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ARTICLE

DIVERSITY OF ODONATA IN NATURAL AND ARTIFICIAL LAKE HABITATS IN SERANG, BANTEN

[*Keanekaragaman Odonata pada Habitat Danau Alami dan Danau Buatan di Wilayah Serang, Banten*]

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ABSRACT

Indonesia is recognized as one of the countries with high biodiversity, including insects from the order Odonata, which consists of dragonflies (Anisoptera) and damselflies (Zygoptera). However, information on Odonata biodiversity in freshwater habitats in the Serang region of Banten Province remains limited. This study aims to describe and analyze Odonata diversity and community structure in two lake habitat types, namely an artificial lake and a natural lake. Sampling was conducted over eight days using an exploratory survey and direct collection method with an insect net, with observations carried out in the morning (08:00-10:00 WIB) and afternoon (15:00-17:00 WIB). Environmental factors measured included temperature, humidity, wind speed, and surrounding vegetation. A total of 10 Odonata species comprising 189 individuals were recorded. The natural lake was strongly dominated by *Orthetrum sabina* (85.71%), whereas the artificial lake was dominated by *Agriocnemis pygmaea* (33.61%). The artificial lake showed biodiversity index values of D = 0.241, H′ = 1.644, E = 0.714, and Dmg = 1.883, while the natural lake showed D = 0.7449, H′ = 0.509, E = 0.463, and Dmg = 0.47. These results indicate that the artificial lake has moderate diversity with relatively even species distribution, whereas the natural lake shows strong species dominance and lower diversity. Overall, the artificial lake provides more suitable habitat conditions for supporting Odonata diversity, highlighting the importance of habitat heterogeneity in freshwater ecosystems.

Keywords: Banten, Biodiversity, Lake, Serang, Odonata

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ABSTRAK

Indonesia dikenal sebagai salah satu negara dengan keanekaragaman hayati tinggi, termasuk serangga dari ordo Odonata yang terdiri atas capung (Anisoptera) dan capung jarum (Zygoptera). Namun, informasi mengenai keanekaragaman Odonata pada habitat perairan tawar di wilayah Serang, Provinsi Banten, masih terbatas. Penelitian ini bertujuan untuk mendeskripsikan dan menganalisis keanekaragaman serta struktur komunitas Odonata pada dua tipe habitat danau, yaitu danau buatan dan danau alami. Pengambilan sampel dilakukan selama delapan hari menggunakan metode survei eksploratif dan penangkapan langsung dengan jaring serangga, dengan waktu pengamatan pada pagi hari (08.00-10.00 WIB) dan sore hari (15.00-17.00 WIB). Faktor lingkungan yang diukur meliputi suhu, kelembapan, kecepatan angin, dan kondisi vegetasi di sekitar perairan. Hasil penelitian mencatat sebanyak 10 spesies Odonata dengan total 189 individu. Danau alami didominasi oleh Orthetrum sabina (85,71%), sedangkan danau buatan didominasi oleh Agriocnemis pygmaea (33,61%). Nilai indeks keanekaragaman pada danau buatan adalah D = 0,241, H′ = 1,644, E = 0,714, dan Dmg = 1,883, sedangkan pada danau alami adalah D = 0,7449, H′ = 0,509, E = 0,463, dan Dmg = 0,47. Hasil ini menunjukkan bahwa danau buatan memiliki tingkat keanekaragaman sedang dengan distribusi individu yang relatif merata, sedangkan danau alami menunjukkan dominansi spesies yang tinggi dengan keanekaragaman yang lebih rendah. Secara keseluruhan, danau buatan memberikan kondisi habitat yang lebih sesuai dalam mendukung keanekaragaman Odonata, yang menegaskan pentingnya heterogenitas habitat dalam menjaga keberagaman hayati pada ekosistem perairan tawar.

***Kata Kunci**: Banten, Biodiversitas, Danau, Odonata, Serang*

INTRODUCTION

Indonesia is recognized as one of the world's megadiverse countries, possessing several regions with exceptionally high biodiversity due to its complex geographical and geological conditions (von Rintelen *et al.,* 2017). Insects represent the most diverse group of animals, contributing significantly to global biodiversity (Wajnberg & Desouhant, 2018). Among insect groups, the order Odonata, which consists of dragonflies (Anisoptera) and damselflies (Zygoptera), is widely known for its ecological importance and high diversity in tropical regions.

