The Bioscan
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES 19(3): 148-154, 2024 www.thebioscan.com

DIVERSITY AND ABUNDANCE OF PHYTOPLANKTON AND ZOOPLANKTON IN FRESHWATER ECOSYSTEMS OF RI-BHOI AND EAST KHASI HILLS DISTRICTS, MEGHALAYA

KYNTIEWLANG MARY KHARBYNGAR[1], JOHN ALKIN KHONGJOH[2], IADALANGKI BAMON[3], PYNSHANLANG LASO[4], MANDY MARY KHARBYNGAR[5] AND ELVIS KHONGMAWLOH[6]

Sankardev College, Lumshatsngi, Shillong, Meghalaya-793004

Email ID: sankardevcollege@gmail.com

"Plankton Diversity in Freshwaters of Ri-Bhoi and East Khasi Hills, Meghalaya"

Corresponding author

E-mail: khongmawlohelvis@gmail.com

Ph.no: 8974590922, 7005734215

DOI: https://doi.org/10.63001/tbs.2024.v19.i03.pp148-154

KEYWORDS
Diversity;
Dominant;
Freshwater;
Phytoplankton;
Zooplankton

Received on:

19-09-2024

Accepted on:

23-12-2024

ABSTRACT

Plankton was found to play essential roles in nutrient cycling, energy transfer, and maintaining ecosystem stability. This study, conducted during 2023–2024, examined the diversity of freshwater phytoplankton and zooplankton in two locations in Meghalaya: Ri-Bhoi District (Umsning) and Laitsohpliah Tyngammasi in the East Khasi Hills. A rich variety of plankton, including green algae, blue-green algae, diatoms, desmids, protozoa, rotifers, and crustaceans, was documented across these sites. While some species exhibited regional specificity, many were widely distributed, highlighting their adaptability and ecological significance. The findings underscore the importance of identifying and conserving freshwater plankton due to their critical contributions to aquatic food webs and ecosystem functions, providing valuable insights for the sustainable management of freshwater habitats.

INTRODUCTION

Biodiversity, a term popularized in the 1980s, gained global significance during the 1992 UN Conference on Environment and Development (Chazournes, 2009; Davies, 2008; National Research Council. 1999; Warren, 1996). It encompasses the variety of life forms in a given area, playing critical roles in ecosystem functioning (Hong et al., 2021; www.cbd.int). Freshwater ecosystems harbour a rich diversity of micro-eukaryotes, including rotifers, crustaceans, and protists, which are integral to ecological processes and services. Despite the early onset of limnological studies in India (Gopal and Zutshi, 1998, Jana, 1998; Sharma and Pachuau, 2016), the subtropical environments of North-East India remain underexplored, particularly concerning plankton diversity and dynamics (Sharma and Pachuau, 2016).

Plankton is microscopic organisms that drift with water currents and play vital roles in aquatic ecosystems (Naselli-Flores and Padisak, 2022). They serve as indicators of ecological variations and form the foundation of food webs (Kahsay et al., 2022). Phytoplankton, as primary producers, captures sunlight and converts it into energy that is transferred through the food web by zooplankton (Naselli-Flores and Padisak, 2022). They also play a pivotal role in removing CO_2 from the atmosphere, contributing to global carbon cycling (Naselli-Flores and Padisak, 2022).

Zooplankton, a critical component of aquatic ecosystems, facilitates the transfer of energy and nutrients through the food web (Steinberg and Robert, 2009; Pamai and Sharma, 2023). Predominantly inhabiting the pelagic zones of ponds, lakes, rivers, and oceans, they are crucial for sustaining omnivorous and carnivorous fishes, which directly or indirectly rely on them for nutrition (Singh et al., 2021). Zooplankton excretes organic matter, enriching the water with nutrients that support the growth and development of fish (Yewale, 2021). They are also an ideal food source for brood fishes, with carp larvae primarily feeding on zooplankton to sustain their rapid growth (Singh et al., 2021).

