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# Insect Diversity of Freshwater Ecosystems in Meghalaya, Northeast of India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors KK and MKY did Conception and design, Authors KK, MKY, HP, SS and DK did acquisition of data, Performed statistical analysis and interpretation of the results All authors read and approved the final manuscript.*

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## ABSTRACT

The study was carried out on the biodiversity of freshwater insects in Meghalaya (northeast India). Seven different sampling points were selected: Umngot river, Umkhen River, paddy field (Mawryngkneng village), and Fish dale farm (Directorate of Fisheries), Puriang sung valley in East Khasi Hills District; Umiam River (Dwarksuid bridge) in Ri-Bhoi district; Dawki Wah Umngot in West Jaintia Hills District during August 2023 – January 2024 (including the three seasons summer, autumn, and winter). Insects were gathered every month by using a dip net having a mesh size of

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500 µm. A total of 24 species of insects belonging to 16 families and 6 orders were found and the most abundant order was Hemiptera consisting of (25%), and followed by Odonata (21.3%), Coleoptera (15.74%), Megaloptera (14.81%), Ephemeroptera (12.96%), and Diptera (10.19%). This study attempts to emphasize that unregulated mixing of different pollutant in rivers and its effect on the freshwater insect's biodiversity and rivers ecosystem of Meghalaya.

*Keywords: Environment; ecosystem; preservation; aquatic insects; pollution, Meghalaya.*

## 1. INTRODUCTION

Freshwater biodiversity, from fish to insects and microorganisms to macrophytes, delivers an immense range of amenities to human. Rising anxieties attention on the hastening pace of biodiversity loss and deteriorating natural function [1]. Freshwater insects are classified into 12 orders and 150 families, totalling over 8600 species. The health of the freshwater ecosystem is significantly influenced by aquatic insects. Most bug species are classified as aquatic since they are found in freshwater environments like swamps, ponds, lakes, springs, streams, and rivers (lotic and lentic habitats). The benthic, limnetic, and littoral fauna of aquatic environments are home to the dominant group of insects [2]. According to Lewis and Gripenberg [3], aquatic insects usually serve as excellent indicators since they may be found in almost any type of environment and because many of them are habitat specialists.

Because of their varied reactions to stimuli in their aquatic habitat and ability to gauge the quality of that environment, aquatic insects are employed for monitoring the health of aquatic habitats (Berg et al*.,* [4], Andersen, [5]. Aquatic insects are highly colourful and their abundance or absence can reveal the health or pollution of a body of water. Among the well-known insect groups found in inland wetlands are the caddisflies (Trichoptera), mayflies (Ephemeroptera), and dragonflies (Odonata). When wood and leaf litter from the surrounding terrain enter the marsh, aquatic insects mainly break them down. Fungal and bacterial activity further breaks down nutrients that aquatic insects have processed into a state that may be absorbed [6,7]. Aquatic insects perform an important ecological role in addition to being fish's main food source.

The eleven orders into which water insects are taxonomically categorized are Collembola, Ephemeroptera, Odonata, Plecoptera, Hemiptera, Megaloptera, Neuroptera, Trichoptera, Lepidoptera, Coleoptera, and Diptera [8]. One of the most important aspects of an aquatic ecosystem for preserving stability is its aquatic biodiversity [9,10]. Aquatic habitats are under increasing strain due to numerous disruptions. Tachet et al*.,* [11] The human population and aquatic life resources are both at risk due to these circumstances [12-14]. Freshwater habitats are seeing an increasing loss of biodiversity, primarily as a result of human activity [15]. According to Saunders et al*.* [16], the primary causes include the introduction of exotic species, habitat destruction, and defragmentation, and the effects of global climate change. The variety of aquatic ecosystems may suffer from the removal or disappearance of aquatic insects [17,18].

The study was carried out in the rivers of Meghalaya which is in the northeastern part of the Indian subcontinent. The state is situated on a mountainous plateau with incredible biodiversity. This state has many rivers because it gets the heaviest rainfall in the country which facilitated creations of many valleys. Umiam Lake, sometimes referred to as bara-pani or Big-water is a picturesque location located approximately 15 km from Shillong. The Wah Ro-ro stream, which originates at the junction of the Umkhrah and Umshyrpi streams, flows northwest of the town and meets the River Umiam, which encompasses Shillong and the surrounding areas of the Ri Bhoi district. The lake is a well-liked location for adventure and water sports facilities. The river drains an area of 1355 square kilometers and is 234 kilometers long overall. The Umngot River is situated in Meghalaya at the border of Dawki town. The Umngot River is one of the most famous tourist places in Meghalaya. It is also known as the clean water river which looks like crystal glass. The river works as a trade hub between the two countries named- India and Bangladesh. The total length of the river is 96 km. The presence of freshwater insects in rivers indicates healthy populations that contribute to maintaining a clean and clear aquatic environment, as these insects feed on algae, detritus, and organic matter from the riverbed. Decline in Meghalaya's aquatic insect

population may be caused by environmental deterioration, human activity, and acidic water from cement plants and coal mining [19]. To date, the population of aquatic insects is present in high abundance.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site and Design