Odonata are commonly used as bioindicators of environmental quality because they are highly sensitive to habitat changes, particularly in aquatic ecosystems (Oliveira-Junior *et al.,* 2022). In addition, they play an important role in maintaining ecosystem balance by acting as predators of pests and mosquitoes (Magsalay *et al.,* 2024). Most stages of their life cycle occur in freshwater habitats, making them strongly dependent on water quality and surrounding vegetation (Choong *et al.,* 2020).

Lakes, both natural and artificial, provide important habitats for Odonata. Natural lakes generally have more complex ecological structures, including diverse vegetation and relatively stable environmental conditions. In contrast, artificial lakes are often influenced by anthropogenic activities, resulting in differences in habitat structure and water quality (Richmond *et al.,* 2024). These differences can affect the diversity, abundance, and distribution of Odonata communities (Beaujour *et al.,* 2024). In addition, habitat quality and surrounding environmental factors such as vegetation structure and water conditions are important determinants of Odonata diversity (Gieser *et al.,* 2025).

Several studies on Odonata diversity have been conducted in Indonesia. Fitriana (2016) reported 15 Odonata species with a Shannon–Wiener diversity index (H′) of 2.41 in Situ Pamulang, South Tangerang. Rachmawati *et al.* (2024) recorded 26 species in the Rawa Danau Nature Reserve, Serang, indicating moderate to high diversity levels. Previous studies have shown that habitat characteristics influence the composition of Odonata communities (von Plüskow *et al.,* 2025). Environmental gradients also play an important role in shaping species distribution and diversity patterns (Seemab *et al.,* 2025). However, most previous studies focused on single habitat types or conservation areas and did not specifically compare Odonata diversity between natural and artificial lakes.

These limitations indicate a knowledge gap regarding how different lake types influence Odonata communities, particularly in the Banten region. Therefore, this study aims to inventory

Odonata species and analyze species diversity, dominance, evenness, and richness in two freshwater habitat types, namely natural and artificial lakes in the Serang area.

MATERIALS AND METHODS

This study was conducted in the Serang region, Banten Province, at two aquatic habitats: a natural lake located in Rancasanggal Village, Cinangka District, and an artificial lake at Campus 2 of Sultan Maulana Hasanuddin State Islamic University of Banten, Curug District (Figure 1). The study was carried out over eight sampling days between 27 September and 9 November 2025. Observations were conducted in the morning (08:00–10:00 WIB) and afternoon (15:00–17:00 WIB), corresponding to the active periods of Odonata. Sampling at the artificial lake was conducted on 27–28 September and 4–5 October 2025, while sampling at the natural lake was conducted on 1–2 November and 8–9 November 2025. Although observations were conducted at two different times of day, all individuals recorded were pooled and analyzed as total counts for each habitat. The artificial lake covered an area of approximately 3,892.75 m², whereas the natural lake covered approximately 18,088.56 m². Sampling was conducted using a free-ranging (exploratory) capture method around the lake edges without the use of fixed transects. Sampling points were determined purposively based on the presence of vegetation, water margins, and visible Odonata activity to ensure representative habitat coverage.

Odonata specimens were collected through direct capture using an insect net and were subsequently identified in the Biology Laboratory, Faculty of Science and Technology, Sultan Maulana Hasanuddin State Islamic University of Banten, using reference books by Orr (2005) and Kalkman & Orr (2013). Environmental parameters measured included air temperature, humidity, wind speed, and surrounding vegetation conditions. Data were analyzed using descriptive and quantitative approaches, including the calculation of relative abundance and ecological indices, namely Simpson’s dominance index, Shannon–Wiener diversity index, Shannon evenness index, and Margalef richness index. The sampling period occurred during a transitional season from the dry to the rainy season, characterized by warm conditions with occasional rainfall, which may have influenced Odonata activity. It should be noted that the relatively short sampling duration (eight days) represents a limitation of this study, as it may not fully capture temporal variations in species diversity and abundance.

