Community Structure of Dragonflies (Odonata) at Garahan Resort, Sempolan, Perhutani, Forest Management Unit (KPH) Jember

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Abstract. A community is a conglomeration of diverse groups coexisting within a shared geographical location and temporal framework. Different approaches can be used to explain community structure, focusing on species diversity, species interactions, and functional organization. The biodiversity of dragonflies in Indonesia is significantly abundant. Dragonflies play multiple ecological roles and inhabit diverse habitats, as evidenced by recent research conducted in January 2023. This study aimed to investigate the composition and organization of the dragonfly community. The research design employed in this study is exploratory and descriptive. The identification of station sites through the purposive sampling method. The sampling locations consisted of a pine forest and the Garahan jungle. The road sampling approach utilizes the sweeping technique. The investigation yielded a total of thirteen distinct species of dragonflies. The study reveals the presence of two endemic species, *Paragomphus reinwardtii* and *Heliocypha fenestrata*, with a diversity index value (H') of 1.653, falling into the medium group. The dominance index (D) exhibits a value of 0.263, indicating its classification within the low group. The evenness index (E) value at 0.401 falls into the medium group. A species similarity index (SI) of 75% is categorized as high. Canonical Corresponding Analysis (CCA) reveals a positive correlation between the species *Ortherum Sabina, Orthetrum glaucum, Vestalis luctuosa, Diplacodes trivialis, Euphaea variegata, Coeliccia membranipes, Gynacantha subinterrupta, Paragomphus reinwardtii, and Zygonix ida* with light intensity, air humidity, and wind speed.

1 Introduction

A community can be defined as a conglomeration of diverse populations coexisting within a shared spatial and temporal context [1]. The characterization of community structure can be accomplished using three distinct approaches: species diversity, species interactions, and functional organization [2]. Dragonfly populations show a high level of diversity [3]. According to [4], the global population of dragonflies is estimated to consist of approximately

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6,850 species. Indonesia is home to over 900 distinct species of dragonflies [5]. During their presence on Java Island, approximately 150 dragonfly species have been documented, with 26 of these species being classified as endemic to the region [6]. Many species of dragonflies that are indigenous to Java include *Paragomphus reindwardtii, Rhinocypha fenestrata, and Drepanosticta sundana* [7].

Dragonflies are significant in the ecosystem as they serve as bioindicators for assessing water quality and environmental pollutants [8]. Dragonflies are a taxonomic group of insects that exhibit a heightened sensitivity to alterations in their surrounding environment. The utilization of dragonfly nymphs as water indicators are attributed to their inability to thrive in polluted water environments [9]. Furthermore, dragonflies have a crucial function as pest control agents, specifically as predators and natural adversaries of noxious organisms [10].

Dragonflies exhibit a wide geographic range in their distribution [11]. Dragonflies exhibit a wide distribution throughout diverse ecological settings, encompassing natural and manufactured habitats. These encompass a range of geographical features, including lowland and highland regions, coastal areas, swamps, rivers, lakes, and ponds. Dragonflies are typically observed near bodies of water [10]. Furthermore, dragonflies can also be observed in forested regions. The Garahan area in Sempolan, Perhutani Forest Management Unit (KPH) Jember, is known to provide a suitable habitat for dragonflies [12]. The Garahan region is situated within a diverse forest ecosystem of various plant species, with pine and coffee exhibiting a prominent presence [12]. Dragonflies are supported by forest regions that exhibit heterogeneity [13]. There is a positive correlation between the level of vegetative variety within an ecosystem and the diversity of dragonflies present in that ecosystem [14].

A study by [9] in the Curug Semirang Tourism Wana woodland region revealed the presence of 17 distinct species of dragonflies[15]. In a previous investigation conducted by [2] within the Curug Lawe Benowo Tourism region, 19 species were documented. *Euphaea variegata, Drepanosticta sundana, and Orthetrum glaucum* had the highest abundance levels. The study conducted by [16] investigated the community structure of dragonflies in the Petungkriyono Perhutani Area, located in Central Java. The researchers documented a total of 17 dragonfly species during their research. *Drepanosticta spatulifera*, a dragonfly species has been documented as being endemic to a specific geographic region [16].

The above paragraph outlines the research undertaken on the dragonfly community structure within the Garahan Resort, located in the Sempolan region of the Perhutani, Jember Forest Management Unit. Furthermore, implementing population monitoring is a tangible measure of monitoring trends and can serve as a foundational framework for developing conservation policies.

