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Effect of Physicochemical Parameters on Abundance and Diversity of Insects in Jabi Lake, Abuja, Nigeria

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ABSTRACT

Insects represent the most diverse and adaptable group of animals, comprising over 80% of all identified species and occurring in nearly all habitats except marine environments. This study assessed the abundance, diversity, and ecological distribution of aquatic insects in Jabi Lake, Abuja, from May to October 2025, with emphasis on their relationship to seasonal changes in water quality. Five ecological stations were established, and samples were collected triweekly using standard sweep netting techniques. Physicochemical parameters—temperature, pH, turbidity, depth, dissolved oxygen (DO), and biochemical oxygen demand (BOD)—were measured concurrently**.**

Mean water temperature declined from 28.46 ± 0.03 °C in May to 25.99 ± 0.00 °C in August ($p < 0.05$), while pH fluctuated between 5.90 and 6.94. Depth increased from 1.74 m to 2.46 m, and turbidity rose from 8.45 to 9.49 NTU. Dissolved oxygen ranged between 5.18 and 6.04 mg/L, showing an inverse relationship with BOD (2.02–2.90 mg/L).

Seven insect taxa were recorded: *Chironomus sp., Notonecta glauca, Gerris sp., Dytiscus sp., Orthetrum sp., Brachythemis sp.,* and *Pseudocloeon sp.*, with peak species richness in July under moderate temperature and elevated DO. The Shannon–Weiner diversity index peaked at 1.946 during July–September, coinciding with optimal conditions for *Odonata* and *Ephemeroptera* emergence. RLQ ordination explained 78.4% of trait–environment covariance, distinguishing oxygen-demanding taxa in deeper, well-oxygenated waters (Axis 1 = 58.2%) from tolerant species in nutrient-enriched zones (Axis 2 = 20.2%). Hydrological variability, oxygen concentration, and organic enrichment were key drivers of species composition. Aquatic insects are affirmed as reliable bioindicators, supporting integrated monitoring for sustainable Jabi Lake management.

Keywords: Abundance, Diversity, Insects. Jabi Lake, Physicochemical parameters, Seasons

INTRODUCTION

Aquatic ecosystems are dynamic environments whose biological composition and ecological stability are strongly influenced by physicochemical conditions (Fusi *et al*., 2023; Mariu *et al*., 2023). Variations in parameters such as temperature, pH, dissolved oxygen, turbidity, conductivity, nitrate concentration, phosphate concentration, and total dissolved solids significantly affect the distribution, survival, abundance, and diversity of aquatic organisms, including insects (Hébert *et* al., 2022; Fusi *et al*., 2023; Larance *et al.*, 2025). Aquatic insects constitute an essential component of freshwater ecosystems because they participate in nutrient cycling, organic matter decomposition, energy transfer, and serve as important food sources for fish, amphibians, and birds (Thaware, 2023; Ali *et al.*, 2024). Their sensitivity to environmental changes also makes them reliable bioindicators for assessing water quality and ecological health (Baskar and Gawade, 2021).

In recent decades, increasing anthropogenic activities such as urbanization, agricultural runoff, industrial discharge, sewage contamination, and recreational activities have contributed to the deterioration of freshwater ecosystems worldwide (Fang *et al*., 2025). These activities alter the physicochemical characteristics of water bodies, thereby influencing aquatic biodiversity and ecosystem functioning (Larance *et al.*, 2025). Among aquatic organisms, insects respond rapidly to environmental disturbances due to their relatively short life cycles and varying tolerance levels to pollution. Consequently, changes in insect abundance and diversity often reflect alterations in water quality and habitat conditions (Pfister *et al*., 2025; Keerthika *et al*., 2026).

The relationship between physicochemical parameters and aquatic insect communities has attracted considerable scientific attention because of its ecological and environmental significance (Ali *et al*., 2024). Several studies have demonstrated that dissolved oxygen, water temperature, nutrient concentrations, and pH are major determinants of insect distribution patterns in freshwater habitats (Fadel *et al.*, 2023). Sensitive insect groups such as Ephemeroptera, Plecoptera, and Trichoptera are generally associated with clean and well-oxygenated waters, whereas pollution-tolerant taxa such as Chironomidae and certain Diptera species tend to dominate degraded environments (Fadel *et al*., 2023; Gerstle *et al*., 2024). Understanding these ecological relationships is therefore important for biodiversity conservation, environmental monitoring, and sustainable management of freshwater resources.