Figure 1. (A) Banten Province; (B) Research locations at the natural lake, point 1 (-6.1819, 105.9253, 90 masl), and at the artificial lake, point 2 (-6.1829, 106.1559, 68 masl) *((A) Provinsi Banten; (B) Lokasi penelitian di danau alami, titik 1 (-6.1819, 105.9253, 90 mdpl), dan di danau buatan, titik 2 (-6.1829, 106.1559, 68 mdpl)*).

Data Analysis

The data were analyzed using four main ecological indices, namely:

Simpson's Dominance Index

Simpson's Dominance Index was used to determine the dominance level of species within the community by estimating the probability that two individuals randomly selected from a sample belong to the same species.

$$D = \frac{\sum n_i(n_i - 1)}{N(N - 1)}$$

Where n_i is the number of individuals of species i, and N is the total number of individuals. Values approaching 1 indicate high dominance, whereas values near 0 indicate low dominance (Morris *et al.,* 2014).

Shannon-Wiener Diversity Index (H')

The Shannon–Wiener Diversity Index was used to measure species diversity by considering both species richness and the proportional abundance of each species, providing an estimate of community complexity.

$$H' = \Sigma \text{ pi 1n pi, with pi} = \frac{ni}{N}$$

Where p_i is the proportion of individuals of species i. Values of $H' < 1$ indicate low diversity, values between 1–3 indicate moderate diversity, and values > 3 indicate high diversity (Spellerberg & Fedor, 2003).

Shannon Evenness Index (E)

The Shannon Evenness Index was used to assess how evenly individuals are distributed among species within the community.

$$E = \frac{H'}{In\, S}$$

Where H′ is the Shannon diversity index and S is the total number of species. Values range from 0 to 1, where values close to 1 indicate high evenness and values close to 0 indicate low evenness (Tumisto, 2012).

Margalef Richness Index (Dmg)

Margalef Richness Index was used to measure species richness based on the number of species relative to the total number of individuals.

$$Dmg = \frac{(S - 1)}{In\,(N)}$$

Where S is the total number of species and N is the total number of individuals. Values < 2 indicate low richness, values between 2-4.9 indicate moderate richness, and values > 5 indicate high richness (Margalef, 1958).

RESULTS

Based on the capture results at the artificial lake, a total of 119 individuals were recorded, consisting of 10 Odonata species belonging to two suborders, Anisoptera and Zygoptera, each represented by five species (Figure 2). The Zygoptera suborder was dominated by *Agriocnemis pygmaea* with a relative abundance of 33.61%, followed by *Agriocnemis femina* at 16.81%, while

Pseudagrion microcephalum, Copera marginipes, and *Ceriagrion glabrum* were found in lower numbers. In the Anisoptera suborder, *Orthetrum sabina* was the most abundant species 29.41%, followed by *Crocothemis servilia, Tholymis tillarga, Brachythemis contaminata,* and *Diplacodes trivialis*, each with low relative abundances ranging from 0.84% to 2.52%. Meanwhile, at the natural lake, 70 individuals were recorded, consisting of only 3 dragonfly species, all belonging to the Anisoptera suborder. The most dominant species was *Orthetrum sabina* with a relative abundance of 85.71%, whereas *Crocothemis servilia* and *Tholymis tillarga* each accounted for only 7.14% (Table 1).

Table 1. Relative Abundance of Odonata Species

Suborder *(Subordo)*	**Family** *(Famili)*	**Species** *(Spesies)*	**Abundance** *(Kelimpahan)*		**Relative Abundance** *(Kelimpahan Relatif)*		**Total** *(Total)*
			Artificial *(Buatan)*	**Natural** *(Alami)*	**Artificial** *(Artificial)*	**Natural** *(Alami)*	
Anisoptera	Libellulidae	*Brachythemis contaminata*	3	-	2.52%	-	3
		Crocothemis servilia	12	5	10.08%	7.14%	17
		Diplacodes trivialis	1	-	0.84%	-	1
		Orthetrum sabina	35	60	29.41%	85.71%	95
		Tholymis tillarga	5	5	4.20%	7.14%	10
Zygoptera	Coenagionidae	*Agriocnemis femina*	20	-	16.81%	-	20
		Agriocnemis pygmaea	40	-	33.61%	-	40
		Ceriagrion glabrum	1	-	0.84%	-	1
		Pseudagrion microcephalum	1	-	0.84%	-	1
	Platycnemididae	*Copera marginipes*	1	-	0.84%	-	1