2 Materials and Methods

This study employed an exploratory and descriptive research design. The approach utilized for determining the sampling points used the *purposive sampling* technique. The study was undertaken in January 2023 at Garahan Resort, Sempolan, KPH Jember, encompassing two distinct habitats: the pine habitat (stations 1-5) and the jungle habitat (stations 6-10) (see Figures 1 and 2). The study employed the road sampling approach, which systematically surveyed a 100-meter sampling area. The sampling technique utilized was the sweeping technique. The sample procedure was conducted in three iterations, each from 07:00 to 15:00.

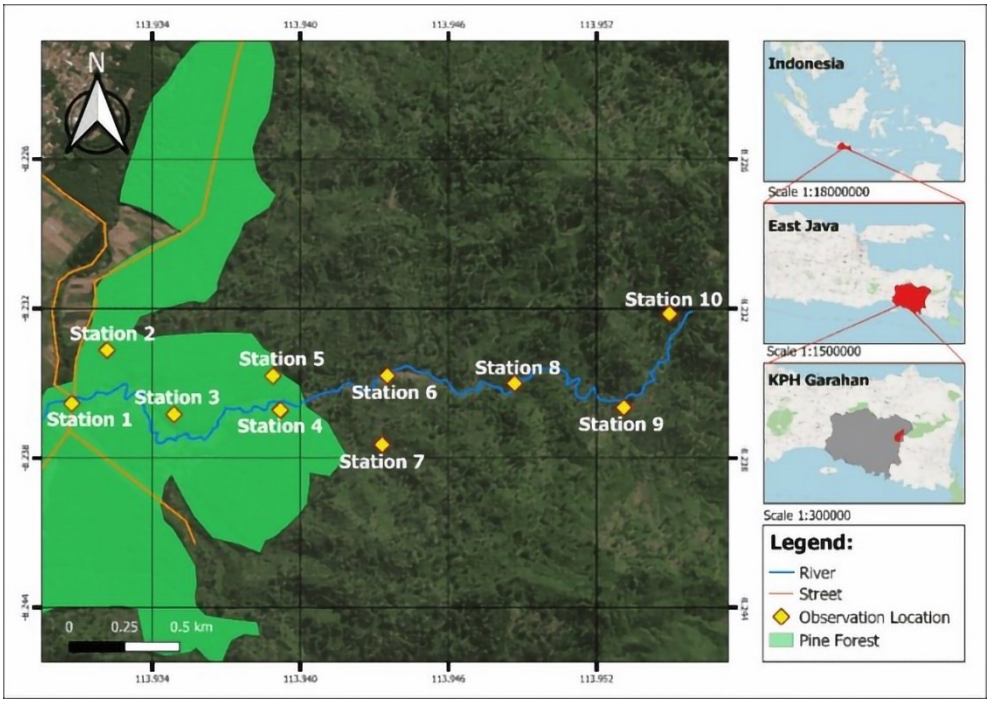

Fig. 1. Sampling location.

Fig. 2. Pine Forest and Jungle Resort Garahan.

The tools and equipment utilized in this study encompassed a range of items, including a sweep net, stationery, a ruler, styrofoam, needles (specifically insect needles), cardboard paper, cotton, cardboard, pilot paper, a syringe, a camera, a 5-watt yellow light, a lux meter, a thermohygro meter, an anemometer, a killing jar, and a Garmin GPSmap 60CSx. The dragonflies that were acquired were afterwards subjected to a process of desiccation and preservation. Subsequently, the samples were identified. The data analysis was conducted using the PAST4.09 software, which involved the utilization of several indices, including the

Shannon-Wiener diversity index (H'), the relative abundance index (KR), the evenness index (E), the similarity index (SI), and the dominance index (D). The abiotic environmental characteristics were examined using the application of *Canonical Correspondence Analysis* (CCA) to demonstrate the impact of these abiotic factors on the existence of Odonata within a given habitat.

3 Result and Discussion

Thirteen dragonfly species belonging to 7 different families were observed within the Garahan forest region. These species were represented by a combined population of 544 individuals, as indicated in Table 1. In the pine habitat, 10 distinct species were observed, comprising a population of 288 individuals. Conversely, a count of 11 species was recorded in the jungle habitat, with a population size of 256 individuals (Figure 3).

Table 1. Dragonflies (Odonata) in the Garahan Area, Sempolan, KPH Jember.

