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Diversity of dragonflies (Odonata) as bioindicators of water quality in Mangkol river, Terak village, Simpang Katis subdistrict, Central Bangka regency

Zunnikah[1*], Suwarno Hadisusanto[2], and Emilya Nurjani[3]
[1]*Environmental Science, Graduate School, Universitas Gadjah Mada, Yogyakarta*
[2]*Faculty of Biology, Universitas Gadjah Mada, Yogyakarta*
[3]*Faculty of Geography, Universitas Gadjah Mada, Yogyakarta*

ABSTRACT
Dragonflies (Odonata) can serve as bioindicators of environmental quality, especially water quality. The Mangkol River, located within Bukit Mangkol Grand Forest Park (Tahura), Terak Village, Central Bangka Regency, is a raw water source used by residents of Pangkalpinang City through the regional water company, Perumda Air Minum Tirta Pinang. While the river's upstream serves as a raw water source, illegal tin mining activities in the midstream and downstream sections have altered the river's condition, causing sedimentation and turbidity. This study aimed to examine dragonfly diversity as bioindicators of water quality in the Mangkol River. Dragonflies were observed using the cruising method and direct capture with insect nets, supplemented with water quality data measured in the field and laboratory. Dragonfly diversity comprised 2 families, 12 species, and a total of 104 individuals. The Family Biotic Index (FBI) indicated poor water quality at station 1 (6.90) and very poor quality at stations 2, 3, and 4 (9.00).
Keywords: *Dragonflies (Odonata); bioindicators; river water quality; family biotic index; environmental management*

1. INTRODUCTION

Indonesia hosts approximately 14% of the world's dragonfly diversity, distributed across its archipelago from west to east, in both large and small islands. Papua has the highest number of dragonfly species (375), followed by Kalimantan (291), Sumatra (257), Java (183), Maluku (149), Sulawesi (146), Nusa Tenggara Islands (96), and Bali (58) (Lupiyaningdyah, 2020). According to Baskoro et al. (2018), dragonflies are commonly found in habitats near water sources due to their life cycle requirements. Dragonflies (Odonata) serve as bioindicators of environmental quality, particularly water quality, because their eggs and nymphs can only survive in clean and minimally polluted waters. Consequently, declining water quality can significantly impact dragonfly diversity (Irawan, 2021).

Water quality is an essential component of the environment and an indicator of pollution. Changes in water quality may result from population growth, community activities, and industrial processes, all of which can disrupt aquatic organisms and ecosystems (Setyowati, 2015; Gesriantuti et al., 2018).

The Mangkol River, located in Bukit Mangkol Grand Forest Park (Tahura), Terak Village, Central Bangka Regency, Bangka Belitung Province, covers an area of 6,009.51 hectares. The river originates from Mangkol Waterfall, situated at the foot of Bukit Mangkol, and serves as both a raw water source and a recreational site. However, illegal tin mining activities have negatively impacted the river, causing sedimentation and turbidity.

The use of dragonflies as indicators for environmental quality assessment was first developed by Simaika & Samways (2012) in a South African conservation area. Their research demonstrated that dragonflies are effective and rapid bioindicators for monitoring freshwater environments, forests, restoration areas, changing landscapes, and habitat recovery.

Highly sensitive dragonfly species respond rapidly to environmental changes, often through nymph mortality or by adult dragonflies relocating to more suitable habitats, making them less detectable in degraded environments. Nymphs are particularly vulnerable to water pollution, which makes them reliable indicators of water quality (Hasanah, 2020; Irawan, 2021). The presence of abundant dragonfly eggs or nymphs in a water body

***Coresponding author:** zunnikah@mail.ugm.ac.id

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suggests that the water is clean and free from pollution. Thus, dragonflies are key indicators of healthy ecosystems (Buchori et al., 2019).

This study aims to determine the diversity of dragonfly species as bioindicators of water quality in the Mangkol River, Central Bangka Regency.

2. Material and Methods

The tools and materials used in this research included: the Administrative Map of Central Bangka Regency, Topographic Map (Sheet 1113-61, scale 1:25,000), GPS, insect nets, pH meter, hygrometer, water sample containers, mobile phone, and stationery.

