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A study on the diversity of aquatic insect and water quality assessment of Joysagar Tank, Sivasagar District, Assam, India

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Abstract
Aquatic insects play a vital role in freshwater ecosystems and are widely recognized as reliable indicators of ecological condition and water quality. The present study investigates species diversity of aquatic insects in Joysagar tank, located in the Sivasagar district of Assam, India, with an emphasis on understanding species–habitat relationships in relation to water quality. Field sampling was carried out over a six-month period from January to June 2024 to assess the structure and diversity of the aquatic insect community. A total of 30 aquatic insect species belonging to 6 orders and 17 families were recorded during the study period. Among the recorded taxa, the order Hemiptera was found to be the most dominant, comprising 7 families and 15 species, followed by Coleoptera with 8 families and 4 species. The order Odonata and Diptera with 2 species belonging to 2 families from each order, while Ephemeroptera contributed two species from a single family. The lowest diversity was observed in the order Hymenoptera, which was represented by only one species belonging to one family. Aquatic insect distribution was found to be closely associated with variations in physicochemical characteristics of the water, as different taxa exhibited varying levels of tolerance to water quality conditions. The analysis of physicochemical parameters indicated that the water quality of Joysagar was generally within favorable limits, providing suitable conditions for the growth and survival of a wide range of aquatic organisms. This overall good water quality is considered a major factor contributing to the high diversity and abundance of aquatic insects observed.

Keywords: Insects, aquatic insects, physico-chemical parameters, aquatic ecosystem, water quality

Introduction

Freshwater ecosystems constitute a vital component of the Earth's biosphere, supporting a wide range of biological communities and providing essential ecosystem services such as drinking water supply, irrigation, fisheries, flood regulation, and nutrient cycling [1]. Despite covering a relatively small fraction of the Earth's surface, freshwater habitats harbor disproportionately high levels of biodiversity. However, these ecosystems are among the most threatened globally due to increasing anthropogenic pressures including urbanization, agricultural intensification, industrial discharge, and climate change [2]. Aquatic insects represent one of the most diverse and ecologically important groups of freshwater organisms. They occupy various trophic levels, functioning as primary consumers, predators, and decomposers, and play a crucial role in maintaining ecosystem stability and energy flow [3]. Orders such as Ephemeroptera, Odonata, Coleoptera, Diptera, and Hemiptera are commonly found in freshwater habitats and exhibit varying degrees of tolerance to pollution. Because of their short life cycles, limited mobility, and differential sensitivity to environmental stressors, aquatic insects are widely used as biological indicators for assessing water quality and ecological integrity [4].

Chemical and physical analyses of water provide valuable information about immediate environmental conditions; however, these methods often fail to capture the cumulative and long-term effects of pollution on biological communities. In contrast, biological monitoring using aquatic insects integrates environmental changes over time, offering a more comprehensive assessment of ecosystem health [5]. Consequently, the combined use of physicochemical parameters and aquatic insect diversity has become a widely accepted approach in freshwater biomonitoring programs worldwide.

In India, freshwater bodies such as ponds, tanks, lakes, and wetlands play a critical role in supporting rural livelihoods, biodiversity conservation, and cultural heritage. Traditional tanks, particularly in northeastern India, serve as important reservoirs for domestic use, fisheries, and agriculture. However, many of these water bodies are increasingly subjected to pollution from untreated domestic sewage, solid waste disposal, agricultural runoff containing fertilizers and pesticides, and unregulated tourism activities [1, 6]. These pressures often lead to eutrophication, habitat degradation, and a decline in aquatic biodiversity.

Assam, situated in the biodiversity-rich northeastern region of India, is characterized by an extensive network of rivers, floodplain wetlands, oxbow lakes, beels, and numerous man-made tanks that collectively support a wide range of aquatic flora and fauna. The Brahmaputra river system and its associated wetlands play a crucial role in maintaining regional biodiversity and ecological stability [7, 8]. These freshwater habitats provide favorable conditions for the development of diverse aquatic insect communities, which contribute significantly to ecosystem functioning through nutrient cycling, energy transfer, and trophic interactions.

