

## Dragonfly (Odonata) Community Structure in Bandalit Resort, Meru Betiri National Park

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Received: 09 September 2024

Revise from: 01 November 2024

Accepted: 23 March 2025

DOI: 10.15575/biodjati.v10i1.38986

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**Abstract.** Bandalit Resort is a conservation area encompassing diverse habitats, providing a suitable environment for dragonflies to thrive as permanent inhabitants. The region plays a crucial role in supplying vital water for the life cycle of dragonflies. Human activities occurring in the upstream areas, such as agriculture, can potentially deteriorate water quality due to pollution. This work is highly significant due to the lack of recent monitoring data on dragonflies in the area and the pivotal role of dragonflies as bioindicators. This study aimed to analyze the composition and organization of the dragonfly population at Bandalit Resort (MBNP). A total of twelve dragonfly species were documented, among which were two species that are exclusive to Java. The Shannon-Wiener index study indicated a classification of modest diversity. The Terjun Block had the highest dominance index ( $D$ ) of 0.27, whilst the Pringtali Block had the highest uniformity index ( $e^H/S$ ) of 0.86. The species with the most excellent importance index ( $IVI$ ) in different blocks are as follows: *Euphaea variegata* and *Vestalis luctuosa* in Pringtali Block, *Nososticta insignis* in Terjun Block, and *Crocothemis servilia* in East Muara Block. The canonical corresponding analysis (CCA) revealed that *V. luctuosa*, *Heliocypha fenestrata*, and *Nososticta insignis* exhibited a correlation with air humidity. In contrast, *Copera marginipes*, *Pantala flavescens*, *C. servilia*, and *Diplacodes trivialis* demonstrated a correlation with light intensity, wind speed, and air temperature. This research holds significance as it directly examines the relationship between dragonfly communities and abiotic parameters within the Bandalit Resort, Meru Betiri National Park (MBNP).

**Keywords:** bandalit, conservation, diversity, dragonfly, endemic, forest

### Citation

Rohman, A., Subchan, W., Faradilla, Y., & Firmansyah, P. (2025). Dragonfly (Odonata) Community Structure in Bandalit Resort, Meru Betiri National Park. *Jurnal Biodjati*, 10(1), 90-104.

## INTRODUCTION

Bandalit Resort is situated within the confines of Meru Betiri National Park (MBNP), serving as one of its designated conservation areas (Sulistiyowati et al., 2021). Geographically, the area is situated within the Jember and Banyuwangi regencies (Syarif et al., 2018). The resort encompasses a variety of ecological types, such as coastal forests, lowland forests, and rheophytic ecosystems (Syarif et al., 2018). Several habitat types add to the significant biodiversity, including dragonflies, among the most diverse groups. Adult dragonflies are influenced by canopy closure in their choice of habitats (French & McCauley, 2018). Additionally, dragonflies exhibit preferences for particular environments (Sugiman et al., 2020).

The Bandalit Resort region is ecologically important due to its high biodiversity, primarily because of the presence of rivers that flow through the area. These rivers serve as crucial homes for dragonflies (Kietzka et al., 2017; Buczyńska and spawning (Pelli & Pimenta, 2019). Furthermore, dragonflies serve as bioindicators of water quality, making them valuable for monitoring the state of water in a specific region (Agus et al., 2017).

Nevertheless, human activities occurring upstream, such as agriculture and urban development near water bodies, have the potential to degrade water quality due to pollution, sedimentation, and the runoff of pesticides. Dragonflies, which undergo aquatic and terrestrial life cycles, rely heavily on high water quality during their larval stage (Everling & Johansson, 2022). Diminished water quality can lead to the death of larvae, disturb the life cycles of dragonflies, and reduce their population abundance (Tippler et al., 2018; Palacino-Rodríguez et al., 2020; Perron et al., 2021).

Furthermore, global climate change di-

rectly influences rainfall patterns, temperature, and humidity in forested regions, thereby affecting aquatic ecosystems and the circumstances of dragonfly habitats (Cadena et al., 2023). Climate change can impact the timing of dragonfly phenology, including when they lay eggs and when their larvae emerge. This can lead to mismatches in the availability of resources or suitable habitats (Olsen et al., 2022).

Despite the potential of Odonata species as indicators of habitat quality and biological control agents, they have not been extensively utilized in Bandalit Resort due to limited exploration of its areas. This encompasses the possibility of undiscovered native species that have not been made public. The dearth of data regarding the region's variety, population, and spatial spread of dragonflies has stimulated researchers' curiosity to undertake additional investigations. Due to the absence of recent dragonfly (Odonata) monitoring at Bandalit Resort, it is crucial to monitor dragonfly diversity to contribute to the existing data on dragonfly biodiversity in this region.

