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USE OF AQUATIC INSECTS TO ASSESS THE BIOLOGICAL STATUS OF A PERENNIAL POND IN ASSAM, NORTHEAST INDIA

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ABSTRACT

An investigation was carried out on "Hazara Pukhuri", a perennial pond in Sonitpur district, North East India, between July 2019 and June 2020. To assess the health of the waterbody, various biotic and diversity indices were applied, with aquatic and semi-aquatic hemipteran populations functioning as bioindicators. The pond's hemipterans include 17 species from 13 genera and 8 families, including Gerridae, Corixidae, Pleidae, Notonectidae, Nepidae, Belostomatidae, Hydrometridae, and Mesoveliidae. The biotic indices Average Score per Taxon (ASPT), Stream Invertebrate Grade Number-Average Level (SIGNAL-2), and The Biological Monitoring Working Party (BMWP) Score, as well as other diversity indices, were assessed to indicate that the waterbody was unpolluted/ slightly polluted. The presence or lack of littoral vegetation and flooding and drying of nearby shallow water pools and swampy areas were important drivers of the distribution, abundance, and community composition of aquatic and semi-aquatic hemipterans in the studied water body.

Key words: Perennial pond, Assam, Hemiptera, Heteroptera, BMWP, ASPT, abundance, diversity indices, water quality, hydroperiod, population, vegetation

Aquatic insects represent the majority of the functional feeding group, which includes predators, shredders, grazers, filter feeders, gatherers, piercers, and parasites (Mackie, 2001). Hemipterans are true "bugs" (Hemiptera) and its aquatic and semiaquatic members can be found in and around all types of freshwater habitats. These are classified as suborder Heteroptera (Thirumalai, 2007). Hemipterans are important in the ecology of freshwater ecosystems. Thirumalai and Raghunathan (1988) and Ramakrishna (2000) concluded that aquatic bug population dynamics influence the quality of the aquatic environment. Many organisms, including fish, amphibians, waterfowl, and other animals, rely on them for food (Clark, 1992). These insects typically occupy an intermediate position in food chains and are important predators. Certain hemipteran families are useful in the biological control of mosquito larvae (Jenkins, 1964; Bisht and Das, 1981; Ohba and Nakasuji, 2006; Saha et al., 2007). Aquatic Hemiptera can live in an environment that would be extremely stressful for other organisms, as in German mining lakes with a pH <3 (Woolmann, 2001). Thus, these bugs are frequently used to assess the levels of toxins in an environment as they can survive in heavily polluted areas (Papacek 2001; Woolman 2001; Jansson 1987). The diversity and distribution of aquatic Hemiptera in the freshwater ecosystems of the Indian subcontinent have been extensively studied by Thirumalai (2002a, 2002b, 2007), Thirumalai and Suresh Kumar (2006), Thirumalai and Raghunathan (1988), and Bal and Basu (1994a,b, 2000a,b, 2003, 2004). Thirumalai (2002a) found 80 genera and 275 species of aquatic and semiaquatic Hemiptera in India. Chetri et al. (1997), Kalita (2008), Hazarika and Goswami (2010), Gupta and Purkayastha (2012), Gupta and Das (2012), Barman and Baruah (2013, 2015), Barman and Deka (2015), and Barman and Gupta (2015) studied the aquatic and semiaquatic hemipterans of this region previously. These studies overlook the use of aquatic and semiaquatic hemipterans as bioindicators, particularly in the northeastern region of India. The current study, therefore focused on studying the community composition and population dynamics of aquatic and semiaquatic hemipterans in a manmade, perennial fish pond in Sonitpur, Assam.

MATERIALS AND METHODS

At an elevation of 245 feet, Hazara Pukhuri is located within the geographical ranges of $26^0 38/0//N$-$26^0 37/58//N$ and $92^0 46/30//E$-$92^0 46/47//E$. It is the largest perennial pond in Tezpur, Sonitpur District. The pond attracts visitors from all over the world because of its historic significance and its importance as a migratory and resident aquatic bird habitat. The experiment was conducted from July 2019 to June 2020, selecting four sampling sites. Insects from the littoral zones