Several studies conducted in Assam and other parts of northeastern India have documented high diversity and abundance of aquatic insects, emphasizing their ecological importance and sensitivity to environmental changes [9-11]. Aquatic insect assemblages in the region have been shown to respond strongly to variations in water quality, habitat structure, and seasonal hydrological patterns, making them reliable indicators of freshwater ecosystem health (Subramanian & Sivaramakrishnan, 2007; Subramanian, 2019) [5, 6].

Despite the recognized ecological significance of aquatic insects, integrated studies that simultaneously evaluate aquatic insect diversity and physicochemical water quality parameters remain relatively scarce in Assam. This

limitation is particularly evident for historically significant man-made tanks, which are often subjected to increasing anthropogenic pressures such as urban expansion, agricultural runoff, religious activities, and tourism (Prasad *et al*., 2002; Sharma & Sharma, 2012) [1, 8]. The lack of comprehensive, site-specific ecological assessments hampers effective conservation and sustainable management of these culturally and ecologically valuable freshwater systems.

Joysagar Tank, situated in Sivasagar District of Assam, is one of the largest artificial water bodies in India and holds immense historical, cultural, and ecological value. Constructed by the Ahom king Rudra Singha, the tank has served as a vital freshwater resource for centuries. Given the ecological importance of aquatic insects and the growing anthropogenic pressures on Joysagar Tank, there is a pressing need to assess its ecological status using both biological and physicochemical indicators. Understanding the diversity and distribution of aquatic insects in relation to water quality parameters can provide valuable insights into the health of the ecosystem and inform effective management and conservation strategies. The present study therefore aims to evaluate aquatic insect diversity and water quality of Joysagar Tank, contributing baseline data for long-term monitoring and sustainable conservation of this historically significant freshwater ecosystem.

Materials and Methods

Study site

The present investigation was conducted at Joysagar Tank, a historically significant and the largest man-made water body in Sivasagar District, Assam, India. The tank is situated approximately 5 km from Sivasagar town, near the historic Joy Dol, and lies between 26°56′97″N–26°57′32″N latitude and 94°37′38″E–94°37′54″E longitude. Joysagar was constructed during the reign of Swargadeo Rudra Singha (1696–1714 AD) in memory of his mother, Joymoti Konwari, and represents an important cultural and ecological heritage of the region. Geographically, the tank is surrounded by Rupohi Pothar to the north, Kaloogaon to the south, Salaguri to the east, and Old Rangpur Nagar (present-day Joysagar) to the west. The water level of the tank remains approximately 14 feet above the surrounding ground level, contributing to its perennial nature. A notable hydrological characteristic of Joysagar Tank is the minimal seasonal fluctuation in water level, even during the dry months. This stability is attributed to its subsurface groundwater inflow [12, 13]. The tank supports a rich diversity of aquatic and semi-aquatic flora and fauna, making it an ecologically important freshwater ecosystem. In addition to its ecological value, Joysagar Tank is a major tourist destination in Sivasagar District. During the winter months, it serves as a temporary habitat for numerous migratory bird species, drawing large numbers of visitors and bird-watching enthusiasts. The combined historical, hydrological, and biological significance of Joysagar Tank makes it an ideal site for ecological and biodiversity-based studies.