The Ribhoi district and East Khasi Hills in Meghalaya, India, are known for their rich biodiversity, including a diverse range of freshwater plankton species. Plankton, comprising phytoplankton and zooplankton, play a crucial role in nutrient cycling, energy transfer, and maintaining ecosystem stability by forming the foundation of aquatic food webs (Sharma and Sharma, 2022). The diversity of plankton in these regions is shaped by unique environmental factors such as abundant rainfall, clean water bodies, and varying altitudes (Mawa et al., 2022; Sharma, 2001b). Studying and identifying the plankton diversity in Ribhoi and East Khasi Hills is crucial for preserving ecological balance, supporting freshwater ecosystems, and sustaining the livelihoods that rely on these habitats.

METHODOLOGY

Surveys and inspections were conducted at Laitsohpliah Tyngammasi in the East Khasi Hills District and the Ri-Bhoi District of Meghalaya. Water samples were collected from the selected sites using plankton nets and preserved in vials containing 5% formaldehyde as a fixative. The preserved samples were transported to the laboratory for analysis and identification.

In the laboratory, small volumes of water containing plankton were transferred onto glass slides using a dropper and covered with coverslips. The slides were examined under compound microscopes (Magnus and Weswox; magnifications: 10× and 40×). Specimens were photographed, identified, and analyzed for inclusion in the project report. In cases where microscope images were unclear or inconspicuous, reference images from credible online sources were utilized to aid in species identification.

RESULT

The freshwater ecosystems in Ri-Bhoi District (Umsning) (Figure 2A) and East Khasi Hills (Laitsohpliah Tyngammasi) (Fig. 2B) exhibit a rich diversity of plankton, comprising representatives from green algae, blue-green algae, diatoms, desmids, protozoa, rotifers, and crustaceans (Fig. 1). These species demonstrate varied structural characteristics, habitat-specific adaptations, and critical ecological roles in maintaining biodiversity and supporting ecosystem functions.

Distribution of phytoplankton in Ri-Bhoi District (Umsning and East Khasi Hills (Laitsohpliah Tyngammasi)

Among green algae, species such as *Scenedesmus* (Fig. 3A), with ellipsoid or ovoid cells forming definite colonies, were found in both regions, as were *Spirogyra* (Fig. 3B), with spiral chloroplasts, and *Ulothrix* (Fig. 3C), characterized by cells containing distinct nuclei and large chloroplasts. The colonial algae *Volvox* (Fig. 3D), forming hollow spherical coenobia, was also present in both locations. Specialized green algae like *Chaetophora* (Fig. 3E), which has branching filaments in gelatinous masses, were restricted to Ri-Bhoi District, while *Tribonema* (Fig. 3F), with its H-shaped splitting cell walls, was recorded in both regions. Filamentous algae such as *Mougeotia* (Fig. 3G) with central axial plate chloroplasts, were limited to Ri-Bhoi District, whereas *Zygnema* (Fig. 3H) and *Pediastrum* (Fig. 3I), the latter forming free-floating colonies arranged in rings, were found in both regions.

The desmids displayed wide distribution, with species like *Closterium* (Fig. 3J), crescent-shaped with tapered ends, and *Micrasterias* (Fig. 3K) known for its compressed, bilaterally symmetrical cells, found in both regions. Other desmids such as *Desmidium* (Fig. 3L), forming spirally twisted filaments, and *Cosmarium* (Fig. 3M), with rounded semi-cells separated by an isthmus, were similarly widespread. *Pleurotaenium* (Fig. 3N) characterized by long cylindrical cells and semi-cells that swell at junctions, was ubiquitous across both locations.

Diatoms included *Melosira* (Fig. 3O), with pill-shaped or spherical cells, which were restricted to Ri-Bhoi District, and *Navicula* (Fig. 3P) featuring solitary, elliptical to lanceolate cells, present in both regions. These diatoms play a vital role in primary production and nutrient cycling within these aquatic systems. Blue-green algae such as *Microcystis* (Fig. 3Q), with densely aggregated spherical or ovoid cells, and *Coelosphaerium* (Fig. 3R) forming mucilage-bound spherical colonies, were recorded in both regions, highlighting their adaptability and ecological importance.

Distribution of zooplankton in Ri-Bhoi District (Umsning) and East Khasi Hills (Laitsohpliah Tyngammasi)

In addition to these groups, the plankton communities also included protozoa, rotifers, and crustaceans. Among protozoa, *Euglena* (Fig. 4A), a unicellular organism characterized by its elongated body and flagella for locomotion, was recorded exclusively in Ri-Bhoi District. Rotifers were represented by species such as *Keratella* (Fig. 4B), with a thick protective lorica and six anterior spines; *Brachionus* (Fig. 4C), with a dorso-ventrally flattened body and flexible foot; and *Notholca* (Fig. 4D) which has an oval lorica and distinct anterior spines. These rotifers were found in both regions, showcasing their wide adaptability.