were collected by netting locations inside the pond's specified sampling sites using simple hand-operated nets of various sizes. The floating and swimming insects were collected using circular nets comprised of coarsely woven cotton cloths and finely woven polyester mosquito curtain cloths. The insects associated with macrophytes were collected using a D-shaped dip net with nylon netting of 500 µm mesh. The net's operation is substantially based on Merritt and Cummins'(1996) descriptions. Insects were sorted and preserved in 70% ethyl alcohol, then identified using standard literature, such as Thirumalai (1999), Bal and Basu (1994a, b), Merritt and Cummins (1996), and Pennak (1996). The adults gathered were used to identify the animals, and preservation was done using wet methods. The taxonomy and biodiversity study laboratory of the Post Graduate Department of Zoology, Darrang College, Tezpur, Assam, houses these voucher specimens. The no. of individuals/ sample (N) and the species per sample (S) were tallied. Diversity Indices such as Shannon diversity index (Ĥ), Index of evenness (e), Simpson index (1-D, where D is the Dominance), Berger-Parker dominance index, Margalef's and Menhinick's richness index, and Fisher's alpha were calculated using the statistical software PAST (version 4.03). Standard methods were used to determine the biotic indices- such as average score/ taxon (ASPT), stream invertebrate grade no.- average level (SIGNAL-2), and the biological monitoring working party (BMWP) ccore (Chessmann, 2001,2003; Hawkes 1998; Jackson, 2009). Based on regional climatological changes, the seasonal fluctuation of aquatic insects was researched by classifying the seasons as pre-monsoon (PRM, March-June), monsoon (MON, July-October), and post-monsoon (POM, November-February).

RESULTS AND DISCUSSION

Members of the families Corixidae, Notonectidae, Pleidae, Nepidae, Belostomatidae, Gerridae, Hydrometridae, and Mesoveliidae contribute to the aquatic and semiaquatic Hemiptera of the pond, with 17 species belonging to 13 genera and 1428 individuals. The seasonal occurrence and abundance of the documented hemipterans are shown in Table 1 and Fig. 1, respectively. The significant diversity of the group in the selected pond ecosystem under Assam's agroclimatic conditions is reflected in the 17 documented species, which is consistent with previous studies. All species found are members of the Heteroptera. At the Deepar beel Ramsar site in Assam, Kalita (2008) identified 9 hemipterans, one

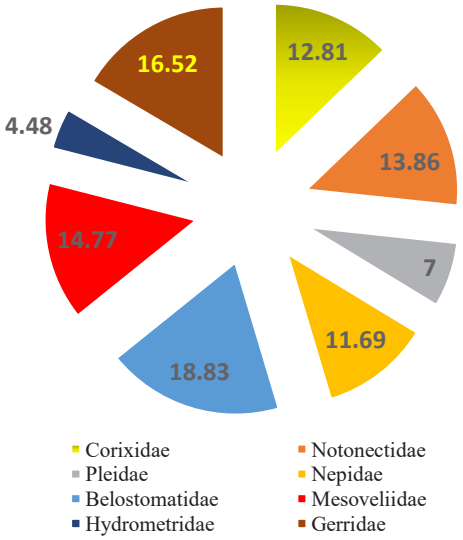

Fig. 1. Relative abundance of aquatic and semi-aquatic Hemiptera- families

of which (*Rhopalosiphum nymphaeae* L.) belongs to the suborder Homoptera. The population density was found often high during the monsoon and pre-monsoon. Among the reported species, 10 species namely *Neogerris parvula* Stal, *Gerris gracilicornis* Horvath, and *Limnogonus nitidus* Mayr (*family* Gerridae); *Diplonychus rusticus* F (Belostomatidae); *Mesovelia vittigera* Horvath (Mesoveliidae); *Hydrometra greeni* Kirkaldy (Hydrometridae); *Ranatra filiformis* F (Nepidae); and *Micronecta scuttellaris scuttellaris* Stal (Corixidae) are the most widely dispersed and dominant species observed. The aquatic macrophytes in the pond, namely, *Eichhornia crassipes (Mart) Solm* and *Hydrilla verticillata* (L.F) Royle, are commonly seen with Belostomatidae and Hydrometridae. Bhattacharya (1998) reported 8 species of aquatic Hemiptera in association with *Eichhornia crassipes* in some freshwater wetlands of West Bengal, while Pal et al. (1998) reported 25 species in association with 39 macrophytes in a freshwater wetland in Southeastern Bengal, supporting the findings of the current study. However, in the littoral section of the pond, species belonging to Gerridae and Mesoveliidae can be found in the open water zone. *On the other hand, Laccotrephes rubber* L, *Laccotrephes griseus* Guerin, *Lethocerus indicus* Lepleiter and Serville, and *Ranatra gracilis* Dallas are uncommon and found in small numbers. *Plea liturata* Fieber and *R. filiformis* while present in significant numbers but not throughout the year. The free-floating *E. crassipes* is associated with most of the insect fauna (8 species), followed by the submerged species *H verticillata* (4 species) and the marginal rooted creeper emergent plant *Jussiaea repens* L (1 species).