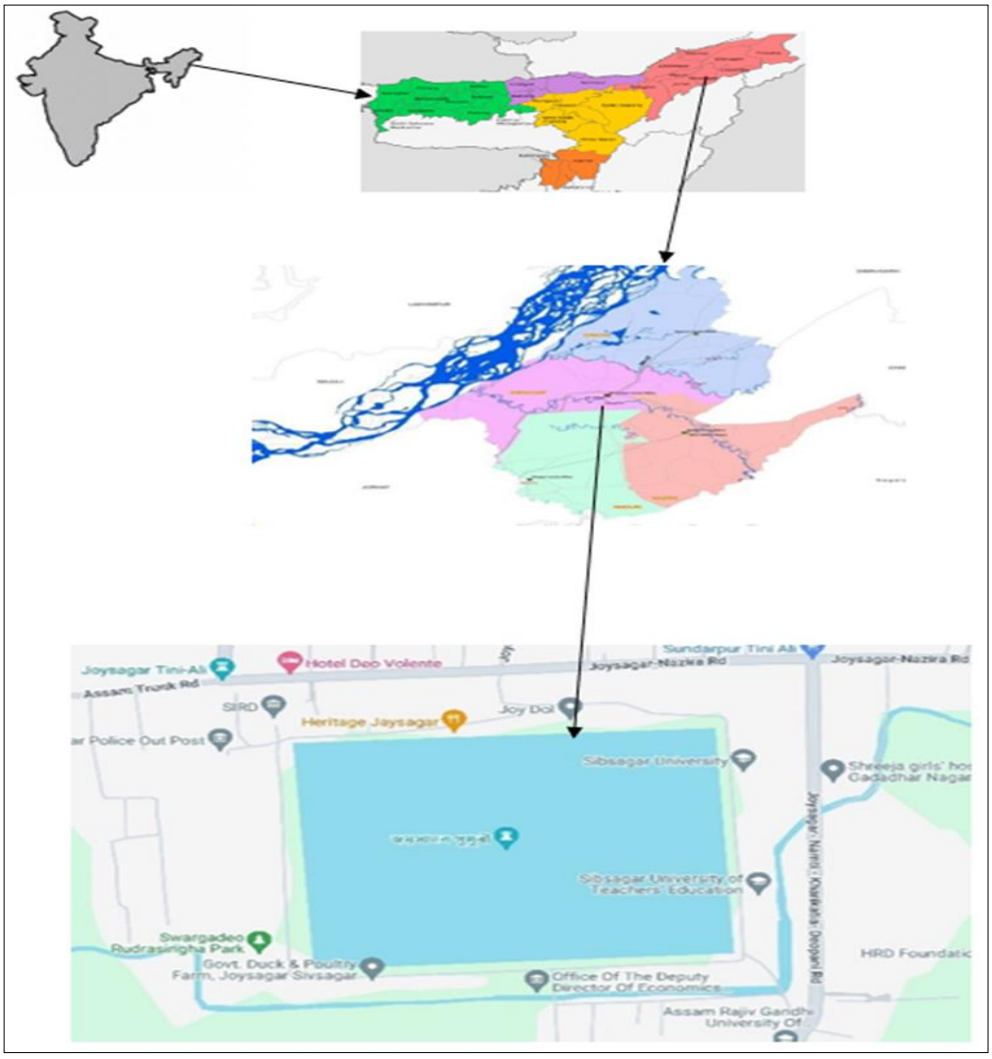

Fig 1: Map showing India, Assam, Sivasagar District and Joysagar Tank

Time and sampling methods

The field investigation was conducted for a duration of six months, from January to June 2024, covering both winter and pre-monsoon seasons. Aquatic insects were sampled from the littoral region of the water body, where insect diversity is generally high due to the presence of aquatic vegetation and shallow-water habitats. Collection of floating and actively swimming insects was carried out using hand-held circular nets fitted with fine polyester mesh, commonly used for mosquito control, which allows efficient capture of small-bodied aquatic insects. During sampling, aquatic plants were gently disturbed and spread, after which the net was swept around the vegetation for a standardized time interval. Each sampling unit consisted of three net sweeps, and sampling was repeated three times at each visit to maintain consistency and reliability of the data. Following collection, specimens were carefully separated from debris, enumerated, and preserved in 70% ethanol for subsequent identification. Taxonomic identification was performed using standard entomological manuals and keys, notably IMMS' General Textbook of Entomology (Vol. I) and Modern Entomology (2nd Edition) by D. B. Tembhare, supplemented by verified online taxonomic databases. Larger insects were identified with the naked eye, whereas smaller taxa were examined under a dissecting microscope. Representative specimens were photographed for documentation. Simultaneously, water samples were collected from the study site and analyses of water quality parameters were carried out following established laboratory protocol.

