidae (Odonata) at Four Habitat Types in Jambi Province

No.	Species	Vernacular Name	Habitat			
			Settlement	Forest	Oil-palm	Rubber
1	*Aethriamanta brevipennis* (Rambur, 1842)	Scarlet Adjutant	-	2	-	-
2	*Brachydiplax chalybea (*Brauer, 1868)	Blue Dasher	1	-	8	1
3	*Brachydiplax farinosa* (Kruger, 1902)	Black-tailed Dasher	-	1		-
4	*Brachygonia oculata* (Brauer, 1878)	-	-	8	-	-
5	*Brachythemis contaminata* (Fabricius, 1793)	Ditch Jewel	-	-	-	2
6	*Cratilla lineata* (Brauer, 1878)	Emerald-banded Skimmer	-	-	5	9

No.	Species	Vernacular Name	Habitat			
			Settlement	Forest	Oil-palm	Rubber
7	*Cratilla metallica* (Brauer 1878)	Dark-tipped Forest Skimmer	1	1	1	6
8	*Diplacodes nebulosa* (Fabricius, 1793)	Charcoal-winged Percher	-	-	-	2
9	*Lathrecista asiatica* (Fabricius, 1798)	Scarlet Grenadier	-	-	21	6
10	*Lyriothemis biappendiculata* (Selys, 1878)	-	-	8	-	-
11	*Lyriothemis cleis* Brauer, 1868	Bombardier	-	1	-	-
12	*Nannophya pygmaea* Rambur, 1842	Scarlet Dwarf	-	-	4	-
13	*Nesoxenia lineata* (Selys, 1868)	Striped Grenadier	-	1	-	-
14	*Neurothemis fluctuans* (Fabricius, 1793)	Common Parasol	-	-	18	3
15	*Neurothemis ramburii* (Kaup in Brauer, 1866)	Ramburii Red-parasol	2	3	33	11
16	*Neurothemis terminata* (Ris, 1911)	Straight-edged Red-parasol	1	-	10	-
17	*Orchithemis pruinans* (Selys, 1878)	Blue Sentinel	-	-	-	5
18	*Orchithemis pulcherrima* (Brauer, 1878)	Variable Sentinel	-	5	1	4
19	*Orthetrum chrysis* (Selys, 1891)	Spine-tufted Skimmer	3	6	4	-
20	*Orthetrum glaucum* (Brauer, 1865)	Common Blue-skimmer	-	-	-	2
21	*Orthetrum sabina* (Drury, 1770)	Variegated Green-Skimmer	3	-	2	1
22	*Orthetrum testaceum* (Burmeister, 1839)	Scarlet Skimmer	-	1	7	3
23	*Pantala flavescens* (Fabricius, 1798)	Wandering Glider	-	-	1	1
24	*Potamarcha congener* (Rambur, 1842)	Yellow-tailed Ashy Skimmer	1	-	1	1
25	*Rhodothemis rufa* (Rambur, 1842)	Spine-legged Redbolt	1	-	4	3
26	*Rhyothemis obsolescens* Kirby, 1889	Bronze Flutterer	-	-	-	1
27	*Rhyothemis phyllis* (Sulzer, 1776)	Yellow-striped Flutterer	-	-	1	5
28	*Rhyothemis triangularis* Kirby, 1889	Sapphire Flutterer	1	5	3	-
29	*Risiophlebia dohrni* (Kruger, 1902)	Potbellied Elf	-	4	-	-
30	*Tetrathemis irregularis* Brauer, 1868	Rainforest Elf	-	-	2	9
31	*Tholymis tillarga* (Fabricius, 1798)	Old World Twister	-	-	5	1
32	*Tramea transmarina* (Brauer, 1867)	Red Glider Dragonfly	-	-	-	1
33	*Trithemis aurora* (Burmeister, 1839)	Crimson Marsh Glider	3	2	-	2
34	*Trithemis festiva* (Rambur, 1842)	Black Stream-glider	-	-	1	-
35	*Tyriobapta torrida* (Kirby, 1889)	Treehugger	11	-	3	5
36	*Zyxomma petiolatum* (Rambur, 1842)	Long-tailed Duskdarter	-	-	3	-
	Total of Individuals		28	48	138	84
	Total of Species		11	14	22	23

