Research Article
Tropical Animals

Dragonfly (*Odonata*) Diversity and Ecological Indicators across Riparian Habitats of the Segara Kenjeran River, Surabaya

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Abstract: Urbanization and habitat fragmentation threaten biodiversity and contribute to ecological imbalance, particularly in freshwater ecosystems. Dragonflies (*Odonata*), which are highly sensitive to environmental changes, serve as reliable indicators of aquatic ecosystem health. However, research on *Odonata* diversity in urban rivers remains limited, including in Surabaya. This study aims to determine dragonfly species diversity and identify habitat-related factors influencing their distribution along the Segara Kenjeran River. A quantitative ecological survey was conducted at three observation stations with differing habitat characteristics. Data were collected using the Visual Encounter Survey technique, enabling direct identification and counting of individuals in the field. Sampling took place from October to November 2022 under similar weather conditions to reduce environmental variability. The three stations were selected based on variations in vegetation structure, shading, canopy cover, and riverbank conditions. Station 3 exhibited the highest species diversity and abundance, while Station 1 had the lowest. Dominant species across all stations included *Orthetrum sabina* and *Pantala flavescens*, both known for broad ecological tolerance. Environmental measurements showed that dissolved oxygen (DO) levels were highest at Station 3, whereas biochemical oxygen demand (BOD) was lowest, indicating better water quality. These results align with dragonfly preference for well-oxygenated habitats. Shannon Wiener diversity indices confirmed the observed patterns, highlighting more stable ecological conditions at Station 3. Overall, the Segara Kenjeran River supports moderate *Odonata* diversity, shaped by environmental factors such as DO levels, vegetation, and water flow. Continued monitoring is recommended to track ecological changes in this urban river system.

Introduction

Biodiversity plays a critical role in sustaining ecosystem function and providing essential services to human societies, including food, medicine, and environmental regulation. Among the diverse organisms that contribute to ecosystem health, insects, particularly *Odonata* (dragonflies and damselflies), serve as both predators and sensitive bioindicators of freshwater quality (1). In rapidly urbanizing regions, such as Surabaya City in East Java, Indonesia, aquatic habitats are increasingly threatened by pollution, habitat conversion, and anthropogenic disturbances (2). However, despite these pressures, scientific information on *Odonata* assemblages in Surabaya's riparian systems remains limited, creating uncertainty about how urban environmental changes influence local dragonfly communities. Additionally, available data on *Odonata* diversity in urban freshwater systems remain fragmented, limiting efforts to assess ecological health and implement targeted conservation strategies (3).

Indonesia, as a megadiverse country, harbors approximately 750 known species of dragonflies, with around 172 species documented on the island of Java alone. However, localized studies show considerable variation in diversity and community structure depending on environmental factors such as water quality, vegetation, light intensity, and land use. For instance, research in various freshwater sources in East Java has reported moderate diversity indices ranging from 1.22 to 2.28. These findings highlight both the sensitivity of *Odonata* communities to environmental degradation and reveal that previous studies have primarily focused on agricultural or semi-natural freshwater habitats, leaving limited understanding of how *Odonata* respond within urban riparian systems (4). In the Segara Kenjeran watershed, a relatively undisturbed urban stream system with vegetative cover and adjacent rice fields, the potential for dragonfly habitation remains high but underexplored, and the site represents one of the few semi-natural freshwater corridors remaining in the city making it ecologically important and scientifically relevant for biodiversity assessment (5).

To address this gap, the present study investigates species richness, diversity, evenness, dominance, and frequency of *Odonata* in the Segara Kenjeran River area, Sukolilo District, Surabaya. Using an adapted Visual Encounter Survey method across three observation stations, this research provides quantitative ecological data that contribute to baseline information on urban freshwater biodiversity. The results are expected to enhance ecological monitoring in urban river systems, support conservation planning, and clarify the ecological roles of dragonflies in riparian habitats. Overall, this study addresses the need for localized biodiversity data in urban river corridors and offers scientific insights relevant to freshwater ecosystem management.

