



Diversity of Dragonflies (*Odonata*) in Puthuk Panggang Welut Waterfall Area, Mojokerto District

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Abstract

Puthuk Panggang Welut is a natural tourist attraction in Mojokerto Regency, located on the slopes of Mount Penanggungan. The area includes a waterfall as its water source. This study aimed to determine the diversity of dragonflies (*Odonata*) in the Puthuk Panggang Welut Waterfall area. The sampling method employed was a sweeping net. The research conducted in three locations revealed 12 species belonging to six families, comprising 265 individuals. The calculated species diversity value for this location was $H' = 1.52$. The waterfall location recorded 10 species, comprising 54 individuals from five families. The upper stream location exhibited four species, with a total count of 164 individuals from four families. In the lower stream location, there were five species from five families, with 47 individuals. The variation in dragonfly species and individual counts across the three research locations could be attributed to each area's differing vegetation, canopy, and environmental conditions.

Keywords: Diversity, *Odonata*, Vegetation, Habitat

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Introduction

Dragonflies, insects from the Order *Odonata* (Sonia et al., 2022), derive their name from the Greek term "*Odonata*," which refers to their toothed jaws located at the end of the lower lip, characterized by sharp protrusions resembling teeth (Pealeu et al., 2022). *Odonata* is divided into two suborders, *Anisoptera* and *Zygoptera* (Mapi-Ot et al., 2013), distinguished by differences in body morphology (Lino et al., 2019). Generally, *Zygoptera* dragonflies are smaller than *Anisoptera* (Wonglersak, 2021). *Anisoptera* possesses a pair of compound eyes fused and front wings larger than the hind wings, while *Zygoptera* has a pair of separate compound eyes (Salsabiela et al., 2022; Sonia et al., 2022).

Dragonflies undergo imperfect metamorphosis, progressing through the stages of eggs, nymphs, and imagos (Simbolon, 2019). The egg and nymph phases of dragonflies are aquatic, while the adult phase finds them dwelling in terrestrial environments near water sources (Soendjoto, 2016). Typically, dragonflies reproduce by laying eggs in clean water environments, and pollution can disrupt their life cycle, leading to a decline in population (Gultom et al., 2021).

Dragonflies commonly inhabit aquatic ecosystems such as waterfalls and rivers (Husnia et al., 2019), and the presence of these ecosystems affects the species' diversity (Harahap et al., 2022).

Dragonflies play a crucial role in the ecosystem (Lino et al., 2019), acting as predators that maintain the balance of the food chain and serving as bioindicators of water cleanliness (Virgiawan et al., 2016). As natural predators, dragonflies prey on insects smaller than themselves, including aphids, mosquitoes, flies, and other

dragonfly species, earning them the nickname "cannibal insects" (Mubarak et al., 2022). According to Virgiawan et al. (2016), dragonfly nymphs are sensitive to environmental changes, making them valuable as bioindicators. Thus, a decrease in the dragonfly population within an ecosystem can indicate environmental or water quality shifts. Consequently, studying dragonflies can be an early indicator of environmental changes, particularly in tourist areas like waterfalls.

Puthuk Panggang Welut Waterfall, located on the slopes of Mount Penanggungan, is a natural tourist attraction with a water source. The development of infrastructure and increased tourist activity in this area might lead to pollution and environmental changes, posing a threat to the diversity of dragonfly species and the destruction of their natural habitat. Therefore, this study aimed to assess the diversity of dragonflies (*Odonata*) in the Puthuk Panggang Welut Waterfall Area, Nogosari Village, Pacet District, Mojokerto Regency, in response to these challenges.

Research Method

Research Time and Location

The present research on dragonflies was conducted in the Puthuk Panggang Welut Waterfall Area in Nogosari Village, Pacet District, Mojokerto Regency, East Java Province. The research took place on June 25, 2023. Data collection on dragonflies was carried out during their active hours, between 09:00 and 11:00 WIB, as dragonflies are diurnal insects (Firdaushi and Rijal, 2018). The study began by measuring abiotic factors, including temperature, humidity, and light intensity. There were three

research locations, starting from the waterfall tourism site and then exploring

the two river flows: the upper and the lower.

Figure 1

(A) Waterfall Tourism Site; (B) Upper stream; (C) Lower stream



Data Collection Technique

The data collection technique for dragonfly species involved capturing them using an insect net, specifically a sweep net. One representative dragonfly from each species was captured as a sample for identification. The captured dragonfly was subsequently placed in a papilot paper and specimen box. Photographs were taken using a camera to document the dragonflies found at the research site, and the number of species was recorded. The collected data was entered into a table, including the species' names and the corresponding counts. The identification process of the dragonflies was based on the works of Setiyono et al. (2017) and Irawan and

Rahadi (2021). All known dragonfly species were recorded and tabulated for further data analysis.