This study is of great significance due to the absence of recent surveillance of dragonflies (Odonata) at Bandalit Resort. Obtaining extensive data on the variety and distribution of dragonflies is crucial since they serve as bioindicators. This information will offer valuable insights into the state of the aquatic ecosystems in the region. Enhanced surveillance will not only contribute to the existing data on dragonfly biodiversity in the region. Moreover, it will establish a solid foundation for implementing more efficient habitat management and conservation practices at Bandalit Resort. This research aims to discover dragonfly species that have not been documented before and to comprehend how continuous environmental changes influence their population dynamics.

## MATERIALS AND METHODS

### Study area

The research was conducted in Bandalit Resort, Meru Betiri National Park (MBNP), from March to April 2022. A purposive sampling method was employed to determine the sampling points. Dragonfly data collection was conducted along the river course, divided into three locations: Pringtali Block, Terjun Block, and East Muara Block (Figures 1 & 2).

### Dragonfly data collection

The sampling method employed was road sampling, which involved investigating a 100-meter-long and 10-meter-wide sampling area. The sampling technique used was sweeping. The action was conducted thrice. The sample period was from 07.00 am to 15.00 pm. The parameters collected consist of the dragonfly species present and the population size of each species.

### Measurement of abiotic factors

The abiotic factors are air temperature, light intensity, air humidity, and wind speed. Tools and materials used: Sweepnet, stationery, ruler, styrofoam, needles, insect needles, cardboard paper, cotton wool, cardboard, papilot paper, syringe, camera, 5 watts yellow light, lux meter, thermohygrometer, anemometer, killing jar, and Garmin GPSmap 60CSx. The dragonflies that had been obtained were then dried, preserved, and identified.

### Data Analysis

The conservation status is determined using the International Union for Conservation of Nature (IUCN) Red List of Endangered Species (<https://www.iucnredlist.org/>). Data analysis was conducted using the PAST4.09 software to calculate the Shannon-Wiener

diversity index ( $H'$ ), Evenness (E), and dominance (D). The influence of abiotic factors on the presence of Odonata in the habitat was assessed by analyzing environmental (abiotic) parameters using Canonical Corresponding Analysis (CCA). The importance index (IVI) of a dragonfly community was calculated by considering its density, frequency, and dominance. Subsequently, this index was used to evaluate the species' significance at each location.