Jabi Lake, located in the Federal Capital Territory of Nigeria, is an important urban freshwater ecosystem that supports recreational, ecological, and socioeconomic activities (Dankishiya, 2024; Adejuwon *et al.*, 2025). However, increasing urban expansion, tourism, waste disposal, and human activities around the lake may potentially influence its water quality and aquatic biodiversity (Dankishiya, 2024). Despite the ecological and economic importance of Jabi Lake, limited information exists regarding the influence of physicochemical parameters on the abundance and diversity of insect communities within the lake ecosystem (Daniel *et al*., 2023; Dankishiya, 2024). Such information is essential for evaluating the ecological condition of the lake and developing effective conservation and management strategies.

Therefore, this study was aimed at investigating the effect of physicochemical parameters on the abundance and diversity of insects in Jabi Lake. Specifically, the study evaluated selected physicochemical characteristics of the lake water and examined their relationships with insect abundance and diversity patterns. The findings of this study will contribute to the understanding of freshwater ecology, provide baseline data for environmental monitoring, and support sustainable management of aquatic ecosystems in Nigeria.

MATERIALS AND METHODS

Aquatic ecosystems are dynamic environments whose biological composition and ecological stability are strongly influenced by physicochemical conditions (Fusi et al., 2023; Mariu et al., 2023). Variations in parameters such as temperature, pH, dissolved oxygen, turbidity, conductivity, nitrate concentration, phosphate concentration, and total dissolved solids significantly affect the distribution, survival, abundance, and diversity of aquatic organisms, including insects (Hébert et al., 2022; Fusi et al., 2023; Larance et al., 2025). Aquatic insects constitute an essential component of freshwater ecosystems because they participate in nutrient cycling, organic matter decomposition, energy transfer, and serve as important food sources for fish, amphibians, and birds (Thaware, 2023; Ali et al., 2024). Their sensitivity to environmental changes also makes them reliable bioindicators for assessing water quality and ecological health (Baskar and Gawade, 2021).

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RESULTS AND DISCUSSION

Physicochemical Properties of Jabi Lake, Abuja

Aquatic insect distribution across the five sampling stations in Jabi Lake revealed distinct habitat-specific patterns (Table 3). Station 1, characterized by open water with minimal vegetation, was dominated by *Chironomus* sp., *Notonecta glauca*, *Orthetrum* sp., and *Brachythemis* sp., representing a mix of Dipteran larvae, aquatic Hemiptera, and Odonata taxa. Typically associated with well-oxygenated, open aquatic environments.

Station 2, located in shallow vegetated areas, supported *Gerris* sp. and *Chironomus* sp. The presence of these species reflects their preference for littoral zones with emergent vegetation that provides both food and shelter.

At Station 3, representing the stagnant water zone, *Notonecta glauca*, *Dytiscus* sp. and *Chironomus* sp. were recorded. These taxa are adapted to low-flow environments and can tolerate reduced oxygen conditions, suggesting habitat stability but limited water exchange.

Station 4, situated in a section with noticeable flow, harbored *Gerris* sp., *Chironomus* sp., and *Pseudocloeon* sp. (Ephemeroptera). The occurrence of *Pseudocloeon* sp. indicates improved water circulation and higher oxygen levels typical of lotic habitats.

Finally, Station 5, characterized by marshy and bank-side conditions, was inhabited by *Dytiscus* sp. and *Notonecta glauca*. These species are often associated with marginal and semi-aquatic environments, where they exploit both aquatic prey and emergent vegetation.

In general, *Chironomus* sp. and *Notonecta glauca* occurred in multiple stations, signifying their ecological tolerance and adaptability to varying microhabitats within Jabi Lake. The observed species composition underscores habitat heterogeneity as a key driver of aquatic insect distribution in the lake ecosystem.

Table 2: Seasonal Dynamics of Selected Physicochemical Properties in Jabi Lake, Abuja: Comparative Analysis from May to October 2025