The biodiversity indices show that in the artificial lake, the Simpson Dominance Index value of 0.241 indicates the absence of a single species that strongly dominates the community. This is consistent with the Shannon Diversity Index value of 1.644, which reflects a moderate level of diversity, as well as the Shannon–Wiener Evenness Index value of 0.714, indicating that individuals are relatively evenly distributed among species. In addition, the Margalef Index value of 1.883 represents low to moderate species richness in the habitat. In contrast, in the natural lake, the higher Simpson Dominance Index value of 0.7449 suggests a tendency toward dominance by a particular species. This aligns with the Shannon Diversity Index value of 0.509, which indicates low diversity, and the Evenness Index value of 0.463, showing that the distribution of individuals among species is less even. The Margalef Index value of 0.47 further confirms that species richness in the natural lake is relatively low (Table 2).

Representative dragonfly and damselfly species observed in this study are illustrated (Figure 2).

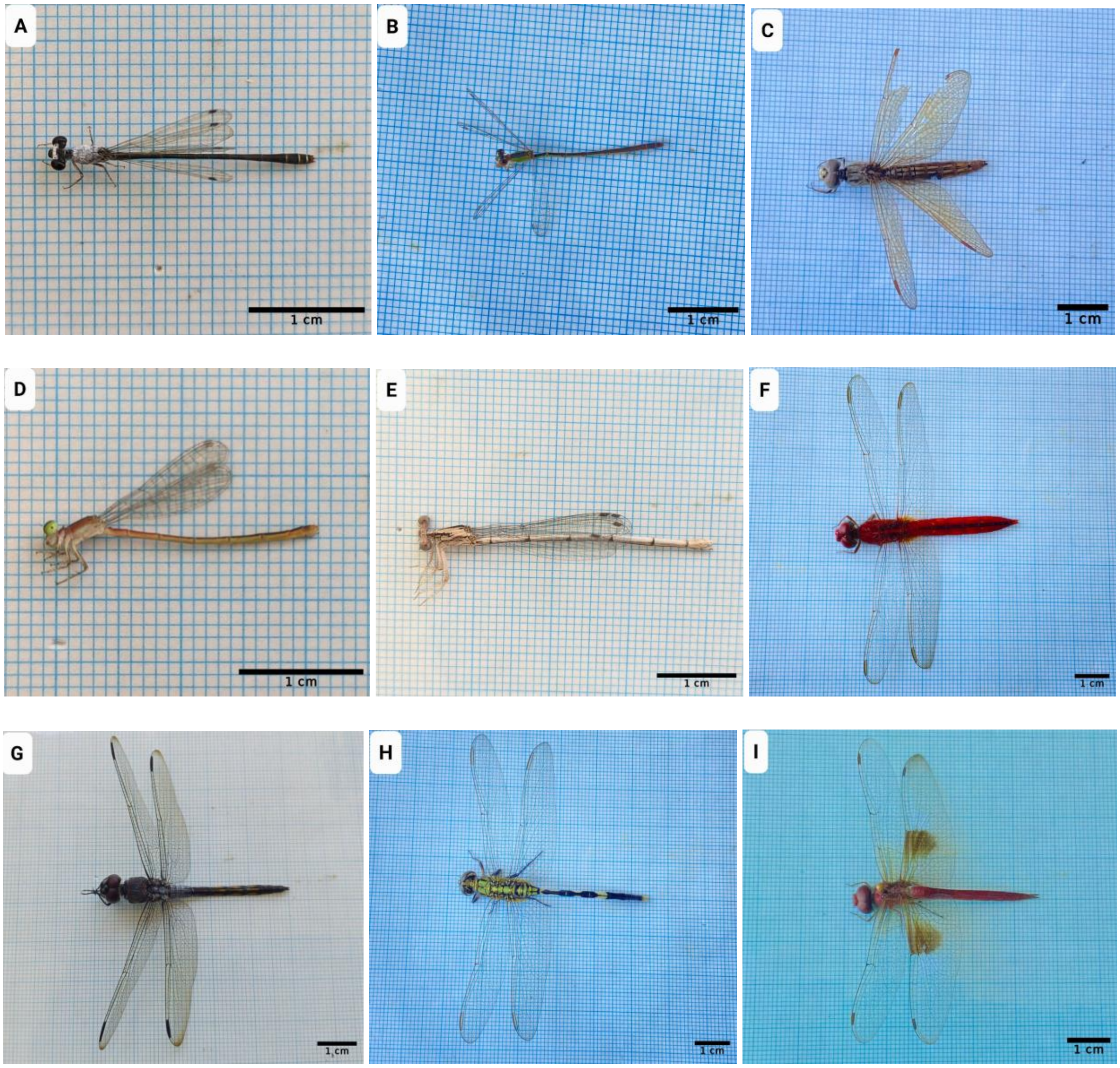

Figure 2. Representative dragonfly and damselfly species recorded in artificial and natural lakes (*Spesies capung dan damselfly yang representatif tercatat di danau buatan dan alami*).
Remark (*Keterangan*): (A) *Agriocnemis femina*; (B*) Agriocnemis pygmaea*; (C) *Brachythemis contaminata*; (D) *Ceriagrion glabrum;* (E*) Copera marginipes;* (F) *Crocothemis servilia;* (G) *Diplacodes trivialis;* (H) *Orthetrum sabina;* (I) *Tholymis tillarga.*

Table 2. Indices of Diversity, Evenness, Dominance, and Species Richness of Odonata (*Indeks Keanekaragaman, Kemerataan, Dominasi, dan Kekayaan Spesies Odonata*).

Biodiversity Index *(Indeks Biodiversitas)*	**Artificial Lake** *(Danau Buatan)*	**Natural Lake** (*Danau Alami*)