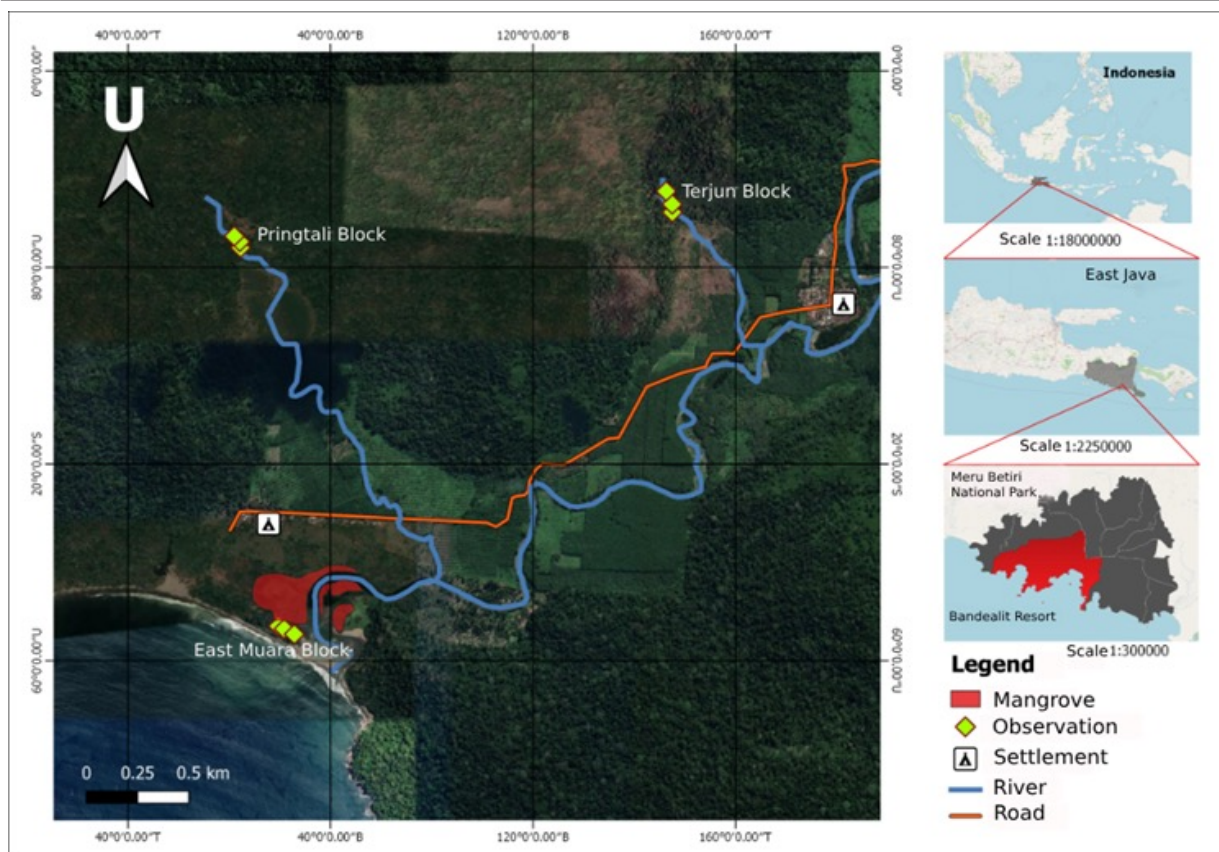
## RESULTS AND DISCUSSION

### Dragonfly Diversity

A total of 571 individuals consisting of 12 dragonfly species from 7 families were recorded at Bandalit Resort, Meru Betiri National Park. A total of twelve species were discovered, namely: *Copera marginipes*, *Euphaea variegata*, *Vestalis luctuosa*, *Nososticta insignis*, *Ischnura senegalensis*, *Heliocypha fenestrata*, *Crocothemis servilia*, *Orthetrum sabina*, *Pantala flavescens*, *Neurothemis ramburii*, *Diplacodes trivialis*, and *Trithemis festiva* (as listed in table 1). The species *V. luctuosa* has the largest population count (Figure 2.D). This species exhibits a broad geographical range, particularly in lowland forests and mountainous regions with clear water features in small streams. *V. luctuosa* can be observed in protected regions, pristine forests, and places designated for resource utilization (Nafisah & Soesilohadi, 2021; Rohman et al., 2024).

The family Libellulidae exhibited the most significant proportion regarding the number of individuals and species, accounting for 50% (Figure 4). The family Libellulidae is highly prevalent among dragonflies and has many species. This variety is intricately linked to their ability to adapt to various habitat circumstances. The data was collected





**Figure 1.** Research location Bandalit Resort Meru Betiri National Park



**Figure 2.** A. Pringtali Block; B. Terjun Block; C. East Muara Block

in several natural habitats, including forested areas, highland forests, beaches, and islands (Rohman et al., 2020; Akbar & Basukriadi, 2021; Koneri et al., 2022; Rohman et al., 2022). Libellulidae primarily inhabits tranquil aquatic environments, such as ponds, swamps, lakes, irrigation channels, and rice fields (Susanto et al., 2024). Members of this family can flourish in a wide range of environmental circumstances, spanning from pristine waters to waterways with elevated levels of eutrophication. Libellulidae typically thrive in open habitats that receive ample sunlight, directly impacting their daily activities and ability to regulate body temperature (Guillermo-Ferreira & Gorb, 2021). Riparian vegetation around water bodies is essential for providing roosting locations for several species (O'Malley et al., 2020). Aquatic and eutrophically influenced settings generally exhibit a high level of species diversity within the Libellulidae family (Li et al., 2019). These

conditions promote the proliferation of larvae in the water (Moreno Pallares et al., 2022).

Two dragonfly species, *Nososticta insignis* (Figure 3.A) and *Heliocypha fenestrata* (Figure 3.B), were discovered exclusively in Java. According to data from the International Union for Conservation of Nature (IUCN), *N. insignis* is classified as Least Concern; on the other hand, *H. fenestrata* is Least Concern. Both endemic species exhibit a distribution that spans from the eastern to the western regions of Java Island. Rohman et al. (2022) conducted a study documenting the presence of *Nososticta insignis* in Alas Purwo National Park, situated at the furthest eastern point of Java Island. The research undertaken by Rachman and Rohman (2016) takes place in the Menoreh district of central Java. Sugiman et al. (2020) discovered it at Ujung Kulon National Park, situated at the furthest point west of Java.

**Table 1.** List of Dragonfly Species in Bandalit Resort, Meru Betiri National Park (MBNP)

No.	Suborder	Family	Species	Location			IUCN
				Pringtali Block	Plunge Block	East Muara Block	
1.	Zygoptera	Platycnemididae	<i>Copera marginipes</i>	17	-	6	LC
2.	Zygoptera	Euphaeidae	<i>Euphaea variegata</i>	98	-	-	LC
3.	Zygoptera	Calopterygidae	<i>Vestalis luctuosa</i>	77	43	-	LC
4.	Zygoptera	Protoneuridae	<i>Nososticta insignis</i>	45	37	-	LC
5.	Zygoptera	Coegrionidae	<i>Ischnura senegalensis</i>	-	-	4	LC
6.	Zygoptera	Chlorocyphidae	<i>Heliocypha fenestrata</i>	44	28	-	LC
7.	Anisoptera	Libellulidae	<i>Crocothemis servilia</i>	-	-	28	LC
8.	Anisoptera	Libellulidae	<i>Orthetrum sabina</i>	-	-	2	LC
9.	Anisoptera	Libellulidae	<i>Pantala flavescens</i>	-	-	3	LC
10.	Anisoptera	Libellulidae	<i>Neurothemis ramburii</i>	-	11	19	LC
11.	Anisoptera	Libellulidae	<i>Diplacodes trivialis</i>	-	-	8	LC
12.	Anisoptera	Libellulidae	<i>Trithemis festiva</i>	22	3	-	LC
Total				303	197	70	