This study also measured abiotic factors such as temperature, humidity, and light intensity. Temperature and humidity were measured using a thermo hygrometer, while light intensity was calculated using a lux meter. In addition to the abiotic factors, vegetation observations were conducted to gather supporting data. The vegetation observations included recording the types of plants used by dragonflies as perching spots when found at the observation site.

Data Analysis

The data analysis techniques utilized in this study included the Shannon-Wiener diversity index (H'), the dominance index (D), and the evenness index (E). The formulas used for data analysis are as follows:

1. Shannon-Wiener diversity index (Tarihoran et al., 2020):

$$H' = -\sum p_i \ln p_i$$

Notes:

H' = Shannon-Wiener diversity index

$p_i = n_i/N$ (Number of individuals of species *i*/Total number of individuals of all species)

n_i = Number of individuals of species *i*

N = Total number of individuals of all species

2. Simpson's dominance index (D):

$$D = (n_i/N)^2$$

Notes:

D = Simpson's dominance index

n_i = Number of individuals of species *i*

N = Total number of individuals of all species

3. Evenness index (E) (Baderan et al., 2019):

$$E = H' / \ln S$$

Notes:

E = Evenness index

H' = Diversity index

S = Number of species

Research Results and Discussion

The research conducted in the Puthuk Panggang Welut area revealed 12 species from six families: *Calopterygidae*, *Chlorocyphidae*, *Coenagrionidae*, *Corduliidae*, *Euphaidae*, and *Libellulidae* (Table 1). A total of 265 individuals were found, with 54 in the waterfall location, 164 in the upper stream location, and 47 in the lower stream location.

Based on the research findings, the suborder *Zygoptera* consisted of four species from four families: *Calopterygidae*, *Chlorocyphidae*, *Coenagrionidae*, and *Euphaidae*, totaling 235 individuals. On the other hand, the suborder *Anisoptera* had eight species from two families, namely *Corduliidae* and *Libellulidae*, with a total of 30 individuals. The results indicated that suborder *Zygoptera* had more individuals than suborder *Anisoptera*, while suborder *Anisoptera* had a greater species diversity than suborder *Zygoptera*.

In the Puthuk Panggang Welut location, the researchers predominantly observed species from the *Libellulidae* family (Table 1). In this regard, a total of seven species were found, comprising 24 individuals. According to Abdillah et al. (2018), members of the *Libellulidae* family often engage in activities such as hunting, perching, and mating while basking in the sun.

The dominant dragonfly species in this study were *Vestalis luctuosa* (Figure 2-a), with 127 individuals, and *Euphaea variegata* (Figure 2-b), with 69 individuals (Table 1). *Vestalis luctuosa* and *Euphaea variegata* share the same habitat type and are frequently found together at each research site due to their similar habitat requirements and

food sources. However, these two species differ in their perching behavior. *Vestalis luctuosa* primarily uses flight activity for short-distance movement and perching.

Vestalis luctuosa was the only dragonfly species observed in all study sites, totaling 127 individuals. It belongs to the *Calopterygidae* family. The dominance of *Vestalis luctuosa* in the upper stream site could be attributed to its preference for habitats characterized by a closed canopy, with trees lining the stream banks and shrubs. The densely closed canopy provides lower temperature, light intensity, and higher humidity values. Vegetation and closed canopy conditions are typical habitat

types for *Vestalis luctuosa* species. It is consistent with the findings of Nafisah and Soesilohadi (2021), who reported that *Vestalis luctuosa* was frequently observed perching on riparian vegetation.

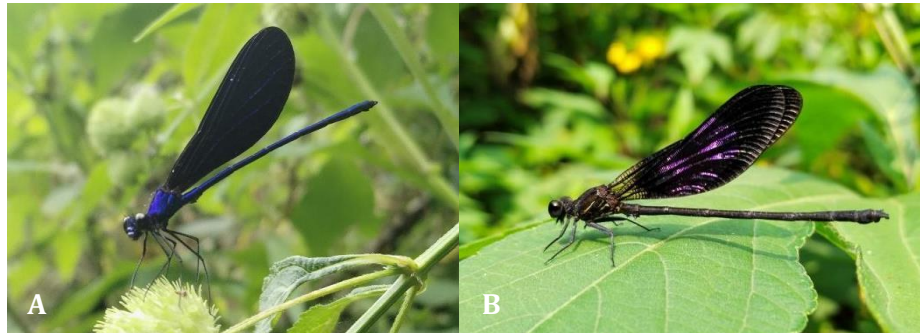
Euphaea variegata, with a total of 69 individuals, was found in each research location. It belongs to the *Euphaidae* family. *Euphaea variegata* is a dragonfly species that inhabits forest rivers with rocky streams and thrives in areas with dense vegetation. It aligns with the observations of Nafisah and Soesilohadi (2021), who noted that *Euphaea variegata* perched on river rocks exposed to high light intensity.