The study was conducted on May 21, 22, and 27, 2024, in the Mangkol River, Terak Village, Simpang Katis Subdistrict, Central Bangka Regency, within the Bukit Mangkol Grand Forest Park (Tahura). Dragonfly observations and water sampling were carried out between 07:00 and 13:00 WIB at predetermined stations.

This research employed a survey method focused on primary data collection. Dragonfly observations were exploratory (cruising method), complemented by water quality measurements in both the field and laboratory. Sampling sites were determined using purposive sampling, based on specific criteria outlined by the researchers (Sugiyono, 2019). Sampling for dragonfly diversity and water quality (temperature, pH, TDS, TSS, COD, BOD, DO, Cu, Zn, Nitrite, and Ammonia) was conducted at four stations: station 1 (upstream), station 2 (midstream), and stations 3 and 4 (downstream).

Water quality was analyzed using the Family Biotic Index (FBI) and Pollution Index (IP). FBI relies on the presence and abundance of aquatic insect families, including dragonflies, which have varying levels of tolerance to pollution. The Pollution Index (IP) was used in conjunction with FBI to quantify pollution levels in the river, taking into account the diversity and abundance of bioindicator organisms such as dragonflies (Husnia et al., 2019; Virgiawan et al., 2015).

Table 1. Water quality classification based on FBI

No	Family Biotic Index	Water Quality	Organic Pollution Level
1	0.00 – 3.75	Excellent	No organic pollution
2	3.76 – 4.25	Very good	Slightly polluted
3	4.26 – 5.00	Good	Moderately polluted
4	5.01 – 5.75	Fair	Considerably polluted
5	5.76 – 6.50	Rather poor	Heavily polluted
6	6.51 – 7.25	Poor	Very heavily polluted
7	7.26 – 10.00	Very poor	Severely polluted

3. Results and Discussion

The research findings show that across the four stations, a total of 12 dragonfly species were identified: 10 belonging to the suborder Anisoptera and 2 to the suborder Zygoptera, with a total of 104 individual dragonflies observed. The Anisoptera species, from the family Libellulidae, included: *Crocothemis servilia, Diplacodes trivialis, Neurothemis fluctuans, Orthetrum chrysis, Orthetrum glaucum, Orthetrum pruinosum, Orthetrum sabina, Orthetrum testaceum, Pantala flavescens*, and *Rhyothemis phyllis*. From the Zygoptera suborder, family Calopterygidae, the species were *Heliocypha biforata* and *Vestalis amethystina*.

Each station exhibited different characteristics, with station 1 being notably distinct. Station 1, located upstream, had clear water, numerous large rocks along the riverbanks, dense forests with thick vegetation, and an abundance of small fish and insects providing food. In contrast, stations 2, 3, and 4 had turbid water, fewer riverside trees, and were affected by illegal tin mining activities by local communities.

Species diversity and abundance varied among stations. Station 1 recorded the highest species diversity and abundance with 80 individuals, while station 2 had the lowest, with only one species and 3 individuals. According to Hartika et al. (2017), differences in dragonfly species at each station are influenced by varying environmental conditions.

Dragonfly diversity at each station was affected by both biotic and abiotic ecosystem components, including environmental factors such as temperature, humidity, and light intensity. River water conditions such as flow rate, substrate composition (rocks, plants, branches), and the availability of prey (small insects) also influenced dragonfly diversity. Selvarasu et al. (2019) noted that food availability, light intensity, and suitable habitats support dragonfly populations.

The highest dragonfly diversity at station 1 included *Neurothemis fluctuans*, *Orthetrum chrysis, Orthetrum glaucum, Orthetrum pruinosum, Orthetrum testaceum*, and *Rhyothemis phyllis* (Anisoptera), as well as *Heliocypha biforata* and *Vestalis amethystina* (Zygoptera).

Figure 1. *Neurothemis fluctuans* (a), *Heliocypha biforata* (b), *Vestalis amethystina* (c)

Station 2 only had one species, *Orthetrum sabina*, from the family *Libellulidae*, which is known for its wide habitat tolerance and adaptability (Ruslan, 2020). The high diversity index at station 1 was attributed to suitable habitat conditions, such as dense vegetation, clear water, ample food supply, and absence of mining activities. Virgiawan et al. (2015) found that high dragonfly diversity is influenced by abiotic factors (e.g., air and water temperature, light intensity, pH, DO, BOD, TDS, TSS) and human activities.