IUCN Status = LC: Least Concern

Furthermore, it exhibits a distribution range that includes a small island outside Java, specifically western Nusakambangan (Zaman et al., 2018). Rohman et al. (2024) documented the presence of *Heliocypha fenestrata* in the Jember Forest region of East Java, as per their research findings. Astuti et al. (2022) documented the species found in Central Java. The researchers Sugiman et al. (2020) documented the occurrence of it within Ujung Kulon National Park. The species exhibits habitat specificity, primarily inhabiting rivers within natural forest environments (Nafisah et al., 2021; Rohman et al., 2024). *Heliocypha fenestrata* perched on river rocks and river-side vegetation, specifically *Calliandra* sp.

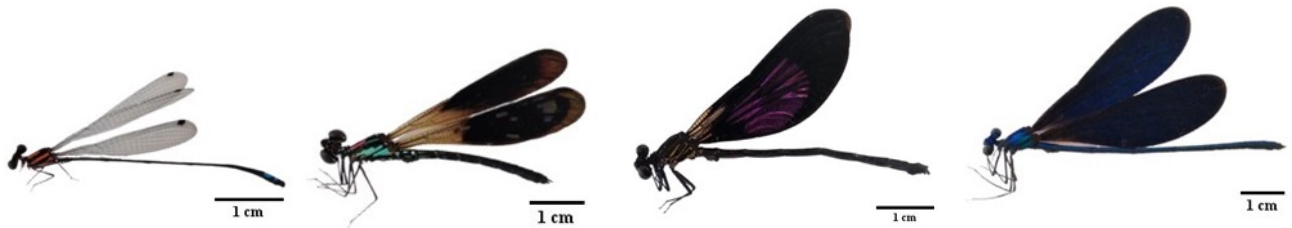
*Nososticta insignis* and *Heliocypha fenestrata* ain habitat of fenestrata is in pristine streams with stony substrates, typically in mountainous regions or undisturbed lowland woods. Pristine, unobstructed water bodies with moderate to rapid flows are essential components that sustain the life cycle of both species, from their larval to adult phases. The boulders on the riverbank serve as a habitat for larvae, allowing them to conceal themselves, grow, and obtain nourishment (Buczyński et al., 2017; Kietzka et al., 2017). Both species possess specialized adaptations specifically suited to the unique conditions of aquatic ecosystems. As a result, they serve as crucial indicators of the viability and quality of these ecosystems (Kietzka, 2019).

Forest vegetation along rivers is crucial for ensuring the stability of these ecosystems (Geng et al., 2019). The thick forest canopy and flora that develop alongside the stream provide shade, which helps maintain steady water temperatures. This flora also facilitates the creation of appropriate microhabitats for both species, serving as roosting, nesting, and refuge areas to protect them from predators (French & McCauley, 2018). Furthermore, riparian vegetation has a role in supplying organic matter, which serves

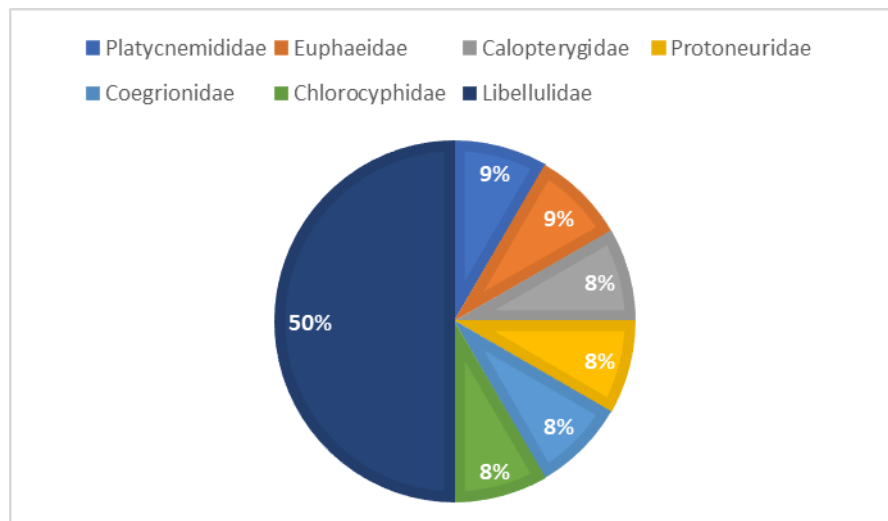
as a food source for aquatic organisms that facilitate the growth of dragonfly larvae.

The strong correlation between *Nososticta insignis* and *Heliocypha fenestrata* and clear, stony riverine habitats indicates that these species are extremely responsive to environmental alterations, particularly water quality and forest vegetation preservation. The presence of these two species can be directly affected by habitat deterioration caused by deforestation, sedimentation, and water pollution. Hence, it is imperative to preserve the forest habitats where they reside.

