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Diversity and Composition of Aquatic Insects in Three Perennial Rural Ponds of Ramnagar-I Block, East Midnapore, West Bengal, India

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ABSTRACT
This investigation focused on the diversity of aquatic insects in three perennial rural ponds located in the Ramnagar-I block of East Midnapore, West Bengal, India. Insects comprise about four-fifths of the world's fauna and are recognized as the most diverse and successful group within the animal kingdom. Many of these insects spend at least part of their life cycle in water, making them aquatic insects. They represent a vital component of the littoral fauna in aquatic ecosystems and play a crucial role in the trophic structure and functions of cultivable water bodies. From March 2023 to February 2024, a total of 1,637 individuals were recorded, belonging to 6 orders, 15 families, and 29 genera across the three ponds (P1, P2, and P3). The rich assemblage of aquatic insects found in these ponds suggests a relatively healthy and stable ecosystem, supported by good water quality. The dominant families observed included Gerridae (14.91%), Coenagrionidae (18.51%), and Nepidae (13.62%), highlighting their significant ecological roles at these sites. Seasonal variations in species richness were apparent across the ponds. The highest numbers of individual occurrences were recorded during the post-monsoon season (P1: 12.16%, P2: 10.63%, P3: 9.22%), whereas the lowest were noted in winter (P1: 7.27%, P2: 6.17%, P3: 5.19%). Among the recorded species, the most dominant taxa included *Baetis* sp. (Ephemeroptera), *Gerris spinolae* (Hemiptera), and *Ischnura senegalensis* (Odonata). The seasonal environmental variations largely account for the diversity of insects in the three ponds, as factors such as temperature, dissolved oxygen, and vegetation cover significantly influence species abundance and distribution.

Key words: Aquatic insects, Diversity, Biodiversity indices, Rural Ponds, Ramnagar-I block

INTRODUCTION

Insects are vital representatives of ecosystem biodiversity (McCafferty and Provonsha 1981). Freshwater environments - including swamps, ponds, lakes, springs, streams, and rivers - harbour many insect species known as aquatic insects (Elango et al. 2021). These tiny creatures fulfil various ecological roles, influencing nutrient cycles, food webs, and water quality. Their presence and abundance serve as indicators of the health of aquatic environments, providing essential insights into ecosystem dynamics and environmental changes (Prommi and Payakka 2015). Through their complex interactions with other organisms and their surroundings, aquatic insects are crucial in maintaining the balance and resilience of freshwater ecosystems. Aquatic insects contribute to the breakdown of organic matter, such as leaves and detritus, through their feeding and decomposition activities (Das et al. 2014). This process releases nutrients like nitrogen and phosphorus, essential for the growth of aquatic plants and algae, thus facilitating nutrient cycling within the ecosystem (Elango et al. 2021). Aquatic insects' presence, abundance, and diversity are frequently used water quality indicators (Rosenberg and Resh 1995). Different species have specific environmental tolerances and habitat preferences, so changes in their populations can indicate disturbances or pollution in freshwater habitats, helping to assess aquatic ecosystems' health and ecological integrity (Barbour et al. 1999). Certain aquatic insects, such as some midges and caddis flies species, also pollinate aquatic and riparian plants. By transferring pollen between flowers, these insects contribute to plant communities' reproductive success and genetic diversity in freshwater ecosystems (Jackson and Resh 1989). Aquatic insects inhabit a wide range of freshwater environments, from puddles to rivers and lakes, including both still (lentic) and flowing (lotic) water bodies, hosting numerous species (Cheng 1985, Daly et al. 1998). Perennial ponds are critical hubs for biodiversity, nurturing a rich tapestry of life within their watery embrace. These stable water bodies serve as essential breeding grounds, providing shelter, sustenance, and sanctuary for many aquatic organisms. From amphibians to insects and fish to waterfowl, these ponds support diverse species, fostering intricate food webs and ecological relationships (Dubey 2015). Their presence sustains aquatic life and influences the surrounding terrestrial landscape, acting as oases of biodiversity within the broader ecosystem (Kumar 1992). Estimates suggest approximately 45,000 species of aquatic insects worldwide, with roughly 5,000 species believed to inhabit inland wetlands in India (Amaravathi et al. 2018, Rao et al. 2020). Ramnagar-I is a community development block within the Contai subdivision of the Purba Medinipur district in the Indian state of West Bengal (Bhattacharya and Gupta 1991, Bal and Basu 1994, Srivastava and Sinha 1995, Biswas and