Table 1
Dragonfly Species in the Puthuk Panggang Welut Area

Family	Species	Number of Individuals			
		Waterfall	Upper stream	Lower stream	Total
Zygoptera					
<i>Calopterygidae</i>	<i>Vestalis luctuosa</i>	1	108	18	127
<i>Chlorocyphidae</i>	<i>Heliocypha fenestrata</i>	1	20	3	24
<i>Coenagrionidae</i>	<i>Pseudagrion pruinatum</i>	0	6	9	15
<i>Euphaidae</i>	<i>Euphaea variegata</i>	23	30	16	69
Anisoptera					
<i>Corduliidae</i>	<i>Idionix montana</i>	6	0	0	6
<i>Libellulidae</i>	<i>Orthetrum glaucum</i>	1	0	0	1
	<i>Orthetrum sabina</i>	0	0	1	1
	<i>Orthetrum testaceum</i>	1	0	0	1
	<i>Pantala flavescens</i>	5	0	0	5
	<i>Potamarcha congener</i>	2	0	0	2
	<i>Zygonyx ida</i>	12	0	0	12
	<i>Zygonyx iris</i>	2	0	0	2

Figure 2

(A) *Vestalis luctuosa*; (B) *Euphaea variegata*. (Photo: Dea Ma'rifatul Zahro', 2023)

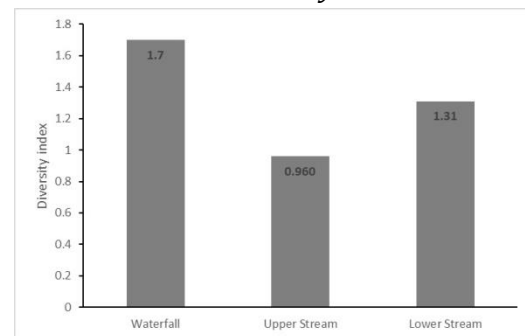


The dragonfly diversity index value in the Puthuk Panggang Welut Waterfall area was $H' = 1.52$ (Figure 3). It indicated that the dragonfly diversity was moderate. This classification aligns with Kurnia et al. (2021), who state that the dragonfly diversity index value can be considered moderate if it falls within the range of $1 < H' < 3$. The dragonfly species diversity value at the waterfall location ($H' = 1.70$) was higher compared to the values at the upper stream location ($H' = 0.96$) and lower stream location ($H' = 1.31$) (Figure 3).

The diversity index value at each location exhibited differences, which might be influenced by the existing number of species. The presence and number of individual dragonfly species varied across the three research locations due to discrepancies in vegetation, canopy, and environmental conditions. This finding is supported by Susanto and Zulaikha (2021), who argue that each species has specific environmental requirements, vegetation preferences, canopy preferences, and habitat types. Therefore, the number of species found in each location in this study differed.

Figure 3

Shannon-Wiener Diversity Index



The evenness index value at the Puthuk Panggang Welut location was $E = 0.61$, which was classified as the high evenness category. It aligns with the findings of Pelealu et al. (2022), who classified values above 0.6 as high evenness. Harahap et al. (2022) also support this statement by stating that locations with high evenness values are more stable than those with low values. Moreover, the dominance index in the Puthuk Panggang Welut area showed a value of $D = 0.31$, suggesting a relatively moderate dominance of dragonflies. The dominance index is crucial in evaluating dominant species within a community. Teristiandi and Riyanto (2021) highlight that higher dominance index values indicate a greater tendency for dragonfly

species to dominate in a given location.

Based on the observations, adult dragonflies were primarily found around the edges of clean and calm flowing waters, consistent with the findings of Putra and Putri (2023), stating that dragonflies preferred habitats with moderate or optimum light intensity. The presence of dragonflies in nature can be influenced by various abiotic factors or climatic elements, such as air temperature, light intensity, and humidity (Aditama and Kurniawan, 2013). Tustiyani et al. (2020) also mention that dragonfly reproduction rates tend to increase at optimum temperatures, which are conducive to breeding. Additionally, temperature, climate, and humidity can affect the

diversity and abundance (Atourrohman et al., 2020).

Microclimate is vital in supporting and sustaining dragonfly populations within their habitats (Susanto and Zulaikha, 2021). The microclimate of a location encompasses air temperature, light intensity, and humidity (Susanto et al., 2022). According to the microclimate data, the upper stream location had lower air temperature and light intensity values (27°C and 1085 lx, respectively) compared to the waterfall location (29°C and 6032 lx) and the lower stream location (30°C and 25283 lx). Additionally, the humidity at the upper stream site (61%) was higher than that at the waterfall (59%) and lower stream sites (53%) (Table 2).