Crustaceans were abundant and diverse across both regions. *Chydorus* (Fig. 4E), with its spherical body and large compound eye, and *Bosmina* (Fig. 4F) distinguished by its carapace hump and beak-like antennules, were present in both locations. Larval crustaceans such as *Nauplius* (Fig. 4G), with segmented bodies and a median eye, and adult forms like *Cyclops* (Fig. 4H), with short antennae and segmented bodies, were also recorded. *Copepods* (Fig. 4I) with short cylindrical bodies and prominent long antennae, and *Eubranchipus* (Fig. 4J), bilaterally symmetrical with 10 pairs of appendages, further demonstrated the diversity of crustaceans in these ecosystems.

This comprehensive analysis of plankton communities highlights the ecological richness and biodiversity of the freshwater systems in Ri-Bhoi District and East Khasi Hills. While some species exhibited regional specificity, many were widely distributed, emphasizing the critical roles these plankton play in nutrient cycling, food web dynamics, and ecosystem stability. These findings underscore the importance of conserving such habitats to maintain aquatic biodiversity and ecological balance.

DISCUSSION

The present investigation aimed to assess the species diversity and abundance of plankton in two districts of Meghalaya: Ri-Bhoi and East Khasi Hills. A total of 18 species of phytoplankton and 10 species of zooplankton were recorded from various locations across the districts. Phytoplankton was found to be more abundant than zooplankton in both regions, consistent with previous findings (Dutta, 2011). Species diversity of phytoplankton was higher in Ri-Bhoi compared to East Khasi Hills, while zooplankton diversity was relatively similar between the districts. Among the recorded plankton, *Microcystis* and *Bosmina* were identified as dominant species. Water bodies in the Ri-Bhoi district exhibited comparatively greater overall plankton diversity.

Accurate identification of plankton is crucial for predicting the impacts of environmental changes; as such predictions depend on precise taxonomic information. This study provides valuable insights into plankton diversity and its role in aquatic ecosystems, which can guide scientific research and fisheries development. Plankton significantly influences the fisheries sector by determining water quality and natural productivity. Seasonal variations in plankton composition offer a useful tool for understanding ecosystem dynamics. Physico-chemical parameters of water strongly affect plankton species composition, abundance, and diversity, ultimately influencing fish distribution. Unfortunately, there is limited information on the seasonal variations of plankton and their relationship with physico-chemical water factors, emphasizing the need for further studies in this area.

The abundance of phytoplankton serves as a key indicator of water quality, with diatoms, in particular, recognized as reliable bio indicators (Odum, 1971). Zooplankton occupies an intermediate position in the food web, feeding on algae and bacteria and, in turn, serving as prey for invertebrates and fish. They also indicate the trophic status of water bodies. Zooplankton exhibit moderate species diversity, low dominance, and high equitability, which reflect temporal variations (Sharma and Sharma, 2021).

Plankton acts as biomarkers of aquatic ecosystem health, responding rapidly to environmental changes and serving as indicators of water contamination. Global climate change poses significant challenges to plankton communities, with profound long-term effects. Bio-monitoring of micro-eukaryotes remains challenging due to their microscopic size, complex morphological characteristics, and immense biodiversity (Xiong et al., 2019). Despite these challenges, every effort was made to accurately identify the plankton species present at the study locations.

In multi-species plankton communities, growth and abundance are influenced by various factors, including nutrient availability, climatic conditions, and human activities (Wetzel, 2001). Zooplankton thrives as long as adequate light and warmth are present, but their numbers, along with phytoplankton, decline significantly during the winter months (Dutta, 2011). Environmental conditions such as high total phosphorus levels, increased turbidity, and low water transparency are generally unfavourable for phytoplankton growth (Chalinda et al., 2004; Moutin et al., 2002; Chowdury et al., 2007). Understanding the dynamics of plankton communities under these conditions provides essential insights into ecosystem health and fishery resource management.