Table 1. Diversity, seasonal occurrence, and relative abundance- Hemiptera

Name of the collected species	Seasonal occurrence and abundance				
	PRM	MON	POM	No. of Individuals	Relative abundance (%)
Order: Hemiptera					
Family: Corixidae					
Micronecta scuttellaris scuttellaris Stal	+	+	+	145	10.15%
Micronecta siva Kirkaldy	+	+	-	38	2.66%
Family: Notonectidae					
Nychia marshalli Scott	+	+	+	125	8.75%
Anisops bauvieri Kirkaldy	-	+	+	73	5.11%
Family: Pleidae					
Plea liturata Fieber	-	+	+	100	7.00
Family: Nepidae					
Laccotrephes griseus Guerin-Meneville	-	+	-	9	0.63%
Laccotrephes rubber Linnaeus	+	-	-	14	0.98%
Ranatra filiformis Fabricius	+	+	+	105	7.35%
Ranatra gracilis Dallas	-	+	-	39	2.73%
Family: Belostomatidae					
Diplonychus rusticus Fabricius	+	+	+	207	14.49%
Diplonychus annulatus Fabricius	-	+	+	54	3.78%
Lethocerus indicus Lepleiter and Serv	-	-	+	8	0.56%
Family: Mesoveliidae					
Mesovelia vittigera Horvath	+	+	+	211	14.77%
Family: Hydrometridae					
Hydrometra greeni Kirkaldy	+	+	+	64	4.48%
Family: Gerridae					
Neogerris parvula Stal	+	+	+	130	9.10%
Gerris gracilicornis Horvath	+	+	+	60	4.20%
Limnogonus nitidus Mayr	+	+	+	46	3.22%

+ = Present, - = Absent; PRM= Pre-monsoon; MON= Monsoon; POM= Post monsoon

The majority of freshwater habitats with appropriate water quality and substrate conditions support various macroinvertebrate communities with a well-balanced species distribution among the overall number of individuals present (Sharma et al. 2008). Hydroperiod (wet and dry cycles), habitat complexity (presence or absence of littoral vegetation), hydromedian depth, trophic status (oligotrophy vs. eutrophy), and surface water quality are all factors that influence the distribution, abundance, and community composition of aquatic macroinvertebrates in a freshwater environment (Growns et al., 1992). The most important single influence on insect communities is probably frequent flooding and drying of wetland habitats, and how insects deal with draught is fundamental to their success (Wiggins et al., 1980). Because the pond under study is a perennial water body, hydroperiod is not a limiting factor in the richness and dispersion of the aquatic insect population. However, flooding and drying of the adjacent shallow water pools and swampy areas may partially impact the seasonal population density of aquatic insects, as seen by some species' abrupt population fluctuations (Fig. 2).

Some of the most successful invertebrates in temporary water bodies, according to Batzer and Wissinger (1996), cannot survive drought and instead use fairly predictable migrations between temporary and permanent waters. Freshwater wetlands are known for having a diverse range of plant species that create a mosaic of communities (Bacon, 1988). Vegetation appears to have the greatest influence on macroinvertebrate assemblages (Battle et al., 2001). The examined pond, which is dominated by *Eichhornia crassipes* and has 12 species of aquatic hydrophytes, serves as a unique home for the colonization of rich and diversified insect communities. The presence or absence of littoral vegetation and the hydromedian

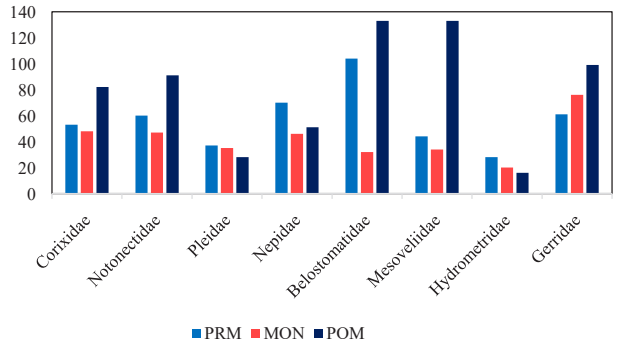

Fig. 2. Seasonal variation of density of Hemiptera- families

depth were found to be the most important parameters influencing the distribution, abundance, and community composition of aquatic and semi-aquatic hemipterans in the investigated water body. Apart from providing habitat, decaying plant material also provides food for aquatic detritivores and increases the availability of shelter, allowing successful avoidance of predation in vegetated areas. The habitat created by the combination of emergent plants and open water is a very prolific area for insect development.