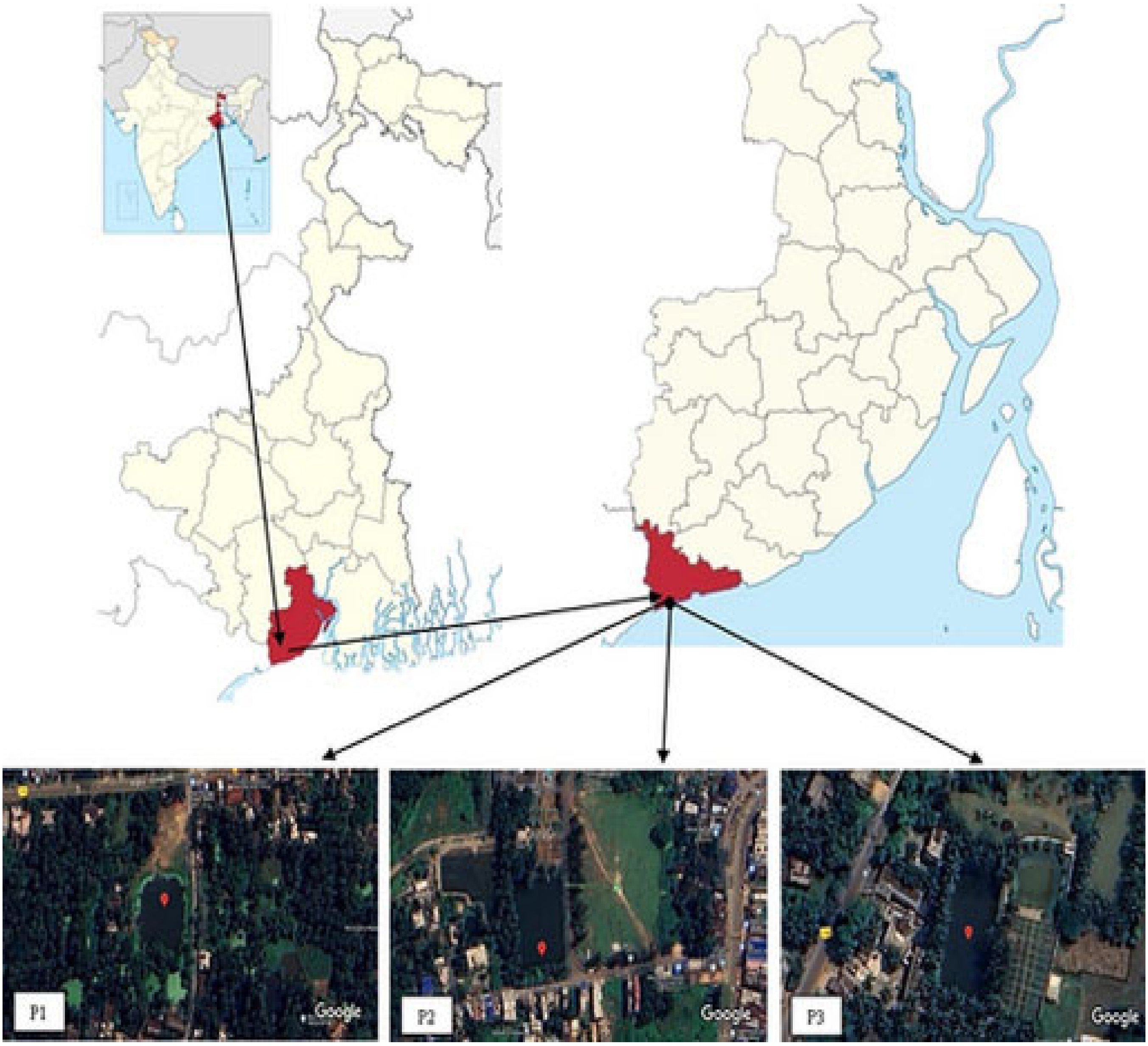

Figure 1. Sampling sites in Ramnagar-I block

Mukhopadhyay 1995, Biswas et al. 1995a, b, Bhattacharya 2000, Khan and Ghosh 2001, Nandi et al. 2001, Saha et al. 2007, Jana et al. 2009, Debnath et al. 2013, Das et al. 2014). This block contains many perennial and non-perennial rural ponds. Various aspects of aquatic insects have been studied in different water bodies across West Bengal; however, there is a lack of research on aquatic insects in the Ramnagar-I block. This study assesses species richness, abundance, and distribution patterns within three perennial rural ponds in Ramnagar-I block.