Table 2

Abiotic Factors in the Puthuk Panggang Welut Area

Location	Temperature (°C)	Humidity (%)	Light Intensity (lx)
Waterfall	29	59	6032
Upper stream	27	61	1085
Lower stream	30	53	25283

The open canopy at the waterfall location could create high light intensity, affecting the air temperature. The upper stream location had a closed canopy inhibiting air temperature and light intensity, resulting in high humidity. The lower stream location had an open canopy and many trees, allowing high air temperature and light intensity values with low humidity. According to Susanto and Zulaikha (2021), an open canopy leads to higher light intensity, affecting air temperature, while a closed canopy and the presence of many trees impede air temperature and light intensity, resulting in high humidity values.

The waterfall site had the highest diversity index value, $H' = 1.70$ (Figure 3). It contained 10 species with a total of 54 individuals from five families: *Calopterygidae*, *Chlorocyphidae*, *Corduliidae*, *Euphaidae*, and *Libellulidae*. Accordingly, the *Libellulidae* family dominated by 6 species. In addition, species exclusively found at the waterfall location included *Idionix montana*, *Orthetrum glaucum*, *Orthetrum testaceum*, *Pantala flavescens*, *Potamarcha congener*, *Zygonyx ida*, and *Zygonyx iris* (Table 1). These species were unique to the waterfall location due to its open habitat and specific

environmental conditions. Albab et al. (2019) support this finding, stating that habitat adjustment can affect species abundance.

The waterfall was located at the main water flow of the Puthuk Panggang Welut area, with numerous large stones in the middle. The vegetation and open canopy provided a suitable habitat for various dragonfly species for food and perching. Moreover, the open canopy created high light intensity, influencing the air temperature at the location. The riverbank was dominated by trees, shrubs, and herbaceous plants, including bamboo trees.

Hence, the upper and lower streams locations were calm water streams branching from the waterfall in the Puthuk Panggang Welut Area. The upper stream had the lowest diversity index value, $H' = 0.96$ (Figure 3), due to low light intensity, lack of vegetation, and closed canopy. Four species with a total of 164 individuals were found at this location, belonging to the families of *Calopterygidae*, *Chlorocyphidae*, *Coenagrionidae*, and *Euphaidae*, with *Vestalis luctuosa* being the dominant species (108 individuals). Additionally, the only species found exclusively in the upper stream and lower stream locations, but not in the waterfall area, was *Pseudagrion pruinosum*.

Pseudagrion pruinosum was a damselfly species found at the upper stream site. It belongs to the *Coenagrionidae* family. This species was found in the upper stream location due to the closed canopy, inhibiting air temperature and incoming light intensity, resulting in relatively high humidity. It is supported by Albab et al.

(2019), who argue that dragonflies from the *Coenagrionidae* family inhabit highland streams with high air humidity and clean water. The upper stream site had a habitat dominated by trees and shrubs, such as *Bambusoideae*, *Impatiens sp.*, *Lantana sp.*, *Colocasia sp.*, and *ferns*. *Pseudagrion pruinosum* often lays its eggs in these plants (Sugiman et al., 2019).

The lower stream location had a diversity index value of $H' = 1.31$ (Figure 3). Five species belonging to five families, *Calopterygidae*, *Chlorocyphidae*, *Coenagrionidae*, *Euphaidae* and *Libellulidae*, were found at this location, totaling 47 individuals. The dominant species at the lower stream location was *Vestalis luctuosa*, with 18 individuals. *Orthetrum sabina* was found only at the lower stream location, not at the waterfall or upper stream. It is a very active species that can adapt to clean and less clean water environments, as Setyawati et al. (2017) described.

The lower stream location had an evenness index value of $E = 0.81$, higher than that of the waterfall and upper stream locations. It was because the lower stream location had open vegetation and canopy, allowing dragonfly species to forage and roost there. The open canopy and the presence of trees and shrubs, such as *Mimosa sp.*, *Chromolaena sp.*, *Impatiens sp.*, and *ferns*, contributed to the favorable conditions at the edge of the Lower stream, where sunlight could enter.

Conclusion

Based on the findings, it can be concluded that the Puthuk Panggang Welut Waterfall Area was home to 12 species of dragonflies, comprising 265 individuals.

The dominant species observed in the study was *Vestalis luctuosa*, with a count of 127 individuals. The diversity index of dragonfly species at the waterfall location ($H' = 1.70$) was higher compared to the upper stream location ($H' = 0.96$) and the lower stream location ($H' = 1.31$). The overall species diversity index in the Puthuk Panggang Welut Waterfall Area was calculated to be $H' = 1.52$, indicating moderate dragonfly diversity. In this regard, temperature, light intensity, and humidity were identified as some of the factors influencing dragonfly diversity and abundance.

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