The research work was carried out under the "Directorate of Fisheries" which is a governmental organization, working in the field of fishery and allied activities. It is located at HV8W+486, Dhankheti, Malki, Shillong, Meghalaya northeast India793014.

### 2.2 Description of the Study Area

The study was carried out from August 2023 - January 2024 in 3 different districts which include 7 sites viz., Umngot River, Umkhen River, (latitude 25.1996o, longitude 92.0206o) paddy field (Mawryngkneng village) (latitude 25.549041o, longitude 91.054820o)and Fish Dale Farm (Directorate of Fisheries), Puriang Sung valley (latitude 25.573208o, longitude 92.108292o) in District East Khasi Hills; Umiam River (at Dwarksuid bridge( in Ri-Bhoi district; (latitude 25.707328o, longitude 91.98978o) Dawki Wah Umngot (latitude 25.5274745o, longitude 92.0625544o) in the district West Jaintia Hills. The forest and agricultural fields still surround these rivers. The water is spotless and clear and the study location was shown in Fig. 1.

### 2.3 Materials Used for the Insect's Collection

The materials that are used for collection and identification are handnet /dipnet, microscope, hand-lens, forceps, collection jar, Borosil bottle, pH meter, thermometer, light color pan, camera, pen, and field notebook. Preservatives and preservation accessory materials included ethyl alcohol (70%), naphthalene, cotton, entomological pin (size 00), specimen bottle (5mL and 10mL), and specimen box (27.5*17.5*7 $cm^2$) were used.