No.	Subordo	Family	Species Name
1.	Anisoptera	Libellulidae	*Orthetrum sabina* (Drury, 1770)
2.	Anisoptera	Libellulidae	*Diplacodes trivialis* (Rambur, 1842)
3.	Anisoptera	Libellulidae	*Orthetrum glaucum* (Brauer, 1865)
4.	Anisoptera	Libellulidae	*Orthetrum pruinosum* (Burmeister, 1839)
5.	Anisoptera	Libellulidae	*Pantala flavescens* (Fabricius, 1798)
6.	Anisoptera	Libellulidae	*Neurothemis terminata* (Ris, 1911)
7.	Anisoptera	Libellulidae	*Zygonyx ida* (Selys, 1869)
8.	Anisoptera	Aeshnidae	*Gynacantha subinterrupta* (Rambur, 1842)
9.	Anisoptera	Gomphidae	*Paragomphus reinwardtii* (Selys, 1854)
10.	Zygoptera	Calopterygidae	*Vestalis luctuosa* (Burmeister, 1839)
11.	Zygoptera	Chlorocyphidae	*Heliocypha fenestrata* (Burmeister, 1839)
12.	Zygoptera	Euphaeidae	*Euphaea variegata* (Rambur, 1842)
13.	Zygoptera	Platycnemididae	*Coeliccia membranipes* (Rambur, 1842)

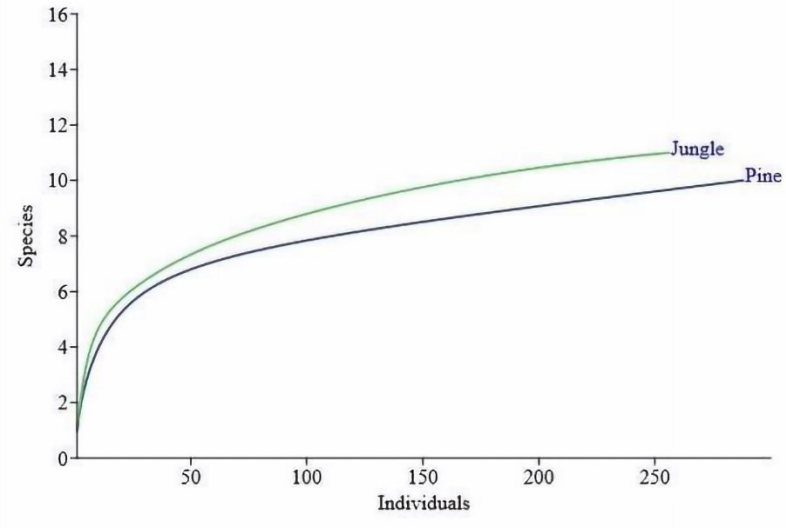

Fig. 3. Dragonfly rarefaction curve.

The family Libellulidae has the highest species diversity. The family under consideration exhibits a broad geographical range. Members of the Libellulidae family exhibit a notable degree of adaptation, enabling their presence across diverse habitat types [17]. The prevailing species observed were *Pantala flavescens* and *Orthetrum sabina. Pantala flavescens* is a species that exhibits gregarious behavior and is typically observed in open habitats during day periods. The species *Orthetrum sabina* was observed at nearly all designated data collection sites. This particular species is frequently observed in solitary perches on trees and plants. Two species exhibit notable environmental resilience, enabling survival in various habitats [18].

The two predominant species typically observed within each respective environment are *Vestalis luctuosa* and *Euphaea variegata*. These two species frequently engage in aerial locomotion and rest on foliage, branches, and geological formations close to bodies of water. This assertion is substantiated by [15], who observed that the two species frequently exhibit gregarious behavior near river habitats.

The present study focuses on two Javanese endemic species, *Paragomphus reinwardtii* from the Gomphidae family and *Heliocypha fenestrata* from the Chlorocyphidae family (see Figure 4). Two species have distinct preferences for particular habitats. *Paragomphus reinwardtii* exhibits a perching behavior on rocks near water sources characterized by moderate currents. The observed species was discovered in tropical rainforest ecosystems, predominantly inhabiting regions around 570 meters above sea level. Meanwhile, *Heliocypha fenestrata* can be observed perching on twigs and leaves within areas of partial shade provided by the canopy, typically near clean water streams characterized by moderate water flow. The present study documented the occurrence of this particular species in several pine forest and jungle habitats situated at an elevation ranging from 559 to 636 metres above sea level (masl). This assertion is substantiated by the findings of [19], who observed that *Paragomphus reinwardtii* exhibits a breeding pattern predominantly in lowland woods adjacent to rivers, with an upper limit of 850 meters above sea level (masl). Conversely, *Heliocypha fenestrata* has been documented to inhabit altitudes ranging from 0 to 1000 masl.