The occurrence of *Nososticta insignis* and *Heliocypha fenestrata* at a location indicates the excellent habitat conditions and long-term viability of the aquatic ecosystems in the area, as these species are native to the region. Additional investigation into these two species' ecology and habitat preferences could yield a more profound understanding of their contribution to the equilibrium of riverine ecosystems in tropical forests and the necessary conservation actions to save their habitats. Figure 5 indicates the East Muara Block with the most species. The East Muara Block in Meru Betiri National Park is known for its significant abundance of dragonfly species. It is situated in the interface area where coastal habitats, lowland forests, and rivers that empty into the ocean converge. Variations can influence the variety of dragonfly species in their habitat (Johansson et al., 2019). The diverse range of habitat types in East Muara Block, accompanied by riparian vegetation, provides an optimal environment for dragonfly species to complete their life cycle. The varied range of plant life along the river also serves crucial roles, such as providing refuge, locations for dragonfly egg deposition, and sites for pollination. According to Rodrigues et al. (2019), there is a correlation between the abundance of species exhibiting exophytic or epiphytic activity and the degradation of riparian forests. Luke et al. (2017) demonstrate that dragonflies



**Figure 3.** Dragonfly species in Bandealit Resort, MBNP. A). *Nososticta insignis* ♂, B). *Heliocypha fenestrata* ♂, C). *Euphaea variegata* ♂, D). *Vestalis luctuosa* ♂



**Figure 4.** Family composition by dragonfly species at Bandealit Resort, Meru Betiri National Park (MBNP)

are affected by changes in land use. Hence, there exists a correlation between plants, water quality, and land cover as a catalyst for the aggregation of Odonata (Perron et al., 2021).

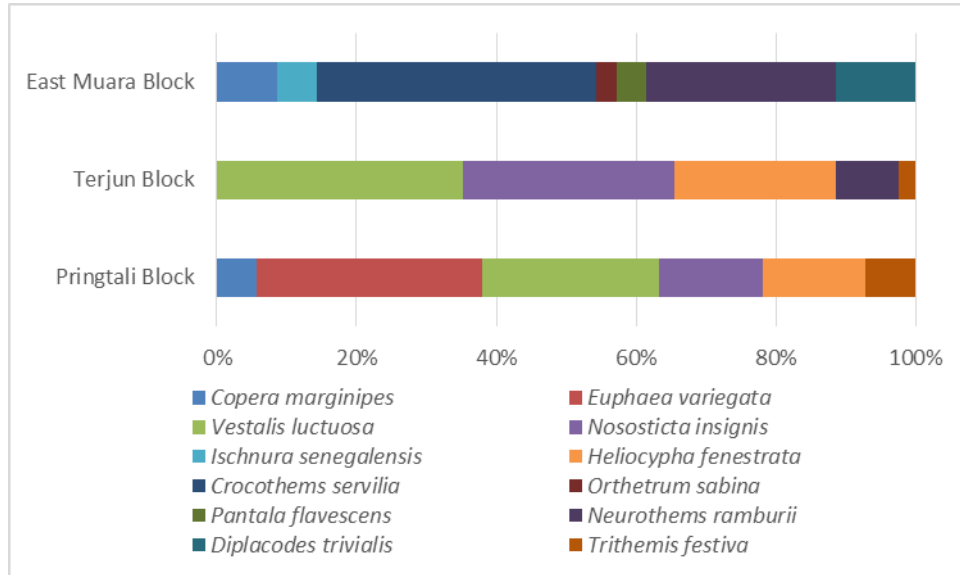
Terjun Block and Pringtali are notable because they include two species found exclusively in those locations. Various elements, including water quality, consistent temperature, and high humidity, contribute to the ideal microclimatic conditions necessary for the growth of dragonfly larvae and the activity of adult dragonflies. This region harbors several dragonfly species that are unique to this area and have limited distribution. This highlights the significance of the Terjun and

Pringtali Block areas for conservation efforts.

Terjun and Pringtali Blocks in Meru Betiri National Park (MBNP) are significant areas with diverse dragonfly species. These blocks hold biological importance and offer considerable potential for study, as well as ecotourism development focused on biodiversity. The presence of many dragonfly species in this location is evidence of the pristine habitat conditions and the crucial function of this place in sustainably maintaining ecological equilibrium.

By employing different ecological indices, such as Shannon-Wiener ( $H'$ ), Dominance ( $D$ ), Simpson ( $1-D$ ), and Evenness





**Figure 5.** Species composition at the three sites in Bandialit Resort, Meru Betiri National Park (MBNP)

( $e^H/S$ ), the analyses of community structure in the region offer a comprehensive understanding of ecosystem stability, species distribution, and ecological equilibrium.