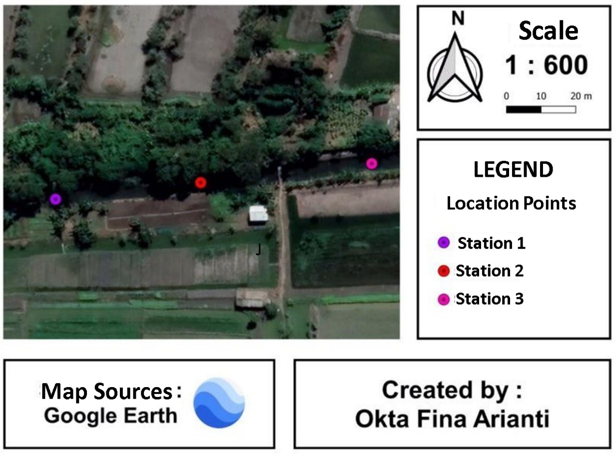

Figure 1. Research area location map, Pura Segara Kenjeran River, Surabaya.

Methodology

Study Design and Site Description

This study used a quantitative ecological survey to assess species richness, abundance, and community composition of adult *Odonata* in an urban riverine ecosystem. The survey covered a 5-km section of the Segara Kenjeran River, Sukolilo, Surabaya, East Java, flanked by rice fields, shrubs, and semi-natural tree cover. Located away from dense settlements and with minimal human disturbance, the area provides a suitable habitat for dragonflies and is appropriate for biodiversity monitoring. **Figure 1** presents a georeferenced map illustrating station distribution and sampling layout.

To capture habitat variation, three observation stations were established along the study area. Station 1 represented a lentic environment characterized by slow-moving or stagnant water, sparse ground vegetation, and partial canopy cover, resulting in moderate light penetration and relatively stable microclimatic conditions. Station 2 was located in a lotic section with flowing water, dense understory vegetation, the presence of a small adjacent pond, and considerable canopy coverage, creating a more heterogeneous habitat with higher structural complexity and reduced light intensity. Station 3 consisted of a lentic zone bordered by well-developed riparian vegetation and an open canopy, allowing greater sunlight exposure and promoting higher primary productivity. These contrasting physical and vegetative characteristics among stations provided a basis for comparative analysis of species diversity, abundance, and community composition under varying hydrological and environmental conditions, thereby enhancing the robustness of ecological interpretation.

Sampling Method and Criteria

Adult *Odonata* were surveyed using the Visual Encounter Survey (VES) method, a standardized observational technique widely applied for active, diurnal flying insects, including dragonflies and damselflies. The method involved direct visual identification and manual counting of individuals encountered along the sampling transect.

Sampling was conducted from October to November 2022, with two repetitions per station each month, resulting in 12 total sampling events (3 stations × 2 repetitions × 2 months). Each survey followed a fixed 200-m transect with a 5-m observation width on both sides of the riverbank. A standardized 60-minute observation period was applied per transect to maintain equal sampling effort across sites.To reduce observer bias, all surveys were conducted by a single trained observer, with species identifications verified using photographic records. Sampling was limited to peak activity h (07:00–15:00) under clear and stable weather conditions, and microclimatic parameters (temperature, humidity, and light intensity) were recorded at each session.

Materials and Identification Tools

Speciesi dentification was conducted in situ using established field guides specific to Southeast Asian *Odonata* (6), which provided detailed morphological keys for accurate taxonomic classification. To support visual observations, binoculars were used to aid in the identification of individuals located at a distance, while entomological nets were occasionally employed to capture specimens for close examination when field identification proved inconclusive. Digital cameras were used to document species characteristics and create a photographic reference library, particularly for species requiring post-field verification. All observation data, including species counts and behavioral notes, were recorded in structured field notebooks. To ensure spatial precision, GPS devices were used to log the geographical coordinates of each sampling point, facilitating habitat-based analysis and replication of the study.

In addition to biological observations, abiotic environmental parameters were measured concurrently to provide ecological context for species presence and distribution. Air temperature was recorded using a digital thermometer, relative humidity was measured with a hygrometer, and light intensity was quantified using a lux meter. These microclimatic variables were documented during each sampling session at all stations to support the interpretation of habitat conditions and their potential influence on *Odonata* diversity and activity patterns.