	Mean ± SE					
Parameter	**May**	**June**	**July**	**August**	**September**	**October**
Temperature (°C)	28.46 ± 0.03^{a}	27.38 ± 0.00^{b}	26.55 ± 0.19^{c}	25.99 ± 0.00^{c}	25.99 ± 0.01^{b}	27.47 ± 0.04^{a}
pH	6.50 ± 0.00^{b}	6.61 ± 0.01^{ab}	6.62 ± 0.12^{a}	6.04 ± 0.02^{b}	5.90 ± 0.03^{c}	6.94 ± 0.02^{a}
Depth (m)	1.74 ± 0.00^{b}	1.79 ± 0.00^{ab}	1.80 ± 0.00^{a}	2.46 ± 0.09^{b}	2.44 ± 0.01^{b}	2.40 ± 0.00^{c}
Turbidity (NTU)	8.45 ± 0.02^{b}	8.48 ± 0.00^{b}	8.52 ± 0.00^{a}	9.04 ± 0.02^{c}	9.49 ± 0.02^{b}	9.38 ± 0.02^{a}
Dissolved Oxygen (mg/L)	5.43 ± 0.01^{a}	5.24 ± 0.00^{b}	5.18 ± 0.00^{c}	5.76 ± 0.02^{c}	6.04 ± 0.02^{a}	5.80 ± 0.00^{b}

	Mean ± SE					
Parameter	**May**	**June**	**July**	**August**	**September**	**October**
BOD (mg/L)	2.90 ± 0.00^{a}	2.04 ± 0.00^{b}	2.02 ± 0.01^{b}	2.62 ± 0.06^{b}	2.84 ± 0.02^{a}	2.46 ± 0.04^{c}

Habitat Characteristics and Dominant Aquatic Insect Species Identified in Jabi Lake

Table 3: Habitat Characteristics and Dominant Aquatic Insect Species Identified at Five Stations in Jabi Lake (May–October, 2025)

Station	Habitat Description	Species Collected/Identified
1	Open water part	*Chironomus* sp., *Notonecta glauca, Orthetrum* sp., *Brachythemis* sp.
2	Shallow water part near vegetation	*Gerris* sp., *Chironomus* sp.
3	Stagnant part area	*Notonecta glauca, Dytiscus* sp., *Chironomus* sp.
4	Flowing water part	*Gerris* sp., *Chironomus* sp., *Pseudocloeon* sp.
5	Marshy/bank areas	*Dytiscus* sp., *Notonecta glauca*

Table 4: Monthly Occurrence of Aquatic Insect Species across Five Stations in Jabi Lake (May–October 2025)

Month	Station 1 (S1) – Open Water	Station 2 (S2) – Shallow Vegetated	Station 3 (S3) – Stagnant Area	Station 4 (S4) – Flowing Water	Station 5 (S5) – Marshy Bank
May	*Chironomus* sp., *Notonecta glauca*	*Gerris* sp., *Chironomus* sp.	*Notonecta glauca*, *Dytiscus* sp.	*Gerris* sp., *Chironomus* sp.	*Dytiscus* sp., *Notonecta glauca*
June	*Chironomus* sp., *Notonecta glauca*	*Gerris* sp., *Chironomus* sp.	*Dytiscus* sp., *Chironomus* sp.	*Gerris* sp., *Chironomus* sp.	*Dytiscus* sp., *Notonecta glauca*
July	*Chironomus* sp., *Notonecta glauca*, *Orthetrum* sp., *Brachythemis* sp.	*Gerris* sp., *Chironomus* sp.	*Dytiscus* sp., *Notonecta glauca*	*Gerris* sp., *Chironomus* sp., *Pseudocloeon* sp.	*Dytiscus* sp., *Notonecta glauca*
August	*Chironomus* sp., *Orthetrum* sp., *Brachythemis* sp.	*Chironomus* sp.	*Dytiscus* sp., *Chironomus* sp.	*Chironomus* sp., *Pseudocloeon* sp.	*Dytiscus* sp., *Notonecta glauca*
September	*Chironomus* sp., *Brachythemis* sp., *Orthetrum* sp.	*Chironomus* sp., *Gerris* sp. (few)	*Dytiscus* sp., *Chironomus* sp.	*Pseudocloeon* sp., *Chironomus* sp.	*Dytiscus* sp., *Notonecta glauca*
October	*Notonecta glauca*, *Orthetrum* sp.	*Gerris* sp., *Chironomus* sp.	*Notonecta glauca*, *Dytiscus* sp.	*Gerris* sp., *Pseudocloeon* sp.	*Dytiscus* sp., *Notonecta glauca*

Total Aquatic Insect Species Count Observed Across the Five Stations in Jabi Lake

Table 5: Monthly Total Aquatic Insect Species Count Observed Across the Five Stations in Jabi Lake (May–October 2025)