Physico-chemical parameters of water sample

Water temperature was measured directly at the sampling sites using a calibrated thermometer, as temperature plays a crucial role in regulating chemical reactions and biological processes in aquatic environments. The pH of the water samples was determined using a portable digital pH meter, which was standardized prior to use to ensure accuracy. Dissolved oxygen and free carbon dioxide levels were estimated using standard titrimetric methods, which are widely accepted for their reliability in freshwater quality assessment. Other physicochemical parameters were analyzed under laboratory conditions following established standard procedures. These parameters included total dissolved solids (TDS), turbidity, iron, calcium, total hardness, magnesium, total alkalinity, chloride, total arsenic, nitrate, fluoride, and residual chlorine. The analysis of these parameters provides comprehensive information on the chemical composition of water and helps in identifying potential sources of contamination. All analytical techniques were conducted following recognized standard protocols to ensure precision and reproducibility of results.

Results and Discussion

Physico-chemical Analysis of water: Assessment of physico-chemical characteristics is fundamental for understanding the overall water quality of any aquatic ecosystem. These parameters provide crucial insights into the environmental conditions that regulate biological productivity and ecological balance. Furthermore, variations in physico-chemical properties can be directly related to the distribution, abundance, and diversity of aquatic organisms inhabiting the water body. In the present study, the measured physico-chemical parameters of Joysagar Tank are summarized in Table 1 and evaluated to determine the suitability of the habitat for aquatic life. The observed values of the analyzed parameters indicate that the water quality of Joysagar Tank remains within favorable and acceptable limits, supporting the growth, survival, and reproductive activities of aquatic organisms. Overall, the results suggest that Joysagar Tank provides a conducive and stable aquatic environment, capable of sustaining diverse biological communities.

Table 1: Water sample analysis result of Joysagar tank during May 2024

Sl No	Parameter	Result
1.	pH Value	6.68
2.	Air Temperature	31.8 ℃
3.	Water Temperature	27 ℃
4.	Turbidity	4 NTU
5.	Dissolved oxygen	6.8 mg/l
6.	TDS (Total Dissolved Solids)	92 mg/l
7.	Iron	0.26 mg/l
8.	Total Hardness	50 mg/l
9.	Calcium	12.02 mg/l
10.	Magnesium	4.88 mg/l
11.	Nitrate	0 mg/l
12.	Total Arsenic	0 mg/l
13.	Fluoride	0.02 mg/l
14.	Residual Chlorine	0 mg/l
15.	Sulphate	1.27 mg/l
16.	Total Alkalinity	60 mg/l
17.	Chloride	4.96 mg/l

Diversity of Aquatic insects

The present investigation documented a total of 30 species of aquatic insects, representing 6 taxonomic orders—Hemiptera, Coleoptera, Odonata, Diptera, Ephemeroptera, and Hymenoptera—and distributed across 17 families. The recorded families include Corixidae, Pleidae, Notonectidae, Naucoridae, Mesoveliidae, Belostomatidae, Nepidae and Gerridae under Hemiptera; Dytiscidae, Gyrinidae, Hydrophilidae and Noteriadae under Coleoptera; Libellulidae and Coenagrionidae under Odonata; Chironomidae and Culicidae under Diptera; Baetidae under Ephemeroptera; and Formicidae under Hymenoptera. Among the recorded orders, Hemiptera emerged as the most dominant order, comprising 15 species belonging to 7

families, followed by Coleoptera with 8 species from 4 families, and both Odonata and Diptera represented by 2 species under 2 families. While Ephemeroptera was represented by 2 species from a single family. In contrast, Hymenoptera showed the least representation, with a single species belonging to one family. The order Hemiptera composed of 50%, Coleoptera composed of 26.6%, Odonata composed of 6.6%, Diptera composed of 6.6%, Ephemeroptera composed of 6.6% and Hymenoptera composed of 3.3% each of total recorded aquatic insect species in Joysagar tank (Fig: 2). A comprehensive list of the recorded insect taxa along with their distribution across sampling sites is presented in Table 2.