The analysis of the Shannon-Wiener index for the three locations shows minimal variation. The variation in the species diversity index is attributed to disparities in species richness at each location. The number of species present is directly correlated with the species diversity index. Increased resource availability promotes more people in a community, increasing species richness by enabling more species with sustainable populations (Storch et al., 2018). The diversity criteria classify it as moderate due to the H value falling between 1 and 3. This indicates that the Bandialit Resort harbors a rather modest diversity of species. This indicates an intricate and thriving environment where interactions between different species and resource availability contribute to species' diversity. According to the analysis, Bandialit Resort has a moderate H' value (table 2), suggesting that the area possesses noteworthy biodiversity

and generally well-preserved ecosystem conditions. The study conducted by Hikmah et al. (2018) demonstrated findings that fell under the medium category. The consistent homogeneity of natural circumstances within a specific Meru Betiri National Park area results in a similar composition of dragonfly species. Consequently, the diversity index of these dragonflies remains consistently moderate.

The dominance index (D) of Terjun Block has been analyzed and found to have the highest value (0.27) compared to other sites (table 2). The dominance index (D) quantifies the level of dominance a species shows within a given community. The low D value at Bandialit Resort suggests that no species considerably dominates over others. This indicates that the allocation of individuals among species tends to be uniform, promoting a high diversity level. Low dominance signifies a state of balanced competition among species, which in turn signals a more stable environment.

The Pringtali Block has the highest evenness index ( $e^H/S$ ) value, 0.86 (table 2). The evenness index provides insight into the



distribution of individuals among the species within a community. The high evenness ratings at Bandalit Resort suggest a relatively equal distribution of individuals among

different species, without any species dominating. Equilibrium is crucial as it signifies a robust ecosystem where every species has generally equitable access to resources.

**Table 2.** Dragonfly Data Analysis of Bandalit Resort, Meru Betiri National Park (MBNP)

Index	Location		
	Pringtali Block	Plunge Block	East Muara Block
Taxa_S	6	5	7
Individuals	303	122	70
Shannon_H	1.64	1.39	1.62
Dominance_D	0.22	0.27	0.25
Evenness_e^H/S	0.86	0.80	0.72

*Euphaea variegata* (Figure 2.C) and *Vestalis luctuosa* (Figure 2.D) had the highest importance value index (IVI) in Pringtali Block, *Nososticta insignis* in Terjun Block, and *Crocothemis servilia* in East Muara Block. Ecological analyses at the three sites showed that *E. variegata*, *V. luctuosa*, *N. insignis*, and *C. servilia* were the dragonfly species with the highest importance value index (table 3). IVI, which includes the components of species density, frequency, and dominance, provides a holistic insight into the ecological role of a species in the community. The high IVI of these two species signaled their dominant role in the dragonfly community structure at the three sites.

*Euphaea variegata* exhibited pronounced dominance in Pringtali Block, indicating its strong adaptability to the specific ecological characteristics found in this location. This species prefers clear riverine settings characterized by moderate to fast water currents and rocky substrates, frequently found in the Pringtali Block. The persistent occurrence of substantial *E. variegata*. Observations at various sites shows that the *variegata* species is the most dominant in distribution and abundance. The species' high frequency and vast spread indicate its ability to tolerate

variations in microhabitat, making it a crucial indicator of consistently stable conditions in aquatic ecosystems. A study by Rohman et al. (2024) documented that *E. variegata* is found in forested regions with stony streams. Furthermore, Nafisah and Soesilohadi (2021) documented the species discovered within the confines of natural forest regions.

*Vestalis luctuosa* exhibited a high IVI, suggesting that this species effectively utilized the resources in the Pringtali Block. This species exhibits a predilection for environments characterized by sluggish water movement and shady river sections encompassed by lush vegetation in a forest. The Pringtali Block, characterized by its thick forest cover and tranquil river current, offers an optimal environment for *V. luctuosa*. The species' high frequency and dominance values in the area suggest its capacity to adapt and maintain a stable population while exerting control over the local dragonfly community. A study by Rohman et al. (2024) documented that *E. Variegata* is found in forested regions with stony streams.

*Nososticta insignis* found in the plunge block showed significant Importance value Index (IVI) values in the ecosystem. A high IVI value reflects the ecological dominance of this species in the local community, both

in terms of distribution, abundance, and influence on ecosystem structure. In the plunge block, the habitat, consisting of clear water flow, riparian vegetation, and rocky substrate, provides optimal conditions for *N. insignis*, allowing this species to thrive and dominate relatively compared to other species. Research by Rachman and Rohman (2016) reported that *N. insignis* in secondary forest in

the Menoreh Karst area. Rohman et al (2022) also found *N. insignis* in coastal forest streams in Pancur Resort, Alas Purwo National Park. Meanwhile, *Crocothemis servilia* in the East Estuary Block is a habitat of estuarine waters. This species has a wide distribution, including mountains, forests, lakes, ponds, and settlements (Astuti et al., 2020; Wakhid et al., 2020; Akbar & Basukriadi, 2021).