Month	Total Unique Species	Species Names
May	4	*Chironomus* sp., *Notonecta glauca*, *Gerris* sp., *Dytiscus* sp.
June	4	*Chironomus* sp., *Notonecta glauca*, *Gerris* sp., *Dytiscus* sp.
July	7	*Chironomus* sp., *Notonecta glauca*, *Gerris* sp., *Dytiscus* sp., *Orthetrum* sp., *Brachythemis* sp., *Pseudocloeon* sp.
August	5	*Chironomus* sp., *Dytiscus* sp., *Orthetrum* sp., *Brachythemis* sp., *Pseudocloeon* sp.
September	6	*Chironomus* sp., *Dytiscus* sp., *Orthetrum* sp., *Brachythemis* sp., *Pseudocloeon* sp., *Gerris* sp.
October	5	*Chironomus* sp., *Notonecta glauca*, *Gerris* sp., *Dytiscus* sp., *Pseudocloeon* sp.

Correlation between Insect Richness and Physicochemical Changes

The temporal trend illustrated in Figure 3 shows notable fluctuations in aquatic insect richness in relation to physicochemical conditions of Jabi Lake between May and October 2025. Insect species richness increased from four species in May and June to a peak of seven in July, coinciding with relatively lower water temperatures (26.55 °C) and moderate turbidity levels (8.52 NTU). Subsequently, richness declined slightly to five and six species during August and September, respectively, as turbidity and depth increased. By October, species richness stabilized at five species alongside a moderate rise in temperature (27.47 °C) and dissolved oxygen (5.80 mg/L). Overall, insect diversity appeared inversely related to temperature and BOD but positively associated with turbidity and dissolved oxygen.

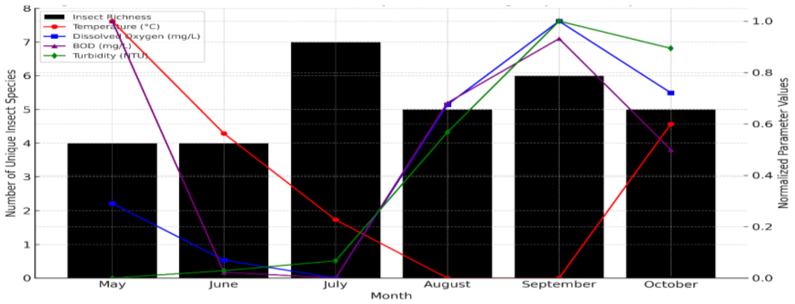

Figure 3: Correlation between Insect Richness and Physicochemical Changes

Species Diversity of Aquatic Insects across Jabi Lake

The Shannon–Weiner Diversity Index varied seasonally, ranging from 1.386 (May–June) to 1.946 (July–September)**.** Species diversity increased markedly during the peak rainy months (July–September)**.** Diversity slightly declined in October, likely due to reduced inflow and habitat contraction as water levels began to fall.

Table 6: Monthly Variation in Shannon–Weiner Species Diversity Index of Aquatic Insects across Jabi Lake (May–October 2025)

Month	No. of Species (S)	H′ (Shannon–Weiner Index)	Implication
May	4	1.386	Moderate diversity – early rainy season onset
June	4	1.386	Similar composition as May, stable community
July	7	1.946	Highest diversity – peak rainy season, optimal conditions
August	6	1.792	High diversity – sustained rainfall and nutrient inflow
September	7	1.946	High diversity – balanced hydrological and habitat mix
October	6	1.792	Slight decline as water level recedes post-rainfall

Functional Trait Composition and RLQ Ordination of Aquatic Insects in Relation to Physicochemical Gradients in Jabi Lake

The RLQ ordination revealed a clear functional structuring of aquatic insect assemblages along environmental gradients in Jabi Lake between August and October 2025 (Figure 4). Axis 1 (58.2% variance) represented a hydrological–oxygenation gradient, distinguishing oxygen-demanding taxa such as *Orthetrum* sp., *Brachythemis* sp., and *Pseudocloeon* sp. associated with deeper, well-oxygenated waters from tolerant forms inhabiting stagnant, nutrient-rich zones. Axis 2 (20.2% variance) captured a nutrient–temperature gradient, with *Chironomus* sp., *Dytiscus* sp., and *Notonecta glauca* dominating areas of higher turbidity and organic load (Figure 4 and Table 7).