Data Processing and Analysis

Species richness (S), individual abundance (N), and community indices were computed per station. The first stage involved calculating community structure indices using standard ecological equations, including the Shannon–Wiener Diversity Index (H′), Pielou's Evenness Index (E), Simpson's Dominance Index (D), and the Frequency of Occurrence (FO), as presented in **Equations 1**-**4**.

The frequency of occurrence (FO) classification used in this study (Very Rare, Rare, Frequent, Very Frequent)

$$\mathbf{H'} = -\sum(\frac{\mathbf{n_i}}{\mathbf{N}} \ln \frac{\mathbf{n_i}}{\mathbf{N}})$$

Equation 1 | H' = Diversity Index, ni Number of individuals of a species, N = Total number of individuals of all species.

$$\mathbf{E} = \frac{\mathbf{H'}}{\ln \mathbf{S}}$$

Equation 2 | E = Evenness Index, H' = Diversity Index, S = Number of species.

$$\mathbf{D} = \sum(\frac{\mathbf{n_i}}{\mathbf{N}})^2$$

Equation 3 | D = Dominance Index, ni = Number of individuals of a species, N = Total number of individuals of all species.

$$\mathbf{F} = \frac{\mathbf{n}}{\mathbf{N}} \times \mathbf{100\%}$$

Equation 4 | FO = Frequency of Occurrence, ni = Number of sampling sites where a species is found, N = Total number of sampling sites.

was adapted from approaches commonly applied in ecological community research where species distribution and relative abundance distinguish commonness and rarity**.** Rare species are generally defined as those representing less than 5% of individuals or occurring in less than 10% of sampling sites (7). This framework is appropriate for assessing *Odonata* assemblages within urban freshwater ecosystems, where spatial occurrence patterns are key to evaluating ecological responses to environmental change. All statistical and index calculations were performed using Microsoft Excel software. After obtaining the Diversity Index (H'), Evenness Index (E), Dominance Index (D), and Frequency of Occurrence (FO), the results were compared across the three sampling locations.

Ethical Considerations

No endangered or protected species were collected, and all observations were non-invasive. As the research involved an observational study of invertebrates in public natural settings, no specific ethical approval was required. However, the study adhered to institutional guidelines for ethical research and biodiversity conservation best practices.

Result and Discussion

Odonata Diversity

A total of 12 dragonfly species from two families, *Libellulidae* (Anisoptera) and *Coenagrionidae* (Zygoptera), were recorded across the three sampling stations along the Segara Kenjeran River, totaling 1,561 individuals. Station 1 hosted 9 species with 530 individuals, dominated by *Ischnura senegalensis* (192 individuals). Its moderate diversity (H’ = 1.58) may be linked to partial canopy openness that allows sufficient sunlight for foraging, benefiting sun-dependent Anisoptera. Station 2 supported 8 species with 443 individuals (H’ = 1.56), with *I. senegalensis* again dominant. The lower diversity compared to other stations may be due to dense canopy cover that limits light penetration, reducing habitat suitability for some species. Station 3 recorded the highest richness and abundance (10 species, 588 individuals, H’ = 1.70). Its open canopy and abundant riparian vegetation likely provide optimal conditions for both feeding and reproduction. Differences in diversity and abundance across stations appear closely related to canopy cover, vegetation density, and water flow type, which influence microclimatic conditions, predator–prey dynamics, and oviposition site availability. The consistently high abundance of *I. senegalensis* across all stations supports previous findings linking this species to aquatic vegetation near agricultural landscapes. Overall, the presence of both lentic and lotic habitats in this relatively undisturbed urban river corridor highlights its value as a biodiversity refuge for dragonflies in Surabaya. The distribution patterns observed in this study align with broader ecological evidence. Lee *et al.* reported that canopy cover and microhabitat structure strongly regulate *Odonata* assemblages, supporting the higher diversity recorded at Station 3 with more open vegetation (8). Comparable urban surveys in Surabaya also report similar diversity index ranges, indicating that urban river corridors can maintain viable *Odonata* communities (9). Furthermore, Ishak *et al.* demonstrated that physicochemical parameters such as dissolved oxygen and pH significantly influence species richness, suggesting that additional environmental drivers may contribute to the spatial differences observed in this study (10).