CONCLUSION

This study concluded that plankton diversity was comparatively higher in the Ri-Bhoi district than in the East Khasi Hills district of Meghalaya. Phytoplankton was more abundant than zooplankton in both districts. These findings provide a foundation for further taxonomic and advanced studies on freshwater and pond water plankton, contributing to a deeper understanding of their ecological roles and potential applications in monitoring and managing aquatic ecosystems.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGMENTS

On behalf of the Department of Zoology, We are grateful to the Principal, Sankardev College, Shillong for providing all the necessary facilities needed in conducting this investigation. We also thank the Fish Farm owners of Umsning village for permitting us to collect the water samples required for the above mentioned project.

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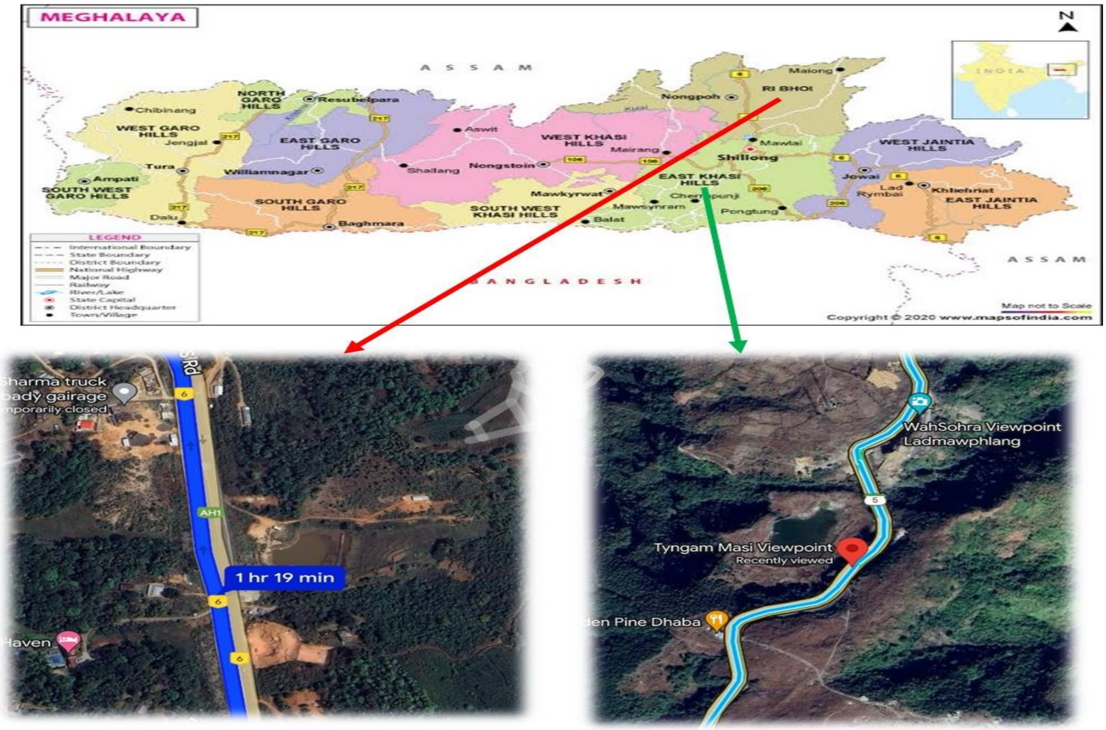

Fig.1: Map showing plankton sample collection sites in Ri-Bhoi District (Umsning) and East Khasi Hills (Laitsohpliah Tyngammasi).

Fig.2: Plankton sample collection sites in Meghalaya, highlighting two key regions: (A) Ri-Bhoi District (Umsning) and (B) East Khasi Hills (Laitsohpliah Tyngammasi).