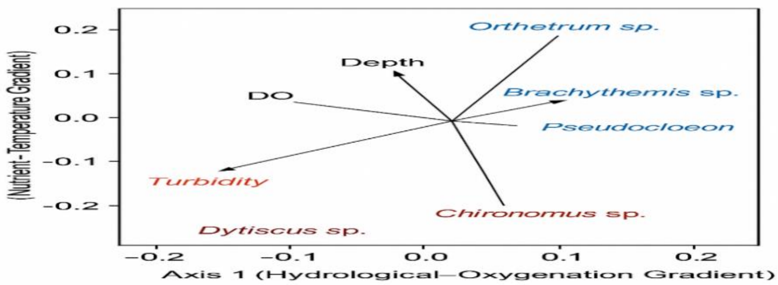

Figure 4: RLQ Ordination Relationship between Environmental Gradient, Functional Traits, and Dominant Aquatic Insects Taxa in Jabi Lake (August-October 2025)

Table 7: Functional Trait Composition and RLQ Ordination of Aquatic Insects In Relation To Physicochemical Gradients in Jabi Lake (August–October 2025)

RLQ Axis / Gradient	Key Environmental Variables (R-Table)	Dominant Taxa (L-Table)	Functional Traits (Q-Table)	Ecological Interpretation
RLQ1: Hydrological–Oxygenation Gradient (58.2%)	↑ Depth (2.3–2.8 m), ↑ DO (5.7–6.1 mg/L), ↓ Temperature (25.9–26.5 °C), ↓ BOD	*Orthetrum* sp., *Brachythemis* sp., *Pseudocloeon* sp.	Odonata and Ephemeroptera; aerial/tegumentary respiration; predators and grazers; strong fliers	Represents oxygen-rich, moderately flowing habitats with active dispersers; peak diversity and emergence (Aug–Sept).
RLQ2: Nutrient–Temperature Gradient (20.2%)	↑ Turbidity (9.0–9.6 NTU), ↑ BOD (2.8–2.9 mg/L), ↓ DO (5.0–5.3 mg/L)	*Chironomus* sp., *Dytiscus* sp., *Notonecta glauca*	Collector-gatherers and predatory beetles; benthic or surface dwellers; tolerant taxa	Reflects nutrient-enriched, stagnant, or marshy zones (S3–S5); dominance under high organic load and reduced oxygen.
Intermediate / Transitional Axis	Moderate pH (6.0–7.0), moderate turbidity and DO	*Gerris* sp., *Notonecta glauca*	Surface dwellers; aerial respiration; generalist predators	Transitional habitats (S2 and S4); exhibit ecological plasticity and adaptability to fluctuating conditions.
Overall RLQ Model Summary	Combined explanation of trait–environment covariance: 78.4% (Axis 1 = 58.2%, Axis 2 = 20.2%)	—	—	Hydrological dynamics (depth, turbidity, DO) and organic enrichment are primary drivers of functional community structure.

Discussion

The decline in water temperature at Jabi Lake from May through August, followed by a gradual rebound in October, reflects the combined influences of seasonal rainfall, reduced solar radiation and an increasing water column (American Pharmaceutical Health Association-APHA, 2012; Addo-Bediako, 2021). As the lake deepens, the larger volume and lower solar penetration typically lead to slower warming and lower mean temperatures. Such thermal dynamics are ecologically significant because water temperature strongly affects metabolic rates, oxygen solubility and the timing of insect life-cycle events and emergence (Chakravarty and Gupta, 2024; Ergović *et al.*, 2025). In a tropical lake system like this, the cooler middle-season temperatures may therefore delay emergence of certain insect taxa or alter developmental rates, with cascading effects through the aquatic food web.

The steady rise in depth during the transition from early to peak rainy season aligns with catchment hydrology and increased inflow: heavier rainfall raises lake level and may flush in sediments and organic matter, deepening the water body. This trend corresponds with the observed increase in turbidity: as runoff intensifies, suspended particles enter the water and raise turbidity values (Woodward *et al*., 2010). Elevated turbidity can reduce light penetration, diminish benthic photosynthesis, alter habitat suitability for visually hunting predators, and favour insect taxa more tolerant of turbid conditions. In our study, turbidity increased by September, indicating a substantial particulate influx likely to affect substrate structure, prey visibility and refuge availability – all factors controlling aquatic insect community composition.

The pH fluctuations from mildly acidic during mid-season toward slightly higher values in October. Lower pH during heavy rainfall may arise from dilution effects, increased CO_2 from microbial respiration, or leaching of acidic soils. Later in the season, as inflow lessens and photosynthesis rises, CO_2 uptake may raise pH and the water column stabilizes. Variations in pH are known to influence aquatic insect assemblages since many taxa have narrow tolerances and respond differently to acidic vs. neutral conditions (Omokunle, 2023). In this sense, the shift toward more neutral conditions in October may have acted as a habitat filter, favouring taxa adapted to pH closer to neutrality.