**Table 3.** Important Value Index (IVI) of Bandalit Resort, Meru Betiri National Park (MBNP)

No.	Species	IVI		
		Pringtali Block	Plunge Block	East Muara Block
1	<i>Copera marginipes</i>	0.14	0.00	0.22
2	<i>Euphaea variegata</i>	0.43	0.00	0.00
3	<i>Vestalis luctuosa</i>	0.43	0.63	0.00
4	<i>Nososticta insignis</i>	0.33	0.67	0.00
5	<i>Ischnura senegalensis</i>	0.02	0.00	0.12
6	<i>Heliocypha fenestrata</i>	0.27	0.41	0.00
7	<i>Crocothemis servilia</i>	0.11	0.00	0.67
8	<i>Orthetrum sabina</i>	0.01	0.00	0.10
9	<i>Pantala flavescens</i>	0.01	0.00	0.11
10	<i>Neurothemis ramburii</i>	0.08	0.23	0.54
11	<i>Diplacodes trivialis</i>	0.03	0.00	0.25
12	<i>Trithemis festiva</i>	0.14	0.07	0.00

The abiotic measurements at Bandalit Resort in Meru Betiri National Park (MBNP) indicate an air temperature range of 28.67-32°C (table 4). The consistent temperature provides optimal conditions for various organisms, such as dragonfly species, which are very responsive to fluctuations in temperature. The air temperature is crucial for facilitating daily biological activity, such as searching for food and engaging in reproductive behaviors. The development of tropical dragonfly eggs during the reproductive stage is influenced by temperature. If the temperature drops to 15°C, eggs will not develop, as shown by Mendonca et al. in 2018. Furthermore, there is a correlation between temperature and hu-

midity, such that when the temperature is low, the humidity tends to be high, and vice versa.

The air humidity ranges from 72.67% to 90.67% (table 4). This humidity level creates a consistent and controlled environment for different species of dragonflies. Elevated humidity facilitates optimal conditions for insect life cycles and reduces water evaporation on plants, which is crucial for sustaining forest flora. Consistent air humidity decreases osmotic stress on organisms and promotes the stability of local biological groups.

The light intensity ranged from 682.33 to 4813.3 lux (table 4). The light intensity at Bandalit Resort fluctuates by the density of the forest canopy. In regions characterized

by a thick covering of trees, the level of light intensity is comparatively low. Conversely, the light intensity level is higher in unobstructed areas or near bodies of water. The variations in light intensity affect both the distribution of habitats and the daily behaviors of specific species. Species with higher activity levels in open habitats use ample light to regulate their body temperature and engage in foraging behaviors. Conversely, the diminished brightness beneath the canopy creates a favorable environment for species that necessitate greater shielding from direct sunshine. French and McCauley (2018) found that increased canopy cover leads to a decrease in adult dragonfly visits, whereas a greater amount of natural canopy cover reduces the diversity of visiting species.

The wind speed varies between 0.08 and 0.18 meters per second (table 4). The wind velocities in Bandialit Resort typically range from low to moderate. The mild breezes in this region impact the moisture levels of the

microenvironments. Furthermore, consistent wind velocities facilitate the aerial movements of insects, particularly dragonflies, who depend on favorable wind conditions to navigate throughout their hunting endeavors. Minimal wind velocities help to equilibrium temperature and humidity within the forest ecosystem.

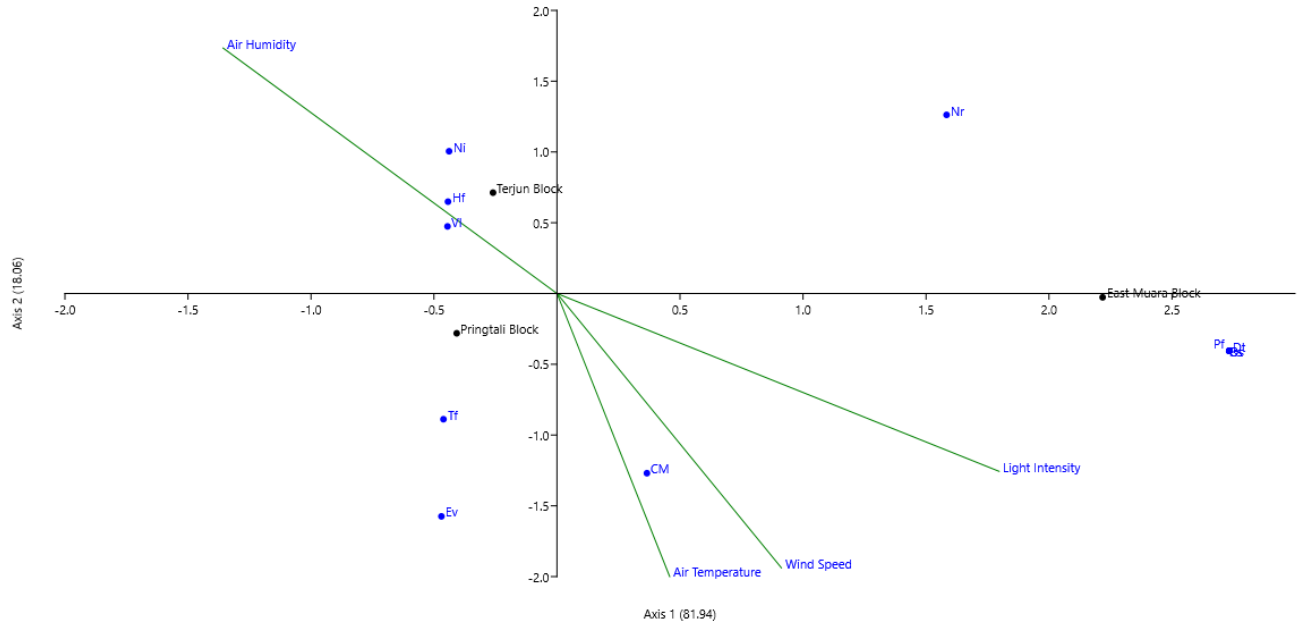
The abiotic parameter measurements offer a momentary assessment of the stability of environmental conditions at Bandialit Resort, which are essential for sustaining the area's biodiversity. The area's abiotic circumstances are rather constant and beneficial, indicating a healthy and well-preserved ecosystem. This ecosystem is crucial for supporting diverse species, including endemic species and those of significant conservation importance. A comprehensive comprehension of these abiotic characteristics is necessary to manage conservation areas. Consistent surveillance of abiotic circumstances aids in predicting forthcoming environmental alterations that could disrupt the ecosystem's equilibrium.