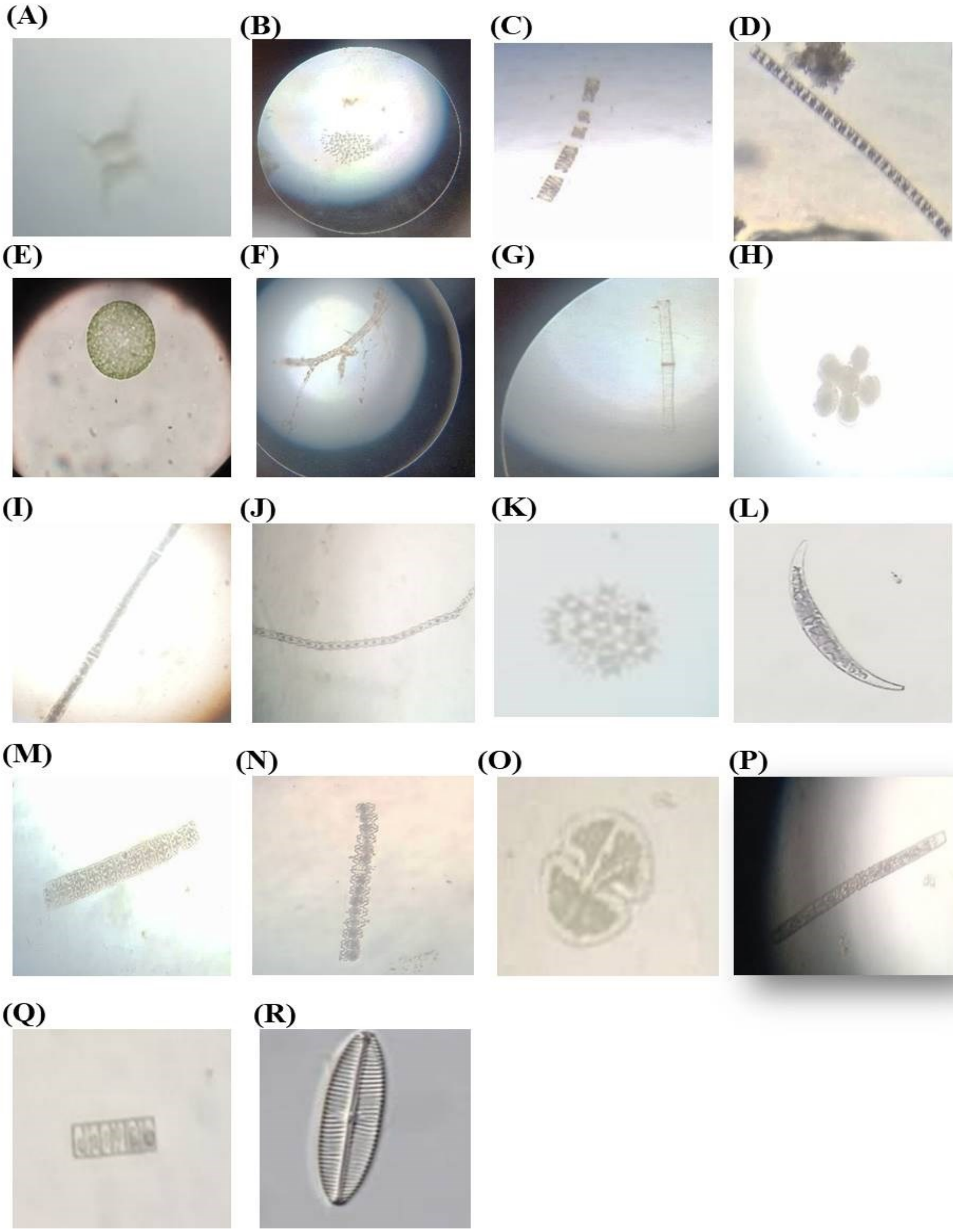

Fig.3: Representative phytoplankton species identified in Ri-Bhoi District (Umsning) and East Khasi Hills (Laitsohpliah Tyngammasi): (A) *Scenedesmus*, (B) *Spirogyra*, (C) *Ulothrix*, (D) *Volvox*, (E) *Chaetophora*, (F) *Tribonema*, (G) *Mougeotia*, (H) *Zygnema*, (I) *Pediastrum*, (J) *Closterium*, (K) *Micrasterias*, (L) *Desmidium*, (M) *Cosmarium*, (N) *Pleurotaenium*, (O) *Melosira*, (P) *Navicula*, (Q) *Microcystis*, and (R) *Coelosphaerium*.