The diversity of Libellulidae species varies clearly among habitat types. Based on the results obtained (Table 2), rubber plantation habitats recorded the highest species diversity, with 23 species, followed by oil palm plantations with 22 species, forests with 14 species, and settlements with the lowest, at 11 species. These results differ from previous studies that showed that Libellulidae diversity tends to be higher in natural forest habitats, particularly in lowland tropical rainforests with optimal humidity and temperature conditions (Laltanpuii et al., 2017). Other studies have found more Libellulidae species in anthropogenic areas (Pandey & Mohapatra, 2017; Shukla, 2025). Habitats with relatively complex vegetation structures have more sunlight penetration, more stable water bodies, and, in turn, support the presence of more Libellulidae species. This is because these habitats provide a variety of microhabitats for flight, roosting, and reproduction (Clausnitzer et al., 2012; Hardersen, 2000). The low abundance of species in residential areas is likely linked to high anthropogenic pressure, habitat fragmentation, and a general tendency toward greater degradation of water and habitat quality (Goertzen & Suhling, 2019).

Figure 2. Representatives of common Libellulidae species in all habitat types: A. *Neurothemis ramburii*, B. *Orthetrum sabina*, C. *Cratilla metallica*

Overall, this study recorded 292 individuals across 36 species from 24 genera within Libellulidae. Some species were found consistently in more than one habitat, such as *Neurothemis ramburii*, *Orthetrum sabina*, and *Cratilla metallica* (Figure 2), which are known as generalists with high ecological tolerance to environmental changes (Rohman & Faradisa, 2020). Conversely, there were species found only in a single habitat type (Figure 3). The species *Aethriamanta brevipennis*, *Brachydiplax farinosa*, *Brachygonia oculata*, *Lyriothemis biappendiculata*, *L. cleis*, *Nesoxenia lineata*, and *Risiophlebia dohrni* were only found in forests; *Nannophya pygmaea*, *Trithemis festiva*, and *Zyxomma petiolatum* were only observed in oil palm plantation habitats. Meanwhile, *Brachythemis contaminata*, *Diplacodes nebulosa*, *Orchithemis pruinans*, *Orthetrum glaucum*, *Rhyothemis obsolescens*, and *Tramea transmarina* are restricted to rubber plantation habitats. The presence of these specialist species is thought to reflect differences in microhabitat conditions, particularly canopy cover, humidity, sunlight intensity, and water quality, which play a key role in determining the distribution of Odonata in general (Goertzen & Suhling, 2019). Interestingly, residential areas lack any distinctive species.

Figure 3. Distinctive species of Libellulidae in each habitat. Forest: A. *Brachygonia oculata*,

B. *Nesoxenia lineata*, C. *Risiophlebia dohrni*; Oil-palm Pltantaion: D. *Nannophya pygmaea*, E. *Trithemis festiva*, F. *Zyxomma petiolatum*; Rubber Plantation: G. *Diplacodes nebulosa*, H. *Orchithemis pruinans*, I. *Rhyothemis obsolescens*

Ecological Indices

Based on the observations, ecological index values were obtained for the Libellulidae community in the four habitats, consisting of diversity (H'), dominance (D), and similarity (E) indices, as can be seen in Table 3 below.

Table 3. Ecological Indices of Libellulidae (Odonata) at four habitat types in Jambi Province

Ecological Index	Settlement	Forest	Oil-palm Plantation	Rubber Plantation
H'	1.988	2.377	2.536	2.853
D	0.202	0.109	0.116	0.070
E	0.829	0.901	0.820	0.910

The highest diversity was found in rubber habitats (H' = 2.853), followed by oil palm plantations (H' = 2.536), forests (H' = 2.377), and the lowest in settlements (H' = 1.988). Previous research found the same, with the highest diversity index observed in natural habitats, where Libellulidae diversity was recorded under optimal conditions (Laltanpuii et al., 2017). Furthermore, research by Oliveira-Junior et al. (2019) found the highest diversity in habitats with good water quality, which can support Libellulidae species diversity, such as forests, secondary forests, and old plantations. A higher H' value indicates a combination of a large number of species and a relatively even distribution of individuals within a habitat (Kumar et al., 2022). In this study, rubber and oil palm plantations provided a mosaic of open and semi-enclosed habitats that enabled the coexistence of various Libellulidae species, thereby increasing diversity (Fahrig et al., 2011). Conversely, the low H' values in settlements reflect the possible dominance of several tolerant species that are better able to adapt to disturbed environments (Goertzen & Suhling, 2019).