Simpson Dominance Index *(Indeks Dominansi Simpson)*	0.241	0.7449
Shannon Diversity Index *(Indeks Keanekaragaman Shannon)*	1.644	0.509
Shannon Evenness Index *(Indeks Kemerataan Evennes)*	0.714	0.463
Margalef Index *(Indeks Kekayaan Margalef)*	1.883	0.47

The measurement results of environmental factors at the artificial lake showed that the average temperature was around 29.4°C, with an average humidity of 55.3% and an average wind speed of 0.91 m/s. The area surrounding the artificial lake was dominated by vegetation consisting of shrubs and grasses growing densely along the water's edge. The vegetation structure tended to be homogeneous and lacked canopy cover, allowing the area to receive direct sunlight throughout the day. Meanwhile, the environmental measurements at the natural lake revealed an average temperature of around 28.9°C, with an average humidity of 72.2% and an average wind speed of 1.55 m/s. The area around the natural lake was characterized by the presence of trees along the shoreline with a canopy that was not too dense, allowing sunlight to still penetrate to the ground surface. This vegetation structure created varying light conditions, ranging from semi-shaded areas to more open sections (Table 3).

Table 3. Environmental Condition (*Kondisi Lingkungan*).

Environmental Factors *(Faktor Lingkungan)*	**Location** *(Lokasi)*	
	Artificial *(Buatan)*	**Natural** *(Alami)*
Average Temperature (°C) *(Rata-rata Suhu (°C))*	29.4	28.9
Average Humidity(%) *(Rata-rata Kelembapan (%))*	55.3	72.2
Average Wind Speed (m/s) **(***Rata-rata Kecepatan Angin*	0.91	72.2
Land Condition *(Kondisi Lahan)*	Abundant shrubs and grasses, with no canopy cover (Figure 3B)	Trees with a loosely spaced canopy, accompanied by shrub vegetation and sparse grasses (Figure 3A)