MATERIALS AND METHODS

Study area

The study was conducted in three different perennial rural ponds in Ramnagar-I block of Purba Medinipur district, West Bengal, India (Fig. 1). The details of the three study sites are given in Table 1.

Sampling method

Samplings were done every month from March 2023 to February 2024. Aquatic insects were collected using a 1 m² kick net with 245 µm mesh (Macan and Maudsley1968). The kick net sampling was conducted for five minutes each time (Nagendran 2007).

Collected samples were placed in wax trays to sort and screen aquatic insects. Then, the aquatic insects were transferred to labelled plastic containers, preserved in 70% ethyl alcohol, and brought to the lab for analysis. In the laboratory, insects were identified at the family level using taxonomic keys described by researchers (Mitra and Kumar 1988, Dudgeon 1999, Wiggins 1996, Khan and Ghosh 2001, Sivec and Yule 2004).

Statistical analysis

The relative abundance (RA) of aquatic insects was estimated. Ecological metrics such as the Shannon-Weiner diversity (5Ø;Ü'), Simpson's diversity index (5Ø7Ü), Margalefs richness index, and Berger-Parker dominance index were calculated using PAST (ver. 3) for each sampling site (Tawfik et al. 2013). MS Excel 2021 was used for descriptive statistical analysis.

Species were classified according to their relative abundance (RA): Subresident (<1%), Resident (1.1–

Table 1. Details of the three experimental study sites

Site	Area	Geographical Coordinates	Pond description
P1	Barsolemanpur	Latitude- 21°40'38.9"N Longitude- 87°34'18.0"E	The total area of P1 is about 2040 m². Approx 30% of the pond is covered by aquatic vegetation. Dominant macrophytes are *Ludwigia adscendens* (L.) H.Hara, *Pistia* sp., *Pontederia crassipes* Mart., *Nymphoides indica* (L.) Kuntze, *Marsilea minta* Linn., *Ipomoea aquatica* Forssk., *Colocasia esculenta* (L.) Schott, *Hygrophila auriculata* Schumach., *Enhydra fluctuans* Lour., *Wolffia arrhiza* (L.) Horkel ex Wimm. etc.
P2	Ramnagar	Latitude- 21°40'37.7"N Longitude- 87°33'34.6"E	The total area of P2 is about 1320 m². This pond experiences a limited number of aquatic vegetation. Dominant species are *Ipomoea aquatica* Forssk., *Hygrophila auriculata* Schumach., *Marsilea quadrifolia* L., *Pontederia* sp., *Colocasia esculenta* (L.) Schott etc.
P3	Alankarpur	Latitude- 21°38'48.9"N Longitude- 87°32'00.2"E	The total area of P3 is about 1496 m². This pond contains moderate vegetation. Out of them, dominance showed by *Pistia* sp., *Ipomoea aquatica* Forssk., *Hygrophila auriculata* Schumach., *Enhydra fluctuans* Lour., *Colocasia esculenta* (L.) Schott, *Nymphaea pubescens* Willd., etc.

Table 2. Checklist of aquatic species and their relative abundance recorded from three study sites