Brachythemis contaminata (Fabricius, 1793)

Kingdom: Animalia; Phylum: Arthropoda; Class: Insecta; Order: *Odonata*; Suborder: Anisoptera; Family: *Libellulidae*; Genus: *Brachythemis*; Species: *B. contaminata.*

Morphological Characteristics

Male individuals of *Brachythemis contaminata* are predominantly orange in coloration, a feature consistent with previous descriptions (11). The compound eyes are yellowish-brown on the upper side and greenish below, as also noted. The thorax and abdomen exhibit a brownish-orange hue, with distinct black linear markings present on abdominal segments 8 and 9. The wings are dominantly orange with transparent apices. Females share similar patterns but have yellow-toned abdomens and clear wings, lacking the male’s intense pigmentation.

Habitat and Ecology

*Brachythemis contaminata*was was observed at all three sampling stations, encompassing both lentic (stations 1 and 3) and lotic (station 2) aquatic environments. These sites were characterized by a combination of open and semi-shaded canopies, often bordered by adjacent agricultural land. The species’ widespread occurrence across diverse microhabitats highlights its high degree of ecological plasticity and adaptability to varying environmental conditions. It is commonly encountered near calm water bodies, including riversides, ponds, and rice fields, where individuals frequently perch on emergent aquatic vegetation or dry twigs. According to Kulkarni and Subramanian (2013), its tolerance for polluted waters explains its ubiquity in disturbed landscapes (12).

Conservation Status

The species is classified as Least Concern (LC) by the IUCN Red List (Sharma, 2010), reflecting its wide distribution and stable population trends.

Diversity Index

Based on the Shannon–Wiener diversity index (H'), the dragonfly community in the Pura Segara Kenjeran River ecosystem, located in Sukolilo, Surabaya, exhibited varying levels of species diversity across the three observation stations. Station 3 recorded the highest diversity with H' = 1.70, followed by Station 1 (H' = 1.58), while Station 2 exhibited the lowest diversity at H' = 1.56.

The Shannon–Wiener index is widely used to evaluate the structural complexity and stability of ecological communities. A higher H' value reflects a more balanced and stable ecosystem, indicating adequate biotic and abiotic components that support species coexistence. Conversely, a lower H' suggests ecological imbalance or stress, typically resulting from limited resource availability or environmental disturbances (13). In this study, the relatively higher diversity observed in Station 3 may be attributed to its open canopy structure, abundant vegetation, and lentic water conditions, which collectively provide favorable microhabitats for a broader range of *Odonata* species. The comparison of Shannon–Wiener diversity index (H') values across the three observation stations is presented in **Figure 2**.

As illustrated in **Figure 1**, the dragonfly diversity index across the three sampling stations falls within the moderate category. This classification is based on Indriani *et al*. (2009) and Irma & Herlina (2013), who stated that an H' value of less than 1 indicates low diversity, a value between 1 and 3 indicates moderate diversity, and a value greater than 3 means high diversity (14, 15).

Station 3 supported the highest species richness, with 10 species from two families and a total of 588 individuals. The habitat, characterized by lentic waters, surrounding trees, and an open canopy, offered favorable microhabitat conditions for various species. These findings align with Herlambang *et al*. (2016), who emphasized the influence of temperature, canopy openness, light intensity, and vegetation density on dragonfly distribution (16). The H' value at Station 3 also surpassed those reported by Putri *et al*. (2019) (H' = 1.47) and Trisna *et al*. (2022) (H' = 2.36) (17).

In contrast, Station 2 recorded the lowest diversity, hosting only 8 species and 443 individuals. The habitat is dominated by lotic water with dense understory vegetation, a closed canopy, and a nearby stagnant pool, which limits sunlight penetration. This aligns with Wijayanto *et al*. (2016), who observed that dense canopies reduce dragonfly presence due to their dependence on direct sunlight (18). Similarly, Setiyono *et al*. (2017) noted that canopy variation influences oviposition site selection, especially in stream environments (19).

Dragonfly diversity and abundance are affected by multiple abiotic and biotic factors, including habitat type (20), temperature (21), humidity (22), food availability (Susanto *et al*., 2020) (23), water quality (24), wind speed (16), and light intensity (25).