Fig. 4. Endemic dragonflies found in Garahan Resort (A) *Paragomphus reinwardtii*; (B) *Heliocypha fenestrata*.

Table 2. Data analysis of the Odonata Community in Garahan Resort.

	Pine	**Jungle**
Diversity (H')	1,428	1,757
Dominance (D)	0,358	0,205
Evenness (E)	0,417	0,526
Similarity Index (SI) %	75%	

The diversity index (H') within the pine habitat is recorded as 1,428, whereas in the jungle habitat, it is seen to be 1,757. The Garahan area exhibits an average diversity score of 1,653 indicating that the diversity of Odonata in the pine and jungle habitats can be categorized as moderate. This observation indicates that the Garahan woodland area exhibits favorable conditions for sustaining dragonfly populations. The diversity of dragonfly species in the jungle habitat is more significant than in the pine habitat. This can be attributed to heterogeneous forests, which offer a more comprehensive range of flora, promoting a more diverse population of dragonflies. Dragonfly life is supported by natural resources found in heterogeneous habitats [20, 21]. Furthermore, as [21] indicated, a suitable environment plays a crucial role in facilitating the survival of dragonflies [22].

The dominance index (D) observed in the pine habitat was 0,358 but in the jungle habitat, it was 0,205. The total dominance value for the entire Garahan region was determined to be 0,263, falling under the low category ($D < 0,5$). The lower dominance score suggests a reasonably equitable distribution of dragonflies across different habitats without any one environment exerting significant dominance. The topic at hand pertains to the significance of the evenness index (E'), which falls within the moderate range ($0,4 < E' \leq 0,6$). Specifically, in the pine habitat, the evenness index is recorded as 0,417, while in the jungle environment, it is noted as 0,526. The overall evenness index value is determined to be 0,401. This observation indicates that the population sizes of dragonflies in ecosystems are comparable, with no discernible dominance of any one dragonfly species.

The species similarity index in environments is 75%, indicating substantial species similarity between the two habitats ($SI > 50\%$). The dragonfly species in the pine habitat exhibit a high degree of similarity to those inhabiting forest habitats. The Odonata species that are present in habitats consist of *Orthetrum sabina, Vestalis luctuosa, Heliocypha fenestrata, Euphaea variegata, Orthetrum glaucum, and Pantala flavesescens.*

Table 3. Odonata relative abundance index at Garahan Resort

No	Species	Abundance Relative Index	
		Pine	**Jungle**
1	*Orthetrum sabina*	16%	19%
2	*Vestalis luctuosa*	10%	21%
3	*Heliocypha fenestrata*	5%	1%
4	*Euphaea variegata*	7%	20%
5	*Diplacodes trivialis*	0%	1%
6	*Orthetrum glaucum*	3%	4%
7	*Orthetrum pruinosum*	1%	0%
8	*Pantala flavesescens*	56%	30%
9	*Coeliccia membranipes*	0%	1%
10	*Neurothemis terminata*	0%	0%
11	*Gynacantha subinterrupta*	0%	0%
12	*Zygonyx ida*	0%	4%
13	*Paragomphus reinwardtii*	0%	0%