Order	**Family**	**Scientific name**	**Common name**	**Number of insects during observation**			**Relative abundance (%)**	**Dominance status***
				P1	**P2**	**P3**		
Coleoptera	Dytiscidae	*Cybister tripunctatus* (Olivier, 1795)	Beetle	12	10	8	1.83	Recedent
		Laccophilus sp. (Leach, 1815)	Dingy diver	21	34	23	4.76	Sub-dominant
		Canthydrus laetabilis (Walker, 1858)	Beetle	7	12	2	1.28	Recedent
		Hydrovatus sp. (Motschulsky, 1853)	water beetles	1	0	6	0.43	Sub-recedent
		Copelatus indicus (Sharp, 1882)	Diving beetle	16	9	14	2.38	Recedent
	Hydrophilidae	*Coelostoma fallaciosum* (Orchymont 1936)	Beetle	17	28	9	3.30	Sub-dominant
		Helochares sp. (Mulsant, 1844)	water scavenger beetle	1	0	8	0.55	Sub-recedent
		Berosus sp. (Leach, 1817)	water scavenger beetles	2	1	7	0.61	Sub-recedent
Hemiptera	Gerridae	*Gerris spinolae* (Linnaeus, 1758)	Water strider	85	58	69	12.95	Dominant
		Limnogonus nitidus (Stål, 1868)	Limnogonus	13	3	10	1.59	Recedent
		Neogerris sp. (Matsumura, 1913)	Water strider	0	1	5	0.37	Sub-recedent
	Nepidae	*Laccotrephes ruber* (Linnaeus 1764)	Water Scorpion	34	25	29	5.38	Sub-dominant
		Ranatra filiformis (Linnaeus, 1758)	water stick-insect/ Water scorpion	45	52	38	8.25	Sub-dominant
	Notonectidae	*Notonecta indica* (Linnaeus, 1771)	Backswimmer	29	10	13	3.18	Recedent
		Anisops barbatus (Brooks 1951)	Backswimmer	2	0	0	0.12	Sub-recedent
	Belostomatidae	*Belostoma minor* (Palisot de Beauvois, 1820)	Water bug	11	16	2	1.77	Recedent
	Mesoveliidae	*Mesovelia mulsanti* (White, 1879)	Water treader	5	9	0	0.86	Sub-recedent
	Micronectidae	*Micronecta* sp. (Kirkaldy, 1897)	Water boatman	7	3	1	0.67	Sub-recedent
Odonata	Libellulidae	*Urothemis signata* (Rambur, 1842)	Scarlet basker	22	19	32	4.46	Sub-dominant
		Pantala flavescens (Fabricius, 1798)	Wandering glider	3	16	9	1.71	Recedent
	Aeshnidae	*Anax* sp. (Leach, 1815)	Dragon fly	13	18	2	2.02	Recedent
	Coenagrionidae	*Ischnura senegalensis* (Rambur, 1842)	Common Bluetail damselfly	68	39	51	9.65	Sub-dominant
		Agriocnemis pygmaea (Rambur, 1842)	Pygmy dartlet damselfly	42	53	14	6.66	Sub-dominant
		Amphiallagma parvum (Selys, 1876)	Little blue damselfly	1	12	3	0.98	Sub-recedent
		Pseudagrion sp. (Selys, 1876)	Damselfly	8	2	10	1.22	Recedent
Ephemerptera	Baetidae	*Baetis* sp. (Leach, 1815)	Mayfly	56	43	70	10.32	Dominant

Order	Family	Scientific name	Common name	Number of insects during observation			Relative abundance (%)	Dominance status*
				P1	P2	P3		
Prostigmata	Tetranychidae	*Diplonychus rusticus* (Fabricius 1781)	Aquatic bug	15	23	5	2.63	Recedent
Diptera	Culicidae	*Culex* sp. (Linnaeus, 1758)	Mosquito	66	50	43	9.71	Sub-dominant
	Chironomidae	*Chironomus* sp. (Meigen, 1803)	Nonbiting midges	5	1	0	0.37	Sub-recedent
			Total Species	28	26	26		
			Total Individuals	607	547	483		

Relative abundance % (RA): (<1%)-Subrecedent; (1.1-3.1%)-Recedent; (3.2-10%)-Subdominant; (10.1-31.6%)-Dominant; (> 31.7%)-Eudominant. *As per Engelmann scale (Engelmann 1978)

3.1%), Subdominant (3.2–10%), Dominant (10.1–31.6%), and Eudominant (>31.7%) (Engelmann 1978).

RESULTS AND DISCUSSION

During the study period, a total of 1,637 individuals from 6 orders, 15 families, and 29 genera were collected from three perennial rural ponds (P1, P2, and P3) in the Ramnagar-I block of East Midnapore, West Bengal. Pond P1 exhibited the highest species richness, with 28 species and 607 individuals, followed by Pond P2, which had 26 species and 547 individuals, and Pond P3, also with 26 species but only 483 individuals. Table 2 presents the species' overall composition and relative abundance recorded during this study. Dey (2016) reported collecting 2,538 specimens belonging to 15 families, 26 genera, and 31 species from Bibhutibhushan Sanctuary in North 24 Parganas, West Bengal. Similarly, Jana et al. (2009) documented 20 species distributed across nine families and three orders in a Midnapore Town, West Bengal pond. Additionally, Das and Gupta (2012) recorded the hemipteran insect community in a temple pond near Silchar in Cachar District, Assam, north-eastern India, noting seven families, 11 genera, and 14 species across different seasons. The distribution patterns of aquatic insects were influenced by seasonal environmental variations, which directly affected species richness, abundance, and diversity indices across the study sites.