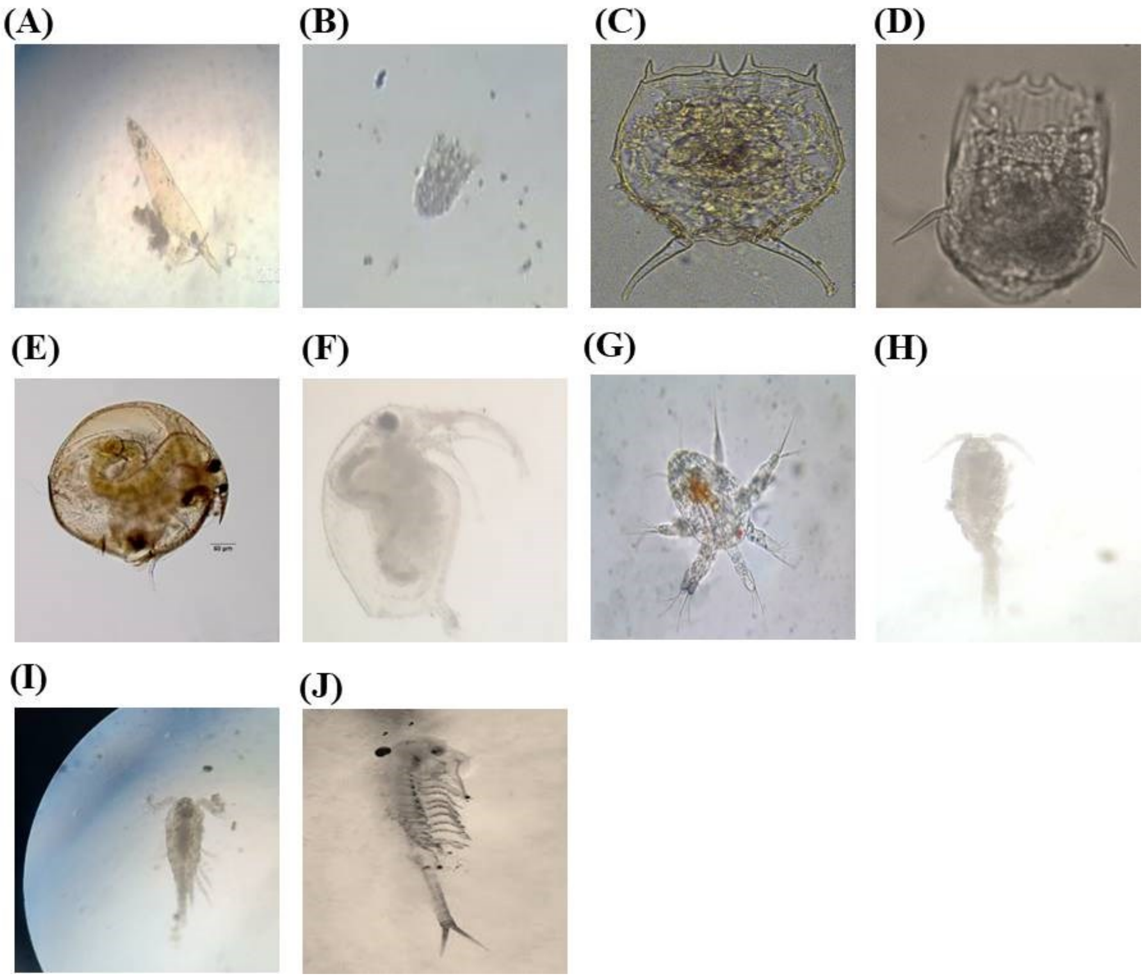

Fig.4: Representative zooplankton species identified in Ri-Bhoi District (Umsning) and East Khasi Hills (Laitsohpliah Tyngammasi): (A) *Euglena*, (B) *Keratella*, (C) *Brachionus*, (D) *Notholca*, (E) *Chydorus*, (F) *Bosmina*, (G) *Nauplius*, (H) *Cyclops*, (I) *Copepod*, and (J) *Eubranchipus*.

Table 1: Phytoplankton species distribution in Ri-Bhoi and East Khasi Hills Districts, Meghalaya:

Sl No.	Scientific name	Features	Locations	
			Ri-Bhoi District (Umsning)	**East Khasi Hills (Laitsohpliah Tyngammasi)**
1.	*Scenedesmus*	Green algae. Ellipsoid or ovoid cells in multiples of two and laterally in contact parallel to one another. Cells forming definite colonies.	(+)	(+)
2.	*Microcystis*	Blue Green Algae. Cells spherical or ovoid, densely aggregated.	(+)	(+)
3	*Spirogyra*	Green Algae. Having helical or spiral arrangement of chloroplasts.	(+)	(+)
4	*Ulothrix*	Green Algae. Each cell contains a distinct nucleus, a central vacuole and a large chloroplast.	(+)	(+)
5	*Volvox*	Green algae. Colonial, spherical or broadly elliptical. Body is a hollow sphere called coenobium; thousands of cells are arranged in the periphery of the sphere.	(+)	(+)
6	*Chaetophora*	Green Algae. Having branching filaments in tufts in a dense gelatinous mass.	(+)	(-)
7	*Tribonema*	Green Algae. Cells cylindrical or barrel-shaped, forming unbranched simple filaments. Cell wall firm, splitting into H-Shaped structure.	(+)	(+)

8	*Coelosphaerium*	Algae. Spherical to oval colonies of cells held in a single outer layer of mucilage.	(+)	(+)
9	*Mougeotia*	Green Algae. Filamentous, unbranched, benthic, with an axial plate chloroplast that goes through the center of the cell.	(+)	(-)
10	*Zygnema*	Green Algae. Short, unbranched filaments and composed of cylindrical cell within a sheath.	(+)	(+)
11	*Pediastrum*	Green Algae. Free floating, usually single layered, consisting of 4 to several cells arrange like a ring.	(+)	(+)
12	*Closterium*	Desmids. Crescent-shaped or elongated and lack spines. Tapered ends and may be pointed or rounded.	(+)	(+)
13	*Micrasterias*	Desmids. Unicellular having bilateral symmetry. Cells very much compressed.	(+)	(+)
14	*Desmidium*	Desmids. Cells united in spirally twisted filaments usually without a gelatinous sheath. Broadly rounded, apex broad and concave in the middle. Cell wall smooth.	(+)	(+)
15	*Cosmarium*	Unicellular desmid with two rounded semi-cells separated by an isthmus or constriction. Each semi-cell contains a green chloroplast.	(+)	(+)
16	*Pleurotaenium*	Green Algae. Unicellular Desmid with long cylindrical cells. The semi cells may have swollen ends at the point they meet.	(+)	(+)
17	*Melosira*	Diatom. Cells are pill shaped, cylindrical or spherical in structure. Chloroplast are numerous and located close to the cell wall.	(+)	(-)
18	*Navicula*	Diatom. Cells are solitary, elliptical to lanceolate in shape with rounded flat or capitate ends. Striations vary, may or may not be visible under microscope.	(+)	(+)

Table 2: Zooplankton species distribution in Ri-Bhoi and East Khasi Hills Districts, Meghalaya:

Sl No.	Scientific name	Features	Locations	
			Ri-Bhoi District (Umsning)	East Khasi Hills (Laitsohpliah Tyngammasi)
1.	*Euglena*	Protozoa. Unicellular, elongated organism having flagella as a locomotory organ.	(+)	(-)
2.	*Keratella*	Rotifer. Six anterior spines present. Lorica (Protective covering) thick, dorsally curved and ventrally flattened. Dorsal plate with polygonal facets.	(+)	(+)
3.	*Brachionus*	Rotifer. Dorso-ventrally flattened, anterior end usually with 6 spines. Foot long and flexible.	(+)	(+)
4.	*Notholca*	Rotifer. Lorica (shell) oval, dorso-ventrally flattened; anterior dorsal margin with 4 long and 2 short spines.	(+)	(+)
5.	*Chydorus*	Crustacean. Spherical body with carapace enclosing limbs and body large compound eye. Antennules short.	(+)	(+)
6.	*Bosmina*	Crustacean. Body oval, dorsal margin of carapace marked by a hump. Antennules greatly elongated and beak-like. Six pairs of feet.	(+)	(+)
7.	*Nauplius*	Crustacean. Body oval and segmented with a broad anterior and narrow posterior end, median eye is present, three pairs of appendages.	(+)	(+)
8.	*Cyclops*	Crustacean. Body elongated with broad anterior and narrow posterior end. Body divided into segments. Antennae short.	(+)	(+)
9.	*Copepod*	Crustacean. Short cylindrical body clearly divided into segments. Head with prominent very long antenna.	(+)	(+)
10.	*Eubranchipus*	Crustacean. Body bilateral, symmetrical, 10 pairs of appendages. Head distinct with a pair of compound eyes.	(+)	(+)