Table 2. Dragonfly diversity, evenness, and dominance at each station

Water Standard Class	Station	H' (Diversity)	E (Evenness)	C (Dominance)
I	1	1.69	0.82	0.21
II	2	0.00	0.00	1.00
II	3	0.67	0.97	0.52
II	4	0.66	0.95	0.53

The rich diversity at station 1 is also supported by the availability of riparian vegetation, which provides perching and oviposition sites, as well as food sources like small fish, aquatic insects, and butterflies. Two species of damselflies (*Zygoptera*) were found here, which prefer shaded and vegetated habitats (Khan, 2015). Sensitive damselflies are usually absent in disturbed or converted habitats (Manurung et al., 2023).

Evenness index (E) was highest at station 3 (0.97), indicating a balanced presence of two species—*Diplacodes trivialis* and *Rhyothemis phyllis*—with individual counts of 3 and 2, respectively. A high evenness index suggests no dominant species (Lino et al., 2019).

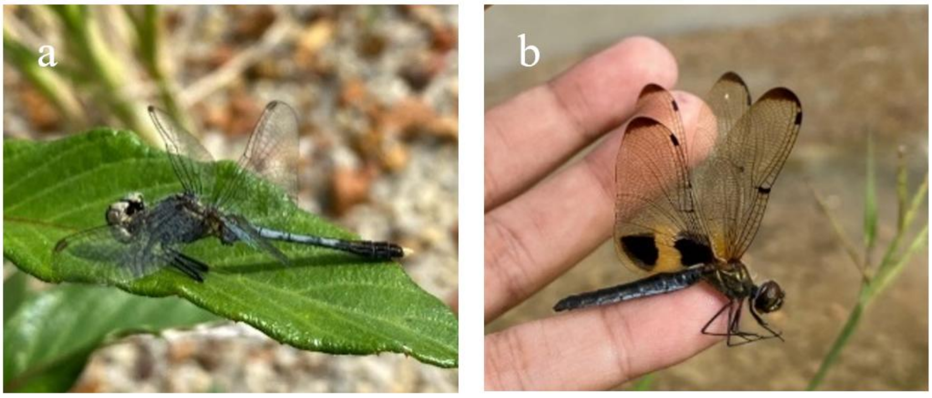

Figure 2. *Diplacodes trivialis* (a) and *Rhyothemis phyllis* (b)

Dominance index (C) was lowest at station 1 (0.21), indicating low dominance. Station 2 had the highest dominance (1.00), with only *Orthetrum sabina* present (3 individuals), reflecting poor species distribution and habitat suitability. According to Rokhmah et al. (2020), habitat suitability greatly influences species dominance. *Orthetrum sabina* is a widespread species with high adaptability (Lantang et al., 2023).

Table 3. Dragonfly Species Diversity at the Four Stations

Sub order	Family	Species	S1	S2	S3	S4	Total
Anisoptera	Libelluidae	*Crocothemis servilia*	-	-	-	10	10
		Diplacodes trivialis	-	-	3	-	3
		Neurothemis fluctuans	1	-	-	-	1
		Orthetrum chrysis	6	-	-	-	6
		Orthetrum glaucum	1	-	-	-	1
		Orthetrum Pruinosum	11	-	-	-	11
		Orthetrum sabina	-	3	-	-	3
		Orthetrum testaceum	2	-	-	-	2
		Pantala flavescens	-	-	-	6	6
		Rhyothemis phyllis	17	-	2	-	19
Zygoptera	Calopterygidae	*Heliocypha biforata*	24	-	-	-	24
		Vestalis amethystine	18	-	-	-	18
Total Individuals			**80**	**3**	**5**	**16**	**104**

Dragonflies (Odonata) exhibit varying sensitivity to environmental changes. Highly sensitive species will leave habitats that have been altered. Riverbank habitats with diverse vegetation and shrubs serve as resting and feeding grounds, supporting higher population densities. A loss of diverse vegetation correlates with declining dragonfly populations (Fitria et al., 2019).