Key environmental factors, such as temperature, dissolved oxygen (DO), pH, and vegetation cover, played a crucial role in shaping the diversity and abundance of aquatic insects. Air and water temperatures varied seasonally, ranging from 26.8 to 32.01°C for air and from 24.5 to 31.01°C for water across the ponds. The pH varied between 5.99 and 8.10, while DO levels ranged from 6.81 to 8.07 ppm. Free CO_2 values ranged from 8.02 to 10.16 ppm, and electrical conductivity varied from 156.19 to 342.1 µS/cm (Table 3). The highest DO level (8.07 ppm) was recorded during the pre-monsoon season, while the lowest (6.81 ppm) was observed in winter. Similar DO levels were reported by Narayan et al. (2007) in a temple pond in Etawah District, Uttar Pradesh, and by Das and Gupta (2012) in a temple pond in Cachar District, Assam. The low DO levels observed during the winter season may be attributed to the decomposition of macrophytes along the pond's margins, likely caused by a reduction in water levels (Das and Gupta 2012). In this study, the total suspended solids (TSS) peaked at 64.43 ppm in the post-monsoon season and dropped to a low of 34.05 ppm in winter. It was also found that TSS levels were consistently lower than the total dissolved solids (TDS), which ranged from 94.6 to 170.0 ppm across all seasons. This observation aligns with the general finding that TSS is typically lower than TDS in most natural water bodies (Moss 1980). The highest occurrences of aquatic insects were recorded during the post-monsoon season (P1: 12.16%, P2: 10.63%, P3: 9.22%), while the lowest were recorded in winter (P1: 7.27%, P2: 6.17%, P3: 5.19%). Post-monsoon conditions, characterized by moderate temperatures, higher DO levels, and increased availability of organic matter, favoured the proliferation of aquatic insects.

Vegetation cover played a significant role in species distribution. Pond P1, with 30% macrophyte cover, supported the highest species diversity, indicating that aquatic macrophytes provide essential microhabitats and food sources for aquatic insects (Butler and Demaynadier 2008, Vasileva et al. 2011, Choi et al. 2020). Studies have demonstrated that areas rich in macrophytes enhance invertebrate abundance by offering shelter, stable food sources, and increased oxygen levels (DeNeiff and Carignan 1997, Declerck et al. 2011, Irma and Sofyatuddin 2012). Aquatic insect communities experience seasonal fluctuations in species richness, abundance, and distribution, which are influenced mainly by abiotic factors such as temperature, dissolved oxygen (DO), pH, total dissolved solids (TDS), and aquatic vegetation coverage. These environmental parameters vary across hydrological seasons: pre-monsoon, monsoon, post-monsoon, and winter. Such variations impact the availability of food resources, reproductive cycles, and habitat suitability for aquatic insects (Turkmen and Kazanci 2010, Warwick et al. 2008). The composition of aquatic insect orders varied significantly between the pre-monsoon, monsoon, post-monsoon, and winter periods, reflecting seasonal ecological shifts (Fig. 2). The highest species occurrences were recorded during the post-monsoon period, while the lowest richness and abundance occurred in winter. Hemiptera showed the highest species richness and abundance across all seasons, accounting for 35% of the recorded species and 38% of individuals. Coleoptera comprised 28% of the total species and 14% of the total individuals. Diptera represented 7% of total species and 13% of individuals, with a noticeable peak during pre and post-monsoon seasons. Ephemeroptera comprised only 3% of the species and 9% of individuals, with their highest presence in the post-monsoon period. Prostigmata accounted for 3% of total species and 2% of individuals, making them the least abundant order. Similar dominance patterns of Hemiptera were reported previously in Deepor Beel, Assam (Choudhury and Gupta 2015), while studies from Midnapore (Jana et al. 2009) and Bhagalpur, Bihar