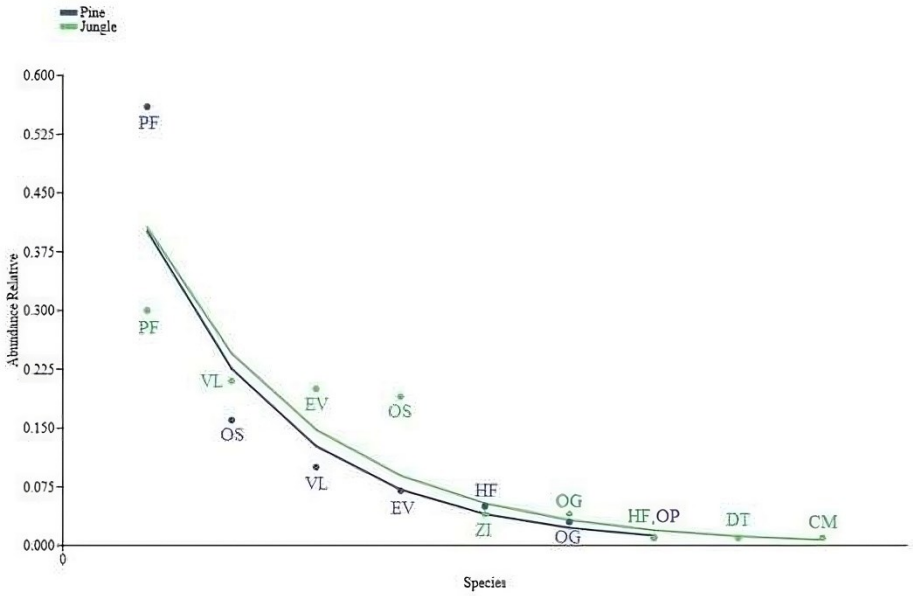

Fig. 5. Odonata relative abundance curve; (PF) *Pantala flavescens*; (VL) Vestalis luctuosa; (EV) *Euphaea variegata*; (OS) *Orthetrum sabina*; (HF) *Heliocypha fenestrata*; (OG) *Orthetrum glaucum*; (ZI) *Zygonix ida*; (OP) *Orthetrum pruinosum*; (DT) *Diplacodes trivialis*; (CM) *Coeliccia membranipes*.

The species with the highest relative abundance index in the pine forest habitat is *Pantala flavescens* species, with a value of 56%. In comparison, in the jungle habitat, there were *Pantala flavescens* species with a relative abundance value of 30%, *Vestalis luctuosa* 21%, and *Euphaea variegata* 20%. Species with a relative abundance index value classified as medium are *Orthetrum sabina* species with a value of 16% in pine forest habitat and 19% in jungle habitat. In contrast, the species of *Heliocypha fenestrata, Diplacodes trivialis, Orthetrum glaucum, Orthetrum pruinosum, Coeliccia membranipes, Neurothemis terminata, Gynacantha subinterrupta, Zygonyx ida,* and *Paragomphus reinwardtii* have a low relative abundance index value.

The habitat type condition and water availability affect the Odonata community structure index. Furthermore, the occurrence of Odonata within an ecosystem is regulated by abiotic variables, including air temperature, light intensity, air humidity, and wind speed (Table 4).

Table 4. Abiotic conditions of sampling sites in Garahan Abattoir.

Habitat	Air Temperature (ºC)	Air Humidity (%)	Light Intensity (lux)	Wind Speed (m/s)
Pine	28,94 ± 1,3	67,00 ± 4,5	5142 ± 1540,5	0,24 ± 0,2
Jungle	27,04 ± 0,8	68,68 ± 3,9	6967 ± 1544,9	0,37 ± 0,3

The findings of the air temperature measurements conducted at the research site exhibited a range of 27,04-28,94 ºC. The temperature range remains conducive and sufficiently supportive of dragonfly existence. According to [13], elevated temperatures substantially impact survival rates. Dragonflies have optimal locomotor and venation pumping capabilities within a temperature range of 25 ºC-29,4 ºC [23]. The recorded air humidity measurements exhibited values between 67,00% and 68,68%. The survival of

organisms can be affected by variations in humidity levels, with low humidity potentially harming survival, whilst high humidity may positively affect survival [24].

Dragonflies prefer atmospheric conditions that provide sufficient warmth to facilitate their various activities. The light intensity measurements obtained at the research site exhibited a 5142-6967 lux range. Dragonflies harness solar radiation to elevate their body temperature, facilitating the fortifying of their flight-related wing musculature. The recorded wind speed parameter readings exhibited a 0,24 to 0,37 m/s range. The mobility of dragonflies is significantly affected by wind speed. The greater levels of wind speed affect the presence of dragonflies during flight activities. The abiotic data were subjected to Canonical Correspondence Analysis (CCA) to assess the relationship between environmental factors and the occurrence of Odonata species (Figure 6).