Family Biotic Index (FBI) values varied across stations, with station 1 scoring 6.90 (Poor category) and stations 2, 3, and 4 scoring 9.00 (Very Poor category). These high values at stations 2–4 reflect a limited presence of dragonfly families, only Libellulidae was found, indicating reduced water quality and unsuitable habitat conditions. According to Hilsenhoff (1988), tolerance values for Odonata families are as follows: Aeshnidae (3), Calopterygidae (5), Coenagrionidae (9), Cordulegastridae (3), Corduliidae (5), Gomphidae (1), Lestidae (9), Libellulidae (9), Macromiidae (3).

At station 1, the FBI was lower due to greater family diversity (e.g., Libellulidae and Calopterygidae). The limited diversity at stations 2–4 may be influenced by abiotic and biotic factors, including turbid water, sedimentation, and reduced aquatic vegetation—conditions unfavorable for dragonfly development (Ilhamdi, 2018).

Table 4. Family Biotic Index (FBI) values

Family	Species	Total (xi)	Tolerantion (ti)	FBI
Class I Water Standard				
Station 1				
Libellulidae	*Neurothemis fluctuans*	1	9	6,90**
	Orthetrum chrysis	6	9	
	Orthetrum glaucum	1	9	
	Orthetrum Pruinosum	11	9	
	Orthetrum testaceum	2	9	
	Rhyothemis phyllis	17	9	
Calopterygidae	*Heliocypha biforata*	24	5	
	Vestalis amethystine	18	5	
Class II Water Standard				
Station 2				
Libellulidae	*Orthetrum sabina*	3	9	9,00***
Station 3				
	Diplacodes trivialis	3	9	9,00***
	Rhyothemis phyllis	2	9	
Station 4				
	Neurothemis fluctuans	10	9	9,00***
	Orthetrum chrysis	6	9	

Legend: * Rather Poor ** Poor *** Very Poor

Table 5. Dragonfly diversity and water quality parameters at the four stations

Parameter	Unit	Station 1	Class I Water Standard	Station 2	Station 3	Station 4	Class II Water Standard
Physical							
Water Temperature	°C	26.6	±3 deviation	28.7	29.5	29.2	±3 deviation
TDS	mg/L	12.9	1000	17.6	16.4	14.2	1000
TSS	mg/L	2.00	40	86.0*	30.4	34.0	50
Chemical							
pH		9.31*	6–9	10.09*	9.88*	9.83*	6–9
DO	mg/L	4.45*	≥6	3.58*	4.33	3.90*	≥4
BOD	mg/L	2.56*	≤2	3.86*	2.73	3.54*	≤3
COD	mg/L	15.0*	≤10	27.6*	17.4	27.4*	≤25
Cu	mg/L	<0.0194	0.02	<0.0194	<0.0194	<0.0194	0.02
Zn	mg/L	<0.0377	0.05	<0.0377	0.0482	0.0377	0.05
Nitrite	mg/L	<0.00313	0.06	0.0357	0.0399	0.0387	0.06
Ammonia	mg/L	0.287*	0.1	0.0712	0.0384	0.154	0.2

Note: *Does not meet quality standards

The physicochemical analysis of water from the Mangkol River revealed variations in parameters such as temperature, TDS, TSS, pH, DO, BOD, COD, Cu, Zn, nitrite, and ammonia across stations. The upstream area (station 1) had clear water, while the midstream and downstream areas (stations 2–4) showed turbidity, attributed to illegal tin mining activities.

TSS levels were highest at station 2 (86 mg/L), exceeding the Class II standard of 50 mg/L, and lowest at station 1 (2 mg/L). High TSS levels indicate turbidity and can lead to sediment accumulation, potentially disrupting river flow and causing siltation (Yuliyanti, 2019).

Increased COD at stations 2 and 4 reflected organic matter contamination, negatively affecting aquatic life, including dragonfly nymphs. At these stations, few nymphs were observed, and no damselfly species were found, likely due to poor habitat conditions.

Pamungkas (2015) reported that dragonflies require unpolluted water bodies for reproduction. Contaminated aquatic environments hinder dragonfly development, signaling ecosystem degradation. Low levels of Cu and Zn across all stations suggest minimal heavy metal contamination, likely due to decreased mining activity. This contrasts with findings from the Baturusa River (Mentari et al., 2017), where intensive mining led to elevated Cu and Zn concentrations.