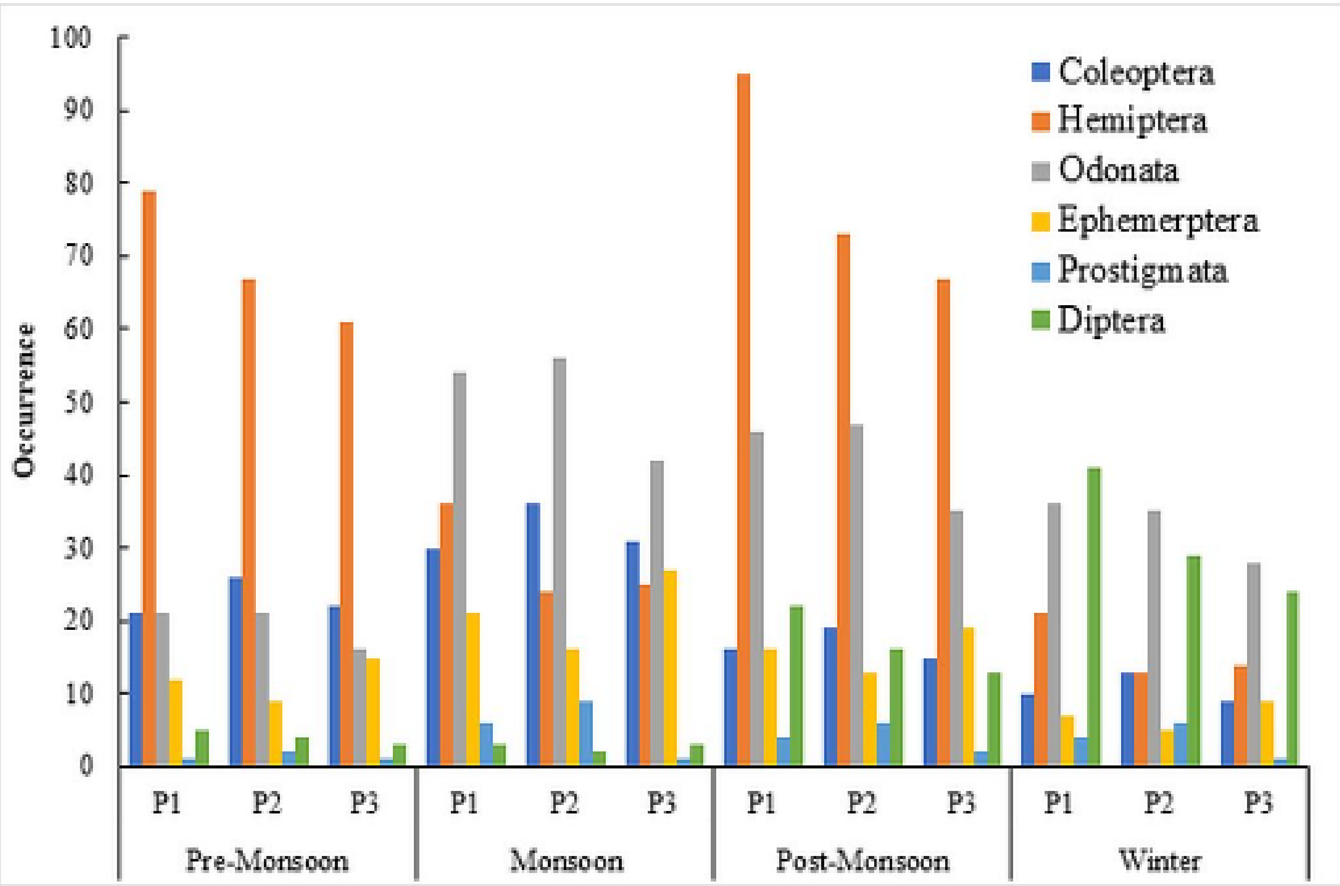

Figure 2. Seasonal occurrence of different insect order in the three study ponds

Table 3. Seasonal variations of the environmental variables (Mean values ± SD) in the three study ponds