The highest dominance values were observed in residential habitats (D = 0.202) and the lowest in rubber habitats (D = 0.070). This is consistent with previous research that found that habitats with high anthropogenic pressure, such as degraded habitats (Suhling et al., 2015), habitats affected by livestock and mining activities (Dutra & De Marco, 2015), and tourist areas (Artika et al., 2024), have high dominance indices. High dominance values indicate that the community is dominated by one or a few species, with much greater abundance than other species (Krebs & Kenney, 2009). This condition is common in habitats with high environmental pressure, where only certain species can survive and thrive, while those unable to do so will disappear or migrate to more suitable habitats. Low dominance in rubber habitats indicates a more balanced community structure and is not dominated by a particular species, which is generally associated with better ecosystem stability (Donohue et al., 2016).

The highest evenness values were found in rubber habitats (E = 0.910) and forests (E = 0.901), while the lowest values were found in oil palm plantations (E = 0.820). Previous research found lower Odonata evenness between anthropogenic and agricultural areas in Nigeria (Bakare et al., 2024). Evenness values between habitats approaching 1 indicate a relatively even distribution of individuals between species (Krebs & Kenney, 2009). The high evenness in rubber and forest habitats indicates that, despite the presence of many species, no single species dominates the community. Meanwhile, lower E values in oil palm plantations indicate the presence of several species with higher individual abundance, possibly influenced by the homogeneity of plantation habitat structure and land management intensity (Simaika & Samways, 2011).

Similarity of Libellulidae (Odonata) Communities

Based on field observation data, the community similarity index for Libellulidae dragonflies across the study habitat types was calculated. The data are presented in Table 4 below.

Table 4. Habitat Similarity Index of (Odonata) in Jambi Province

Habitat	Settlement	Forest	Oil-palm Plantation	Rubber Plantation
Settlement	-			-
Forest	0.400	-		-
Oil-palm Plantation	0.606	0.333	-	-
Rubber Plantation	0.471	0.270	0.711	-

Based on the table above, the Libellulidae community in oil-palm and rubber plantations has the highest similarity value (S = 0.711). This high value indicates a high number of similar species in both habitats, which can be explained by the similarity of their open vegetation structures with high light intensity, as well as by the presence of artificial water bodies or drainage ditches that serve as habitats for Odonata larvae (Donohue et al., 2016). Several previous studies have found a high level of species similarity in habitats with similar characteristics or formation histories (Harabiš & Dolný, 2012; Laltanpuii et al., 2017). Furthermore, in the study area, oil palm plantations are often located adjacent to rubber plantations because many local residents deliberately plant both crops together (pers. obs.). The proximity of the two habitats is also a possible cause of their greater similarity. In contrast, low levels of similarity were observed between forest and rubber plantations (S = 0.270), as well as between forest and oil palm plantations (S = 0.333), reflecting significant differences in environmental conditions, particularly in terms of canopy cover and disturbance levels, thus affecting the presence of Libellulidae species. Forest habitats tend to support species that are more sensitive to environmental changes, resulting in a different species composition compared to plantation habitats (Ali et al., 2025).

CONCLUSION

This study recorded 36 species and 24 genera of dragonflies in the family Libellulidae. The community structure of Libellulidae dragonflies (Odonata) showed clear variation among habitat types, with the highest diversity and uniformity in rubber plantations and the highest dominance in residential habitats. The most similar habitats were between oil palm and rubber plantations. These differences reflect the influence of habitat complexity and the level of environmental disturbance. Furthermore, each habitat has unique species found only there, except in residential areas. These findings confirm the potential of Libellulidae as indicator taxa in landscapes undergoing land-use modification. Further research is recommended to integrate water quality parameters to strengthen the role of Libellulidae as environmental bioindicators.

DECLARATIONS

Conflict of Interest

The authors declare that they have no known conflicts of interest that could have influenced the work reported in this manuscript.

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