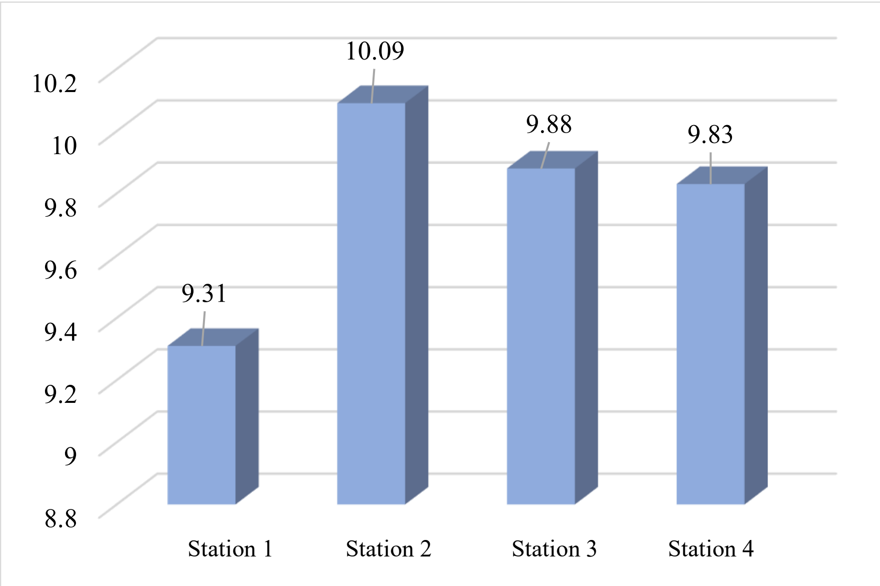

Figure 3. pH levels in the Mangkol River

The value of pH at all stations exceeded the acceptable range (6–9) (Figure 3), indicating alkaline conditions. Even station 1, used as a raw water source for Pangkalpinang City, had a pH of 9.31 (first sampling) and 9.71 (second sampling). Water quality status was further assessed using the Pollution Index (IP) method. IP values indicated all stations were "lightly polluted": station 1 (2.22), station 2 (1.36), station 3 (1.32), and station 4 (1.24). Despite station 1 having the highest IP, it had greater dragonfly diversity and included multiple families, thanks to better habitat conditions.

The discrepancy between IP and FBI values arises from different water quality classifications: station 1 follows Class I standards, while stations 2–4 follow Class II. Thus, station 1's higher IP still corresponds to a relatively better ecological condition due to vegetation, aquatic plants, and stone structures that support dragonfly life (Baskoro et al., 2018).

4. CONCLUSION

The diversity of dragonfly species observed across the four stations totaled 12 species: 10 from the suborder Anisoptera and 2 from the suborder Zygoptera, with a total of 104 individual dragonflies recorded. The Anisoptera species, from the family Libellulidae, included: *Crocothemis servilia, Diplacodes trivialis, Neurothemis fluctuans, Orthetrum chrysis, Orthetrum glaucum, Orthetrum pruinosum, Orthetrum sabina, Orthetrum testaceum, Pantala* *flavescens*, and *Rhyothemis phyllis*. The Zygoptera species, from the family Calopterygidae, included: *Heliocypha biforata* and *Vestalis amethystina*.

Water quality of the Mangkol River based on the Pollution Index (IP) at stations 2, 3, and 4 showed relatively similar values of 1.36, 1.32, and 1.25 respectively, all of which fall into the "Lightly Polluted" category. These stations also had identical Family Biotic Index (FBI) scores of 9.0, indicating a "Very Poor" water quality classification. Meanwhile, station 1 had an IP of 2.22 ("Lightly Polluted") and an FBI score of 6.9 ("Poor" category).

These results indicate that while the pollution index across stations is moderate, the FBI values at stations 2, 3, and 4 are significantly high (indicating poor biological conditions). This discrepancy is likely due to insufficient habitat suitability at these stations. Despite the light pollution status, turbid water and a lack of aquatic vegetation in these areas contributed to lower dragonfly diversity, with only species from the Libellulidae family present. Thus, dragonfly diversity is influenced by various factors, particularly human activities and environmental abiotic conditions, such as water temperature, air temperature, light intensity, pH, DO, BOD, TDS, and TSS.

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