Table 2: Distribution of species based on their family and order recorded in Joysagar tank, Sivasagar

Sl. no	Order	Family	Species
1.	Hemiptera	Corixidae	*Micronecta haliploides* (Horvath, 1904)
			Micronecta scutellaris (Stal,1858)
		Pleidae	*Plea liturata* (Fieber, 1844)
		Notonectidae	*Anisops bouvieri* (Kirkaldy, 1904)
		Mesoveliidae	*Mesovelia mulsanti* (White, 1879)
		Belostomatidae	*Diplonychus rusticus* (Fabricius, 1781)
			Belostoma sp. (Latreille, 1807)
			Abedus herberti (Hidalgo, 1935)
		Nepidae	*Nepa apiculata* (Uhler, 1862)
			Ranatra filiformes (Fabricius, 1790)
			Laccotrephes ruber (Linnaeus, 1764)
			Ranatra linearis (Linnaeus,1758)
		Gerridae	*Neogerris sp.* (Matsumura, 1913)
			Lethocerus americanus (Leidy, 1847)
			Limnogonus nitidus (Mayr, 1865)
2.	Coleoptera	Dytiscidae	*Cybister fimbriolatus* (Say, 1825)
			Cybister chinensis (Motschulsky, 1854)
		Gyrinidae	*Laccophilus indicus* (Gschwendtner, 1936)
			Dineutus sp. (Macleay, 1825)
		Hydrophilidae	*Hydrophilus triangularis* (Say, 1823)
			Hydrophilus piceus (Linnaeus, 1758)
			Berosus infuscatus (LeConte,1855)
		Noteriadae	*Canthydrus sp.* (Sharp. 1882)
3.	Odonata	Libellulidae	*Orthetrum sp.* (Newman, 1833)
		Coenagrionidae	*Ceriagrion sp.* (Selys, 1876)
4.	Ephemeroptera	Baetidae	*Cloeon sp.* (Leach, 1815)
			Baetis sp. (Leach, 1815)
5.	Diptera	Culicidae	*Culex sp.* (Linnaeus, 1758)
		Chironomidae	*Chironomous sp.* (Megien, 1803)
6	Hymenoptera	Formicidae	*Polyrhachis sokolova* (Forel, 1902)

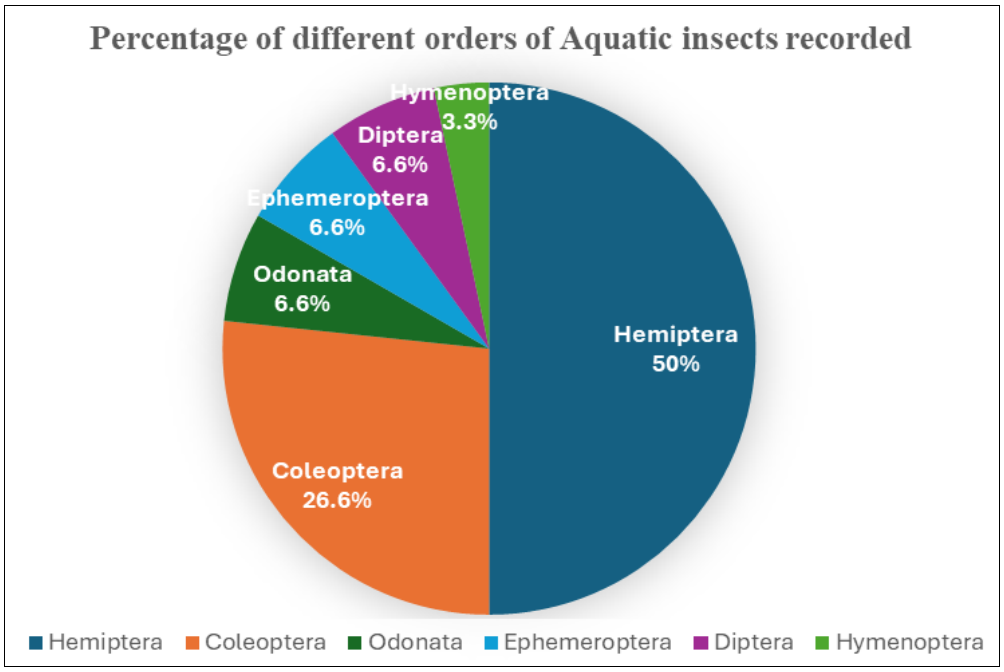

Fig 2: Percentage of different orders of Aquatic insects recorded in Joysagar tank