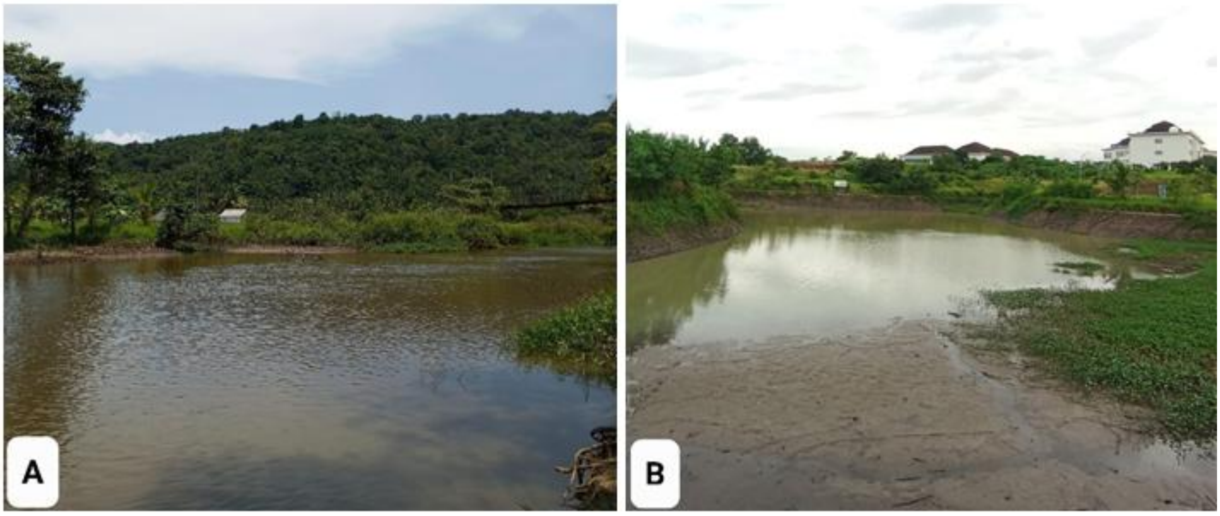

Figure 3. (A) Natural Lake; (B) Artificial Lake *((A) Danau Alami; (B) Danau Buatan*).

DISCUSSION

The species most commonly found in the artificial lake were *Agriocnemis pygmaea, Orthetrum sabina,* and *Agriocnemis femina* (Table 1; Figure 2). The dominance of *Orthetrum sabina* in the natural lake indicates its high ecological tolerance and ability to persist under varying environmental conditions (Table 3). This pattern suggests that the natural lake environment favors generalist species capable of adapting to broader ecological ranges, leading to reduced community evenness. Although morphological traits such as green body coloration with black striping provide camouflage and support thermoregulation, these features primarily contribute to ecological adaptability rather than merely serving as descriptive characteristics. This is consistent with findings that *O. sabina* exhibits high adaptability across different habitat types due to its physiological and behavioral flexibility (Novella-Fernandez *et al.,* 2023). Furthermore, the ability of this species remain active across a wide range of temperature, humidity, and wind conditions supports its dominance in environments with fluctuating microclimates (Lantang *et al.,* 2023).

Agriocnemis pygmaea was one of the most abundant species in the artificial lake (Table 1; Figure 2B). Its dominance is closely related to its ecological preference for sheltered and humid microhabitats, particularly in areas with dense vegetation (Table 3). Due to its small body size, this species is less tolerant of high wind exposure and is typically found in protected areas around the lake rather than open spaces. The small body size of *A. pygmaea* allows rapid heat absorption under sunlight but also increases the risk of water loss, making humid and calm environments more suitable for its survival (Joshi & Agashe, 2020). These characteristics indicate that morphological traits play an important role in shaping species responses to environmental conditions. The relationship between morphological traits and environmental gradients further explains the distribution patterns of Odonata across different habitat conditions (Bastos *et al.,* 2021).

Agriocnemis femina was frequently found among aquatic plants along the lake margin (Table 1; Figure 2A), indicating its association with vegetated microhabitats (Table 3). Its relatively small body size is likely to influence its distribution in more sheltered areas with lower environmental exposure. According to Paul *et al.* (2022), *A. femina* has a body size slightly larger than *A. pygmaea,* with males measuring 27–30 mm and females 29–32 mm, and hindwing widths of 17–20 mm. The species is characterized by a dark greenish to metallic black body with distinct dorsal markings and is typically found in humid environments along water edges. These observations suggest that vegetation structure and microhabitat conditions play an important role in supporting the presence of this species. Environmental heterogeneity, particularly in riparian vegetation, provides diverse microhabitats and ecological niches that influence the distribution and composition of Odonata communities (Kaltas *et al.,* 2025).