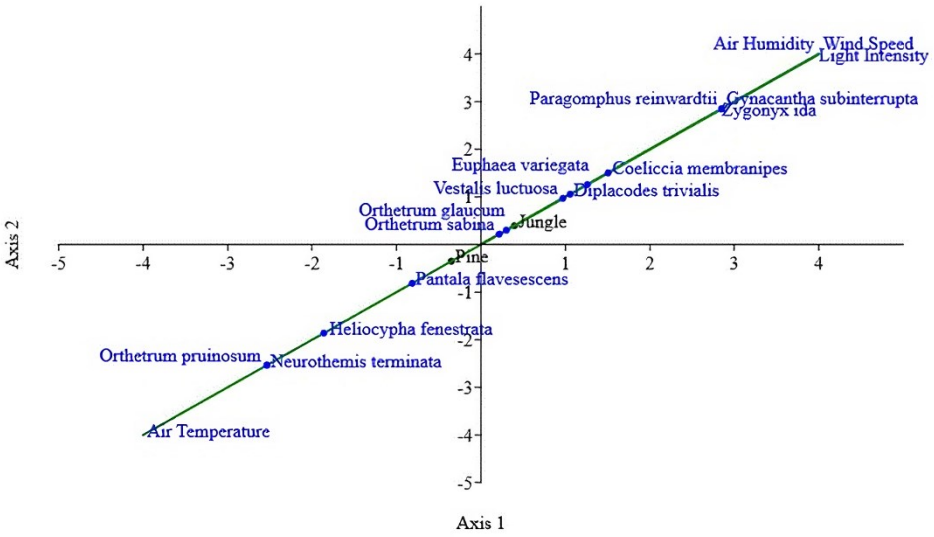

Fig. 6. Analysis CCA (Canonical Corresponding Analysis)

The results of Canonical Correspondence Analysis (CCA) indicate that the distribution of *Orthetrum glaucum*, *Orthetrum sabina*, *Vestalis luctuosa*, *Diplacodes trivialis*, *Euphaea variegata*, *Coeliccia membranipes*, *Gynacantha subinterrupta*, *Paragomphus reinwardtii*, and *Zygonix ida* species in the jungle habitat is affected by the variables of light intensity, air humidity, and wind speed. *Coeliccia membranipes* prefer environments characterized by dense canopies and elevated air humidity levels [25]. In contrast, *Zygonix ida* inhabits forested regions close to water bodies. During the investigation, it was observed that *Coeliccia membranipes* and *Zygonix ida* were present in jungle environments characterized by relatively high levels of air humidity. The species *Orthetrum glaucum* was observed to inhabit regions close to bodies of water characterized by high light intensity levels. The substantial link between light-intensity circumstances and the presence of *Coeliccia membranes* and *Orthetrum glaucum* has been demonstrated in the research conducted by [16]. *Diplacodes trivialis* and *Gynacantha subinterrupta* were observed in habitats characterised by moderately dense vegetation and comparatively elevated levels of atmospheric humidity. *Diplacodes trivialis* was observed in coffee environments, whereas *Gynacantha subinterrupta* exhibited a preference for perching on leaves of moderate density.

Vestalis luctuosa, *Euphaea variegata*, and *Paragomphus reinwardtii* were observed close to aquatic environments with elevated atmospheric moisture levels and intense luminosity.

The *species Orthetrum sabina* is typically observed near the ordinate 0, suggesting its wide distribution across various habitats. The study conducted by [19] demonstrated that *Orthetrum sabina* is a species that appears to be minimally affected by abiotic variables. This conclusion is supported by the observation that the ordinate point is close to zero, indicating that the species may be detected at each observation site.

The study's findings indicated a positive correlation between air temperature and the occurrence of *Orthetrum pruinosum*, *Neurothermis terminata, Heliocypha fenestrata,* and *Pantala flavescens* in the pine habitat. The identified species were discovered inhabiting open environments characterized by elevated air temperatures. The species *Pantala flavescens* is subject to the effect of air temperature [19]. The study showed that the *Heliocypha fenestrata* species predominantly inhabited regions characterized by a relatively dense canopy cover, resulting in reduced exposure to direct sunlight. Additionally, these locations exhibited elevated ambient air temperatures.

4 Conclusion

A total of thirteen distinct species of dragonflies belonging to seven different families under Odonata were documented. *Paragomphus reinwardtii* and *Heliocypha fenestrate* are exclusively found in a specific geographic region. The diversity index (H') exhibited a value of 1,653, placing it within the medium category. Similarly, the dominance index (D) showcases a value of 0,263, categorising it as low. The evenness index (E) attained a value of 0,401, classifying it within the medium category. Lastly, the species similarity index (SI) of 75% is deemed to be in the high group. The prevalent species observed in the study encompassed *Vestalis luctuosa, Euphaea variegata, Orthetrum sabina,* and *Pantala flavescens.*

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