For the aquatic and semi-aquatic hemipteran species inhabiting the analyzed pond, diversity indices such as Shannon Diversity Index ($\hat{H}$), Index of evenness (e), Simpson Index (1-D, where D is the Dominance), Berger-Parker dominance Index, Margalef's richness index and Menhinick's richness index were computed to see the overall trend of population fluctuation during the study period (Table 2). It was discovered that the values of several indices differed depending on their properties. During the inquiry period, the Shannon-Weiner index ranged between 2.231-2.493. Similarly, Simpson's Diversity Index, a measure of diversity that considers both richness and evenness, ranged between 0.860 – 0.909 in the studied water body. Shannon-Weiner index ($\hat{H}$), Simpson's index (1-D), and Index of Evenness (e) of Hemipteran species illustrate no mark fluctuation (Table 2). Maximum abundance is reported in January in the current study, which is due to the higher numerical density of *Mesovelia vittigera*, followed by *Micronecta scuttellaris scuttellaris* and *Diplonychus rusticus* in that month. However, the Shannon-Weiner index ($\hat{H}$) is highest in August (2.493) and lowest (2.231) in January (Table 2), even though the total numerical density of hemipterans is highest in January.

Only *Mesovelia vittigera* had the highest numerical density in that month. Therefore, the maximum abundance of a single species in a population decreases the value of species diversity, corroborating the findings of Roy (1988) on the seasonal fluctuation of aquatic Coleoptera in a freshwater pond at Bhagalpur, India. The migration from the surrounding swamps and pools is thought to be the reason for the highest prevalence of *Mesovelia vittigera* in that month. No rainfall is reported in January, which resulted in drying of the surrounding temporary shallow water bodies. While the species' downward tendency over the next month appears to indicate emigration caused by overcrowding. Julka (1977) discovered this pattern while investigating the Notonectids population in a perennial rainfed pond in Barrackpore, West Bengal, India. The current study on the species diversity and abundance of Hemiptera demonstrates that the pond is not severely contaminated with any form of pollutants as the diversity indices calculated show no significant variations. Pollutants often cause changes in species abundances and community species composition in aquatic ecosystems. However, Margalef's index readings (ranging from 2.50 to 3.02) revealed that the pond's water quality

Table 2. Diversity Indices for the collected aquatic and semiaquatic Hemiptera

Diversity indices	Jul 2019	Aug	Sep	Oct	Nov	Dec	Jan 2020	Feb	Mar	Apr	May	June
Taxa_S	13	14	14	14	14	14	14	14	14	14	14	14
Individuals	73	81	110	74	144	152	180	157	124	131	112	90
Dominance_D	0.103	0.0934	0.09	0.113	0.121	0.137	0.139	0.108	0.1	0.094	0.113	0.098
Simpson_1-D	0.897	0.906	0.909	0.887	0.878	0.862	0.86	0.891	0.899	0.906	0.886	0.901
Shannon_H	2.399	2.493	2.486	2.387	2.333	2.244	2.231	2.396	2.431	2.481	2.378	2.445
Evenness_e^H/S	0.847	0.864	0.858	0.777	0.736	0.673	0.664	0.784	0.812	0.854	0.77	0.823
Menhinick	1.522	1.556	1.335	1.627	1.167	1.136	1.043	1.117	1.257	1.223	1.323	1.476
Margalef	2.797	2.958	2.766	3.02	2.616	2.588	2.503	2.571	2.697	2.667	2.755	2.889
Equitability_J	0.935	0.944	0.942	0.904	0.883	0.85	0.845	0.907	0.921	0.94	0.901	0.926
Fisher_alpha	4.601	4.883	4.255	5.11	3.833	3.759	3.548	3.717	4.055	3.97	4.223	4.644
Berger-Parker	0.164	0.172	0.118	0.229	0.243	0.237	0.261	0.203	0.161	0.168	0.214	0.155

was moderately contaminated during the study period. Margalef's index values > 3 indicate clean water, values <1 indicate severe pollution, and intermediate values indicate moderate pollution of water, according to Lenet et al. (1980).

For determining biological water quality, the selected water body's biotic indexes such as Average Score per Taxon (ASPT), Stream Invertebrate Grade Number-Average Level (SIGNAL-2), and The Biological Monitoring Working Party (BMWP) score were used. The pond's biotic indices score values also show that it is mildly polluted. The system's SIGNAL-2 score was recorded as 2.25. In lotic systems, a SIGNAL-2 score of >5.5 indicates contamination (Chessman 2001). Some of the macroinvertebrate orders with the highest SIGNAL sensitivity scores, such as stoneflies and, to a lesser extent, mayflies and caddisflies, are naturally uncommon in wetlands. As a result, wetlands are more likely to have lower natural scores than streams in the same region (Chessman 2003). In the present study, the low SIGNAL score indicates moderately polluted nature of water. The findings of this study reveal that the pond is not contaminated by any significant contaminants. However, there is still a need for further rigorous inquiry and testing of the effectiveness of the BMWP, ASPT, and SIGNAL-2 scores for usage in ponds in India's northeastern region. The findings also strongly suggest that different biotic and diversity indices be tailored to the geomorphological and environmental characteristics of North East India.

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