**Table 4.** Abiotic Parameter Measurements of Bandialit Resort, Meru Betiri National Park (MBNP)

Location	Air Temperature (°C)	Air Humidity (%)	Light Intensity (lux)	Wind Speed (m/s)
Pringtali Block	32 ± 2.65	77.33 ± 6.43	4813.3 ± 2553.17	0.18 ± 0.06
Plunge Block	28.67 ± 0.58	90.67 ± 1.15	682.33 ± 299.81	0.08 ± 0.03
East Muara Block	31.33 ± 0.58	72.67 ± 0.58	11110 ± 2383.46	0.18 ± 0.06

The results of the CCA analysis showed that the first and second axes of the data accounted for 81.94 and 18.06% of the variation in the data, respectively. The Canonical Corresponding Analysis (CCA) analysis was partitioned into four distinct groups (Figure 6). Initially, no correlation was observed between *Neurothemis ramburii* and environmental conditions. Secondly, *Vestalis luctuosa*, *Helioxypha fenestrata*, and *Nososticta insignis* correlate with atmospheric humidity. At the Pringtali Block location, a correlation was seen between the species *Trithemis festiva* and Eu-

phaea variegata. Fourth, the species *Copera marginipes*, *Pantala flavescens*, *Crocothemis servilia*, and *Diplacodes trivialis* correlate with light intensity, wind speed, and air temperature, as shown in Figure 6. These characteristics significantly impact the distribution and abundance of dragonflies in the East Estuary Block. This area exhibits the utmost light intensity, a crucial requirement for dragonflies to engage in flight. The wings of dragonflies are significantly affected by light intensity, and the venation of their wings will solidify when exposed to sufficiently warm light.



**Figure 6.** Canonical Corresponding Analysis (CCA) of dragonflies in Bandalit Resort, MBNP. Cm: *Copera marginipes*; Ev: *Euphaea variegata*; Vl: *Vestalis luctuosa*; Ni: *Nososticta insignis*; Is: *Ischnura senegalensis*; Hf: *Heliocypha fenestrata*; Cs: *Crocothemis servilia*; Os: *Orthetrum sabina*; Pf: *Pantala flavescens*; Nr: *Neurothemis ramburii*; Dt: *Diplacodes trivialis*; Tf: *Trithemis festiva*.

## CONCLUSION

The Bandalit Resort, located in Meru Betiri National Park (MBNP), is a significant conservation area renowned for its rich variety of dragonfly species. Three distinct locations inside Bandalit Resort exhibited differences in the measuring of variety, Evenness, and dominance indices of dragonfly species. The family Libellulidae had the highest species diversity, with *Crocothemis servilia*, in particular, displaying predatory behavior. Java is home to two dragonfly species found nowhere else: *Nososticta insignis* and *Heliocypha fenestrata*. The abiotic elements in this area fall within the necessary tolerance range to sustain dragonflies.

## AUTHOR CONTRIBUTION

**A.R.** and **W.S.** developed and designed the research. **Y.F.** and **P.F.** conducted the fieldwork and sample collection. **A.R.** and **Y.F.** run the laboratory work. **A.R.** and **Y.F.** analyzed the data. **A.R.**, **W.S.**, and **Y.F.** wrote the manuscript

## ACKNOWLEDGMENTS

We would like to thank the Head of the Meru Betiri National Park Office and the staff who gave permission and helped during the fieldwork and research. Thanks to the research team for their assistance during sampling, and laboratory examination.



## CONFLICT OF INTEREST

The authors state there is no conflict of interest.

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