Dissolved oxygen (DO) increased from early-season values to higher values during August–September, suggesting improved mixing, aeration and photosynthetic contribution during the wet period. Increased depth plus inflow turbulence can boost DO, as can elevate primary productivity in littoral zones. Higher DO is beneficial for many insect taxa, particularly those with higher oxygen demands (Vitheepradit *et al.,* 2024). On the other hand, the biochemical oxygen demand (BOD) decreased early in the rainy season and then rose again by September, likely indicating variations in organic load: initial dilution of organic matter by rainfall may reduce BOD, but as runoff carries more sediment and organic detritus and the water column deepens, organic inputs increase, raising BOD. The interplay between DO and BOD matters for insect habitat suitability. High BOD may reduce available oxygen and signal eutrophic conditions, thereby favouring more tolerant taxa over sensitive ones (Andrades *et al.,* 2019; Ergović *et al.,* 2025).

When these physicochemical patterns are considered together, they help explain the aquatic insect assemblage dynamics observed in this study. The highest species richness in July coincided with moderate temperatures, intermediate depth and rising DO, which are conditions favourable to oxygen-requiring taxa such as Odonata (dragonflies) and Ephemeroptera (mayflies). Reports show that elevated DO and moderate turbidity correspond with higher insect richness (Antczak-Orlewska *et al.,* 2021; Omokunle, 2023; Vithheepradit *et al.,* 2024). Thereafter, the drop in richness during August–October coincided with increasing depth, turbidity and BOD. Thus, the seasonal trajectory of physicochemical conditions appears to regulate both richness and community composition of aquatic insects in the lake.

The functional trait ordination (RLQ) supports the interpretation that the first axis captured a hydrological–oxygenation gradient (depth, DO, temperature) which separated oxygen-demanding, strong-flying taxa from tolerant benthic types. Further, the second axis captured a nutrient–temperature gradient (turbidity, BOD, lower DO) and was associated with tolerant species such as Chironomidae and predaceous Dytiscidae in more stressful habitats. Such trait-environment associations have been documented in recent insect ecology studies of tropical freshwater systems (Akindele *et al.,* 2019; Ergović *et al.,* 2025; Omokunle, 2023). These results affirm that hydrological seasonality and organic enrichment.

From the perspective of lake management and ecological integrity, these findings suggest that relying solely on static, single-time-point water quality measurements may be misleading in tropical lake systems. Seasonal hydrological and physical shifts significantly alter habitat conditions and in turn biological assemblages. The dominance of tolerant taxa during high-turbidity and high-BOD periods implies that parts of Jabi Lake may temporarily shift toward degraded ecological states, favouring disturbance-adapted species. This underscores the importance of integrated monitoring frameworks that combine physicochemical metrics with biological indicators (aquatic insects) to more accurately assess ecosystem status (Chakravarty and Gupta, 2024; Vitheepradit *et al*., 2024).

CONCLUSION

The insects discovered in this study include *Chironomus sp., Notonecta glauca, Orthetrum sp., Brachythemis sp.* The findings demonstrate that the structure of aquatic insect communities in Jabi Lake is strongly influenced by seasonal hydrological dynamics and associated physicochemical changes. Interactions among temperature, turbidity, dissolved oxygen, and organic loading collectively shape species richness, composition, and functional traits across the lake.

The observed peak in diversity during the early rainy period, followed by a gradual dominance of pollution-tolerant taxa under increased turbidity and depth, reflects typical ecological succession patterns in tropical freshwater systems. These patterns highlight the sensitivity of aquatic insect communities to environmental variability and reinforce their value in ecological monitoring.

It also underscores the need for more detailed investigations incorporating finer-scale abundance data, benthic habitat structure, macrophyte influence, and riparian interactions to improve ecological interpretation and inform sustainable management strategies for Jabi Lake and similar aquatic systems.

Future biomonitoring programmes should incorporate environmental DNA (eDNA) metabarcoding techniques. This molecular approach can complement traditional taxonomy by detecting cryptic, rare, or early-life-stage organisms, thereby providing a more comprehensive assessment of aquatic biodiversity with higher sensitivity and efficiency.

A continuous real-time water quality monitoring system should be established. The integration of automated sensors for parameters such as temperature, pH, dissolved oxygen, and turbidity, alongside periodic biological sampling, would allow early detection of ecological disturbances. Linking this system to a digital data platform would enhance accessibility and support evidence-based decision-making.

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