Meanwhile, species represented by only a single individual included *Diplacodes trivialis, Copera marginipes, Ceriagrion glabrum,* and *Pseudagrion microcephalum,* all of which were recorded exclusively in the artificial lake (Table 1). The low abundance of these species suggests that the artificial lake may not fully meet their ecological requirements, limiting their distribution and persistence. Some species, such as *D. trivialis*, are known to occur in open and disturbed habitats, but their low numbers indicate that environmental conditions such as humidity and wind exposure may not be consistently suitable (Ilhamdi *et al.,* 2020). In contrast, Zygoptera species including *C. marginipes, C. glabrum, and P. microcephalum* generally require more stable and humid microhabitats with adequate vegetation cover, making them more sensitive to environmental changes. This sensitivity is reflected in their low abundance, suggesting that the artificial lake provides limited habitat complexity and fewer suitable microhabitats to support these species under optimal conditions (Asrori *et al.,* 2023).

The differences in Odonata community structure between the artificial and natural lakes indicate variation in environmental quality between the two habitats. The artificial lake showed higher diversity and evenness, suggesting more balanced environmental conditions that support a wider range of species with different ecological requirements. This pattern indicates that environmental heterogeneity, including variation in vegetation structure and microhabitat conditions, plays an important role in increasing habitat suitability and allowing multiple species to coexist. This finding is consistent with Huikkonen *et al.* (2019), who reported that Odonata diversity increases in habitats with more complex environmental characteristics and heterogeneous conditions. Similar patterns have been observed in artificial water bodies, which can function as effective alternative habitats for Odonata due to their rapid colonization ability, allowing them to support considerable species richness when environmental conditions are maintained (Vilenica *et al.,* 2020). Furthermore, habitat heterogeneity, particularly the presence of diverse aquatic vegetation, plays a key role in shaping community structure by providing a range of microhabitats that support species with different ecological requirements (Vilenica *et al.,* 2024).

In contrast, the natural lake exhibited a more homogeneous habitat in terms of vegetation cover, humidity, and light intensity. Such uniform conditions tend to support generalist species with broad ecological tolerance, resulting in the dominance of a single species that limits the establishment of others. This pattern is consistent with Koparde *et al.* (2015), who reported that dominance by particular taxa commonly occurs in habitats with simple environmental structure, where limited niche availability and uniform physical conditions reduce overall Odonata diversity. Similar findings have been reported in tropical lake ecosystems, where homogeneous environmental conditions act as strong environmental filters, favoring species with wide tolerance ranges and functional adaptability, thereby promoting dominance patterns within the community (Olive *et al.,* 2025).

Habitat heterogeneity thus serves as a key factor explaining the differences in Odonata community structure between the two habitats. The artificial lake, characterized by more open areas, lower vegetation cover, and greater variation in temperature and humidity, supports higher diversity and evenness, indicating more favorable environmental conditions for a wider range of species. These conditions suggest that the artificial lake provides better habitat quality in terms of supporting species diversity and reducing dominance. In contrast, the natural lake, with more uniform vegetation structure and relatively stable, shaded, and humid microhabitats, exhibits lower diversity and higher dominance, indicating that environmental conditions tend to favor only certain tolerant species. This pattern suggests that, although the natural lake may provide stable conditions, it is less suitable for maintaining a diverse Odonata community. Therefore, variation in vegetation structure, microclimatic conditions, and habitat complexity plays a crucial role in determining environmental quality and shaping Odonata diversity, with the artificial lake showing more optimal conditions for supporting biodiversity in this study.

CONCLUSION

Based on the results of this study, a total of 10 Odonata species comprising 189 individuals were successfully recorded from two freshwater habitat types in the Serang area, namely artificial and natural lakes. The analysis of community structure showed clear differences between the two habitats. The artificial lake exhibited moderate diversity, higher evenness, and greater species richness, indicating a more balanced community structure. In contrast, the natural lake showed lower diversity, lower evenness, and higher dominance, reflecting an uneven community with strong dominance by a single species. These differences demonstrate that habitat type significantly influences Odonata community characteristics, particularly in terms of diversity, dominance, evenness, and richness. Overall, the artificial lake provides more suitable environmental conditions for supporting Odonata diversity compared to the natural lake, as reflected by the ecological indices analyzed in this study.

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AUTHOR CONTRIBUTIONS

RAJ: Developed the research concept, verified the research findings, revised the manuscript; ANH: Collected research data, drafting the article; RO: Collected research data, drafting the article; AMF: Collected research data, drafting the article; AFF: Collected research data, drafting the article.

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