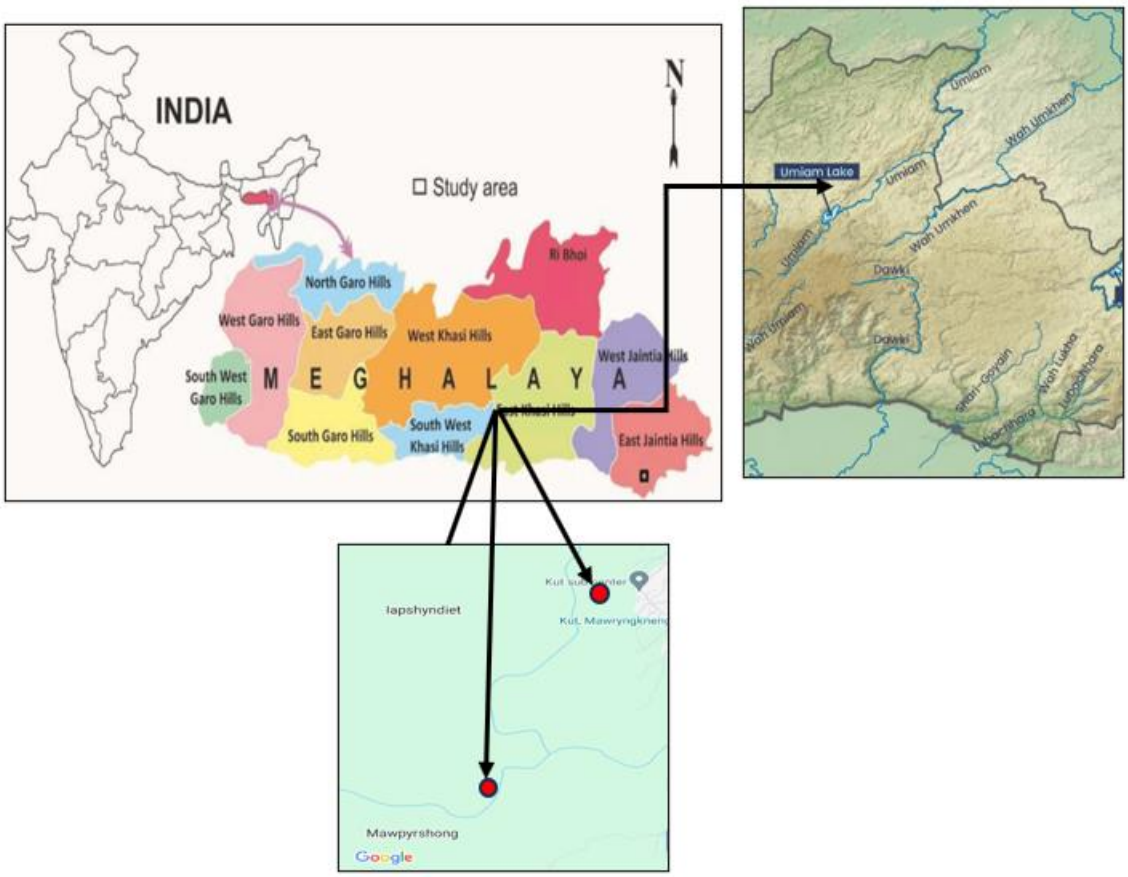



**Fig. 1. Map showing study area in 3 Districts**

### 2.4 Assessment of Insects' Diversity

Almost all aquatic environments, such as lakes, streams, wetlands, and puddles, are home to aquatic insects. Using a dip net is the most effective approach to gather aquatic insects from the water. The triangular net constructed with a long handle, a strong frame, and a mesh size of typically 500 µm, was used in the present study. The insects were collected using the kick-and-dip method. In lentic water like paddy fields and ponds, the insects were collected by sweeping method. Aquatic insects which hide under the rock, dead leaves and dead wood were collected by hand picking method using forceps. After that, the samples were taken to the laboratory for further analysis and placed into a collecting jar or container that holds 70% ethyl alcohol. Ethyl alcohol is combined with cotton at the bottom of the bottle to kill insects without causing damage, allowing for easy identification and preservation [20,21].

The obtained samples were inspected under a microscope (10X and up) in the laboratory, where conventional taxonomic keys were used to identify the insects [6,22]. Following identification, the samples were placed on a light-colored pan for photographs, and they were subsequently carried for preservation. The natural color of the insects was documented before preservation.

The diversity of insects was calculated in each sampling point (24) (Bara and Segura [23]) The abundance (%) and diversity indices were calculated for each monthly season by using statistical tools in Microsoft Office Excel 2021.

## 3. RESULTS

### 3.1 Aquatic Insects of Different Districts in Meghalaya

Different freshwater bodies of three districts - East Khasi Hills, Ri-Bhoi District, and West Jaintia Hills - were investigated in the study between August 2023 and January 2024. The study additionally explored the habitat of water insects and identified 26 species from 16 families and 6 orders.

In the study area, the most abundant order was Hemiptera consisting of 25% of the total insect collection followed by Odonata (21.3%), Coleoptera (15.74%), Megaloptera (14.81%), Ephemeroptera (12.96%) and Diptera (10.19%).

### 3.2 Monthly Variations in abundance of aquatic insects

Monthly collection of insects revealed that August and September, being a monsoon season in Meghalaya, represented a fewer species due to turbidity and high flooding, but Hemiptera species is high during this time as compared to the autumn and winter seasons. The highest collection of species was in October and November which is an autumn season experiencing less rainfall. At this time the order Hemiptera, Odonata, and Coleoptera were found the highest abundance and species richness. In December and January, again the species was less due to cold weather, however, only Megaloptera and Ephemeroptera species were conspicuous during the winter.

The results indicated that there are 24 species of aquatic insects belonging to 16 families and 6 orders were found in the study. Among these six orders, the dominant order was Hemiptera consisted of seven families Notonectidae, Corixidae, Nepidae, Gerridae, Naucoridae, Aphelocheiridae, Belostomatidae which included twelve species *(Notonecta kirbyi, Notonecta glauca, Anisops sardea, Laccotrephes sp, Ranatra sp, Limnoporus canaliculatus, Gerris lacustris, Ptilomera tigrina, Aquarius nebularis, Metrocoris bilobatoides, Ambrysus mormon, Aphelocheirus aestivalis, Belostoma flumineum).* The order Odonata consisted of four families viz., Calopterygidae, Macromiidae, Corduliidae, and Pseudolestidae with four species (*Neurobasis chinensis, Epitheca bimaculate, Macromia illinoiensis* and *Pseudolestes mirabilis*). The order Coleoptera consisted of one family Dytiscidae with four species (*Cybister fumatus.,Cybister fimbriolatus., Cybister dehaanii, Laccophilus fasciatus*). Order Diptera consisted of two families namely Chironomidae and Culicidae with two species (*Chironomous* sp and *Culex* sp). Order Ephemeroptera consisted of one family Heptageniidae with one species (*Leucrocuta aphrodite*). The order Meloptera consisted of one family Corydalidae with one species (*Megaloptera* sp). All insects' biodiversity data are presented in Table 1 and Figs. 1 to 3.