Plate 1: Images of aquatic insects of Joysagar Tank

The findings of the present study indicate that Hemiptera is the most abundant and species-rich order of aquatic insects, followed by Coleoptera. In contrast, Hymenoptera was recorded as the least abundant order. Comparable observations have been reported in earlier studies from Assam and other regions. Similarly, a survey conducted between February and May 2016 in three permanent ponds of Guwahati city recorded 25 aquatic insect species under six orders and 13 families. In that study, Hemiptera accounted for the highest number of species (15), followed by Coleoptera (4), while Odonata, Diptera, Hymenoptera, and Ephemeroptera were represented by fewer species [14]. A seasonal investigation carried out in a temple pond near Silchar, Cachar district, Assam documented 14 Hemipteran species belonging to 11 genera and seven families [15]. Earlier studies further support the dominance of Hemiptera in freshwater ecosystems. Chetri *et al*. (1997) [16] documented the highest species richness for Hemiptera (17 species) in Deepar beel, followed by Coleoptera (7 species) [16]. A subsequent study in the same wetland by Choudhury *et al*. (2015) [17], conducted from March to November 2013, recorded 17 species under eight families of Hemiptera and seven species belonging to five families of Coleoptera [17]. Another investigation carried out between January and March 2018 in the Kaliabor subdivision of Nagaon district, Assam revealed that Hemiptera, represented by nine families and 15 genera, was the most dominant order. This was followed by Coleoptera (three families and four genera), Odonata (two families and four genera), Diptera (two families and two genera), Ephemeroptera (one family and one genus), and Hymenoptera (one family and one genus) [18]. Deepa and Rao (2007) [19] reported eight Hemipteran species representing four families and five genera from Pocharam Lake, Andhra Pradesh [19]. Likewise, Bhattacharya *et al*. (1998) [20] documented eight aquatic insect species associated with *Eichhornia crassipes* in freshwater wetlands of West Bengal. According to Gupta *et al*. (2013) [21], a study carried out in the oxbow lake *Phulbari Anua* in Cachar district, Assam, during the period from February to April 2010 recorded nine aquatic insect species representing nine families under four different orders [21]. Additionally, a year-long study conducted from July 2007 to June 2008 in two pond ecosystems at Gauhati University, Assam recorded a total of 14 aquatic insect species belonging to seven families [22]. The recorded species diversity in Joysagar Tank highlights its ecological health and underscores the importance of maintaining suitable water quality and habitat conditions for sustaining aquatic insect populations.

Conclusion

The present study provides a comprehensive assessment of aquatic insect diversity in relation to the physicochemical characteristics Joysagar tank of Sivasagar District, Assam.

The findings reveal that the water body supports a rich and diverse assemblage of aquatic insects, reflecting favorable environmental conditions and habitat suitability. The dominance of certain insect orders, along with the presence of both pollution-tolerant and pollution-sensitive taxa, indicates a balanced ecosystem with moderate ecological stability. The analysis of physicochemical parameters demonstrated that most water quality variables remained within acceptable limits, creating conditions conducive to the growth, survival, and reproduction of aquatic organisms. The close association observed between aquatic insect distribution patterns and water quality parameters confirms the effectiveness of aquatic insects as reliable bioindicators of freshwater ecosystem health. Furthermore, information on the diversity, distribution, and abundance of aquatic insects in freshwater ecosystems of Assam remains limited and fragmented, underscoring the need for more comprehensive and systematic investigations in the region. In this context, the present study contributes valuable baseline data on aquatic insect communities and associated environmental conditions, which can serve as a reference for future research. The findings are expected to support long-term ecological monitoring and assist in the formulation of effective conservation and management strategies aimed at the sustainable utilization and protection of freshwater resources.

Competing Interests

The authors declare that they have no known competing financial or personal interests that could have appeared to influence the work reported in this paper. All authors have read and approved the final manuscript and agree to its submission and publication.

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