Habitat degradation and pollution were found to adversely impact dragonfly distribution and survival. Since dragonflies are sensitive to changes in aquatic conditions, their absence can disrupt ecological balance, allowing pest insect populations to increase. Vegetation provides essential cover, feeding opportunities, and ecological stability

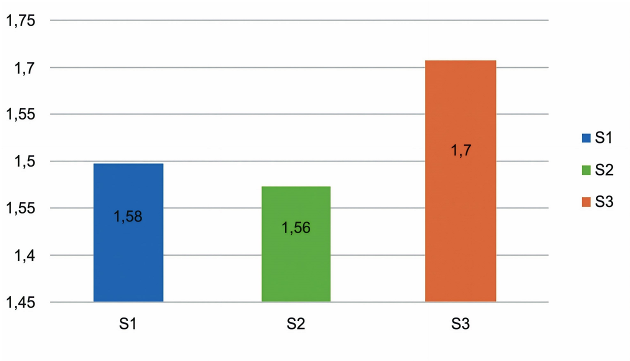

Figure 2. Diversity index graph.

Table 1. Microclimate measurements at each observation station.

Station	Temperature (°C)	Humidity (%)	Light Intensity (lx)
S1	31.60 – 35.00	67.90 – 73.20	33,754 – 46,172
S2	30.72 – 33.42	47.90 – 65.70	21,984 – 29,131
S3	32.52 – 37.00	67.60 – 72.40	42,371 – 53,231

for dragonflies and other insects. Any disturbance in this component may affect the overall balance of the ecosystem (26). Furthermore, microclimate factors, such as temperature, humidity, and light intensity, also play a critical role in regulating dragonfly activity (22). Details of temperature, humidity, and light intensity measured at each observation station are presented in **Table 1**.

Station 3 exhibited the highest temperature and light intensity, while Station 1 had the highest humidity. All stations fell within the optimal temperature range for dragonflies (15–45°C), as supported by Putri *et al*. (2019) (17). These environmental variables significantly affect dragonfly physiology, behavior, and lifespan (27).

While canopy structure and microhabitat characteristics appear to strongly influence *Odonata* distribution in this study, alternative ecological drivers may also contribute to spatial variation in diversity. Factors such as prey availability, water quality parameters (e.g., dissolved oxygen, pH, turbidity), and anthropogenic disturbances including agricultural runoff and waste discharge can significantly affect dragonfly assemblages and should be considered when interpreting community structuring. Several studies have demonstrated that nutrient enrichment and pesticide exposure can shift dominance patterns by affecting larval survivorship and adult emergence success, which may explain differences between lentic and lotic habitats even within similar climatic zones. Therefore, the patterns observed in this study should be interpreted as preliminary ecological signals rather than definitive causal relationships. Future studies incorporating physicochemical water measurements, trophic interaction analyses, and more extensive temporal replication would enhance explanatory power and strengthen ecological inference for urban freshwater ecosystems.

Evenness Index

Evenness (E) was high across all stations, ranging from 0.72 to 0.75, indicating a balanced distribution of individuals among species. The distribution of evenness (E) values across the three observation stations is presented in **Figure 3**.

Station 2 showed the highest evenness (E = 0.75), suggesting that species there share resources relatively evenly.This may be due to the uniform habitat conditions provided by its shaded, flowing-water environment. Station 1 had the lowest evenness (E = 0.72), likely influenced by the dominance of *I. senegalensis* despite overall moderate species richness. High evenness values in all stations reflect ecological stability and balanced interspecific interactions.

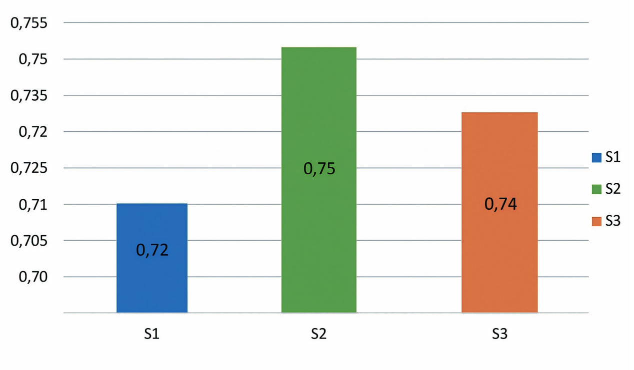

Figure 3. Evenness index chart.