**Table 1. Insects biodiversity in different locations of Meghalaya**

| Sl.no | Order | Family | Genus | Habitat | District | | |
|---|---|---|---|---|---|---|---|
| | | | | | D1 | D2 | D3 |
| 1. | Ephemeroptera | Heptageniidae | *Leucrocuta aphrodite* | Streams\River | + | + | + |
| 2. | Odonata | Calopterygidae | *Neurobasis chinensis* | River\pond\lake | + | + | + |
| | | Macromiidae | *Macromia illinoiensis* | Paddy field\ marshes | + | + | + |
| | | Corduliidae | *Epitheca bimaculata* | Paddy field\ pond\lake | + | + | + |
| | | Pseudolestidae | *Pseudolestes mirabilis* | River\ stream | + | + | + |
| 3. | Hemiptera | Notonectidae | *Notonecta kirbyi* | Pond\paddy field\marshes | + | + | + |
| | | | *Notonecta glauca* | Pond\paddy field\marshes | + | + | + |
| | | | *Anisops sardea* | Stagnant water river bank | + | - | - |
| | | Corixidae | *Corixa punctata* | Pond\lakes\ | + | + | + |
| | | Nepidae | *Laccotrephes sp* | marshes | + | + | + |
| | | | *Ranatra sp* | ond\paddy field | + | + | + |
| | | Gerridae | *Limnoporus canaliculatus* | Both lentic and lotic water | + | + | + |
| | | | *Gerris lacustris* | Slow moving water | + | + | + |
| | | | *Ptilomera tigrina* | Fast running water\river | - | + | - |
| | | | *Aquarius nebularis* | Both lentic and lotic water | + | + | + |
| | | | *Metrocoris bilobatoides* | River bank | + | + | - |
| | | Naucoridae | *Ambrysus mormon* | River\ fast flowing water | - | + | - |
| | | Aphelocheiridae | *Aphelocheirus aestivalis* | River bank slow-moving water | + | + | + |
| | | Belostomatidae | *Belostoma flumineum* | Muddy pond\marshes | + | + | - |
| 4. | Meloptera | Corydalidae | *Megaloptera sp.* | River\stream\ Fast flowing water | + | + | - |
| 5. | Coleoptera | Dytiscidae | *Cybister fumatus* | lentic water\ paddy field | + | - | + |
| | | | *Cybister* | Swamps\bog\ | + | - | + |
| | | | *fimbriolatus* | muddy pond | + | - | - |
| | | | *Cybister dehaanii* | Ponds\lakes\ | + | - | + |
| 6. | Diptera | Chironomidae | *Chironomous sp* | In every shallow stagnant water | + | + | + |
| | | Culicidae | Culex sp | In every shallow stagnant water | + | + | + |

*D1: District 1, East Khasi Hills.*
*D2: District 2, West Jaintia Hills.*
*D3: District 3, Ri-Bhoi District.*
*The species / genus found in the sampling district are indicated by a (+).*
*The species/genus that are not present in the sampling district are indicated by (-)*

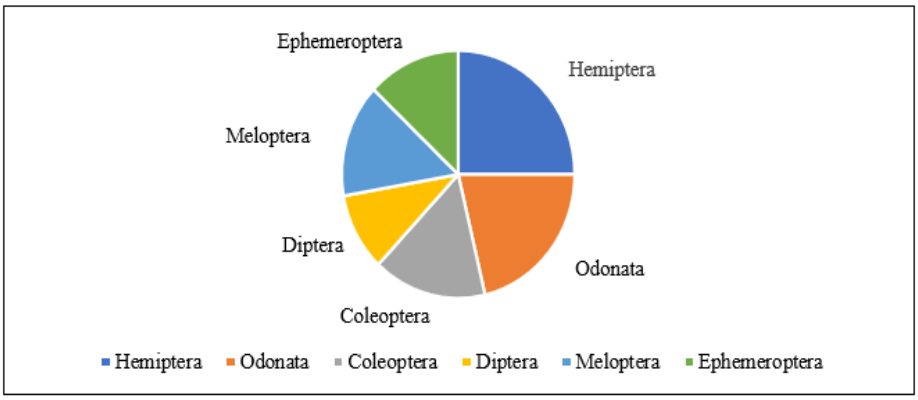
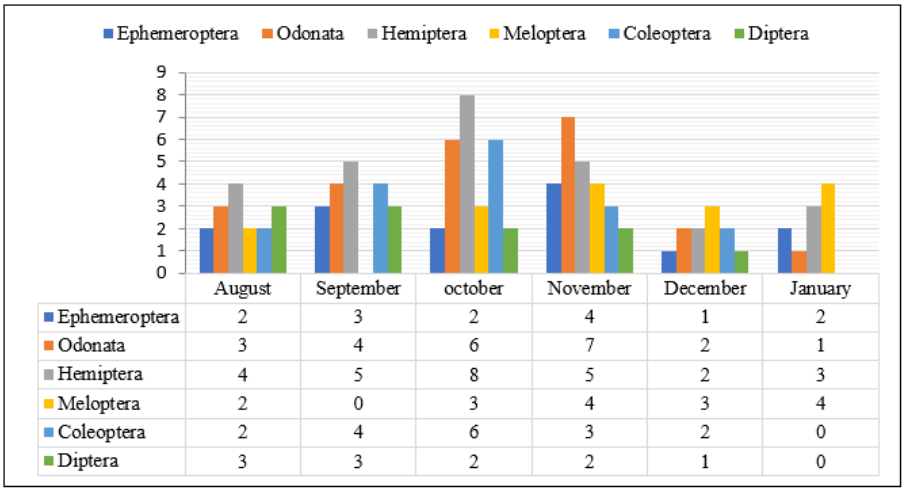



**Fig. 2. Orders of insects recorded during the present study**




| | August | September | october | November | December | January |
|---|---|---|---|---|---|---|
| Ephemeroptera | 2 | 3 | 2 | 4 | 1 | 2 |
| Odonata | 3 | 4 | 6 | 7 | 2 | 1 |
| Hemiptera | 4 | 5 | 8 | 5 | 2 | 3 |
| Meloptera | 2 | 0 | 3 | 4 | 3 | 4 |
| Coleoptera | 2 | 4 | 6 | 3 | 2 | 0 |
| Diptera | 3 | 3 | 2 | 2 | 1 | 0 |

**Fig. 3. Insects diversity variation in different months**

## 4. DISCUSSION

This study attempts to emphasize that unregulated mixing of different pollutant in rivers and its effect on the freshwater insect's biodiversity and rivers ecosystem of Meghalaya. Based on the findings of current study, Hemiptera was the most prevalent order (25%), followed by Odonata (21.3%), Coleoptera (15.74%), Megaloptera (14.81%), Ephemeroptera (12.96%), and Diptera (10.19%). The diversity and the richness of freshwater insect's species were mostly recorded in the autumn season (October and November) which corresponds with warmer temperature with less rainfall and maximum freshwater insect's species habitat was located near to ponds, marshes, paddy fields and agricultural fields and the availability of freshwater insects in different habitats already supported by Morse (2017) Tachet et al. [11], Ramade [12] and Krishnan et al. [17] and the biodiversity of freshwater insects was reliable with the findings of Prabhakar and Choodamani (2018), they concluded that the Katphal Lake Tal, 20 freshwater insects species and 15 families spread across 5 orders. Another related study, made by Sharma et al. [24], Yadav [25] and Wahizatul et al. [26] found 2,230 insects in the Modi Khola river in the Parbat area of Nepal and they consist 48 genera, 33 families, and 8 orders. The findings of this research on aquatic insects align with previous studies, including those by Prabhakar and Choodamani (2018), Suhaila et al. [27], and Ridzuan et al. [28], who recorded 20 species of aquatic insects from 20 genera and 15 families across 5 orders at Katphal Lake, Tal Sangola, District Solapur (Meghalaya). The diversity and richness of species in Meghalaya are present in high populations as the water quality is free from chemicals, pollution, poison, or any harmful substances that affect the water body [29]. The

Meghalaya river were affected by anthropogenic activity of human which causes regular decreasing the aquatic insect's biodiversity and conservation and save the biodiversity of freshwater insects, we suggested that need strict laws and regulation for the use of different types of chemical and pesticide which are used in agriculture as well as aquaculture and by adhering to strict environmental laws and regulations in Meghalaya, we can maintain a healthy aquatic ecosystem and productive environment to insects survival, which will enhance the diversity of aquatic insects, fish, and other flora and fauna.

## 5. CONCLUSION

This study suggested that need strict laws and regulation for the unregulated use of chemical and pesticide in agriculture and by obeying to strict environmental laws and regulations for maintain the Meghalaya biodiversity, which will enhance the diversity of aquatic insects, fish, and other flora and fauna**.**

## HIGHLIGHTS

- The study was carried out on the insect's biodiversity of freshwater in Meghalaya.
- Aquatic insects are employed for monitoring the equilibrium of aquatic habitats.
- This study provides the knowledge about Meghalaya freshwater insect's diversity and richness.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Authors hereby declare that no generative AI technologies such as large language models (Chat GPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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