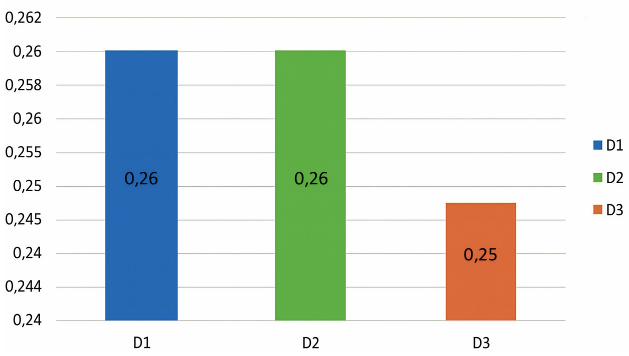

Figure 4. Dominance index of dragonfly communities at three observation stations.

Table 2. Frequency of occurrence of odonata species.

Suborder	Species	Frequency (%)	Occurrence Level
Anisoptera	*Brachythemiscontaminata*	100%	Abundant
Anisoptera	*Diplacodestrivialis*	100%	Abundant
Anisoptera	*Orthetrumsabina*	100%	Abundant
Anisoptera	*Pantala flavescens*	100%	Abundant
Anisoptera	*Crocothemisservilia*	100%	Abundant
Zygoptera	*Ischnura senegalensis*	100%	Abundant
Anisoptera	*Brachydiplaxchalybea*	66%	Moderate
Anisoptera	*Rhyothemisphyllis*	66%	Moderate
Zygoptera	*Agriocnemisfemina*	66%	Moderate
Anisoptera	*Neurothemisferalis*	33%	Rare
Anisoptera	*Acisomapanorpoides*	33%	Rare
Anisoptera	*Potamarcha congener*	33%	Rare

Dominance Index

Dominance (D) was uniformly low at all stations (0.25–0.26), indicating that no single species overwhelmingly dominated the community. The dominance index (D) values across the three observation stations are presented in **Figure 4**.

While *Brachythemis contaminata* and *I. senegalensis* were consistently abundant, their numbers did not suppress other species, suggesting that available resources and habitat niches are sufficiently diverse to support multiple taxa.

Frequency of Occurrence

Six species (*B. contaminata, Diplacodes trivialis,Orthetrum sabina, Pantala flavescens, Crocothemis servilia*, and *I. senegalensis*) were present in all stations, demonstrating high adaptability to both lentic and lotic habitats.In contrast, *Neurothemis feralis*, *Acisoma panorpoides*, and *Potamarcha congener* occurred only in one station each, indicating narrower habitat preferences. Their restricted occurrence suggests sensitivity to specific environmental conditions such as canopy cover, light availability, and vegetation type. Details of species occurrence patterns across stations are shown in **Table 2**.

Conclusion

This study identified 12 species of *Odonata* from two families across three habitat stations along the Segara Kenjeran River, indicating moderate diversity, high evenness, and low dominance values. These community patterns demonstrate the ecological importance of heterogeneous riparian environments particularly variation in canopy structure, vegetation density, and hydrological conditions in shaping *Odonata* assemblages in urban freshwater systems. The findings support the potential role of *Odonata* as bioindicators for assessing habitat quality and ecological stability in urban river corridors.

However, the present research was limited by short sampling duration, restricted spatial replication, and the inherent observer bias of visual encounter surveys, which may influence detection accuracy and temporal representation. To strengthen ecological inference and indicator-based ecosystem assessment, future monitoring should apply increased sampling frequency across multiple seasons, incorporate wider spatial coverage, and integrate physicochemical water quality measurements and trophic resource evaluation. These improvements will support more robust ecological modeling and provide actionable guidance for management priorities such as riparian vegetation restoration and water quality regulation in rapidly urbanizing watersheds.

Declarations

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Contribution: Data Curation, Formal analysis, Visualization,

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Conflict of Interest

The authors declare no conflicting interest.

Data Availability

All data generated or analyzed during this study are included in this published article.

Ethics Statement

Ethical approval was not required for this study.

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Additional Information

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