Parameters	Pre-monsoon			Monsoon			Post monsoon			Winter		
	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
AT(⁰C)	32.01±1.10	32.00±1.13	31.90±1.27	30.16±2.19	30.18±2.21	30.20 ± 2.38	30.76 ±0.98	30.83 ±1.20	30.64±1.01	26.80 ±1.09	26.83±1.70	27.31±1.35
WT(⁰C)	29.32±1.25	30.65±1.37	30.01±1.49	30.26±1.58	31.01±1.43	30.90±1.61	28.90±2.12	29.11±1.90	28.71±2.03	24.50±1.88	25.01±2.41	25.31±2.09
pH	7.76±0.05	7.64±0.13	7.24±0.06	7.91±1.07	7.89±1.13	8.10±0.90	7.10±0.35	6.82±0.41	6.91±0.39	6.13 ± 0.44	6.11± 0.36	5.99 ±1.01
TA (ppm)	109.73 ± 5.46	127.01± 3.34	118.40 ± 7.73	86.71± 2.16	98.66± 3.06	90.29± 4.17	102.01± 2.08	113.00±1.99	97.78±2.21	81.76±2.98	86.93±3.29	89.23±2.07
DO (ppm)	8.07± 0.11	7.35± 0.08	7.65± 0.15	7.62 ± 0.22	7.19± 0.13	7.13± 0.09	7.48± 0.18	7.10±0.10	7.33±0.20	7.11±0.16	6.81± 0.14	7.0±0.07
FCO_2 (ppm)	9.09±0.11	10.01±0.08	9.78±0.09	8.17±0.55	9.82±0.49	8.68±0.23	8.02±0.59	8.75±1.01	8.10±0.79	9.89±0.61	10.16±0.52	10.0±0.49
EC (µS/cm)	342.1±0.32	286.0±1.41	192.02±0.87	305.0±0.20	229.03±0.83	168.1±0.31	322.07±1.23	249.1±0.98	172.03±1.11	267.0±0.92	210.17±0.54	156.19±1.01
TDS (ppm)	170.0±6.95	139.5±7.71	94.6±5.67	149.06±3.41	110.4±4.53	102.76±2.24	160.04±1.69	119.61±2.06	110.51±1.89	128.02±0.73	113.49±0.97	96.37±1.06
TSS (ppm)	62.16±2.09	53.55±1.87	47.31±3.50	57.25±1.04	42.68±1.15	43.51±2.23	64.43±0.89	48.91±1.61	44.58±0.86	54.77±1.72	44.89±1.08	34.05±0.95
TR (cm)	24.26±3.99	21.18±2.37	22.0±3.31	20.07±1.74	18.90±2.62	18.02±3.10	20.11±2.04	19.13±3.79	19.97±2.01	21.90±2.12	21.01±1.76	20.81±2.27

AT=Atmosphere Temperature; WT=Water Temperature; TA=Total Alkalinity; DO=Dissolved Oxygen; FCO_2=Free Carbon Dioxide; EC=Electrical conductivity; TDS=Total dissolved solids; TSS=Total suspended solids; TR=Transparency

(Sharma and Rai 1991) highlighted the prevalence of Odonata and Coleoptera, respectively. Hemiptera had the highest numerical abundance, totalling 680 individuals across six families and 10 genera, with the Nepidae family being the most common (328 individuals). The distribution of insect families across seasons exhibited clear environmental and habitat-driven patterns (Fig. 3). The family Dytiscidae (Coleoptera) represented the highest number of genera, containing five genera (17.24%) (Table 4). Gerridae species, including *Gerris spinolae, Limnogonus nitidus*, and *Neogerris* sp., were dominant across all ponds, particularly during the post-monsoon and monsoon seasons. Coenagrionidae species, such as *Ischnura senegalensis* and *Agriocnemis pygmaea*, were abundant in the monsoon and post-monsoon periods, coinciding with higher humidity and temperature that favour adult emergence. *Culex* sp. was the most dominant Dipteran, showing peak abundance during the pre-monsoon and post-monsoon seasons, which indicates stagnant water conditions and moderate pollution levels. *Baetis* sp. was recorded in all seasons, with peak abundance in the post-monsoon period, confirming its preference for clean, oxygen-rich waters.

Three of the 29 recorded species were dominant: *Gerris spinolae*, *Ranatra filiformis*, and *Culex* sp. Six species were considered sub-dominant, including *Laccophilus* sp., *Laccotrephes ruber, Urothemis signata, Ischnura senegalensis, Agriocnemis pygmaea*, and *Baetis* sp. Eleven species were categorized as recedent, while the remaining nine were classified as sub-recedent, indicating their low relative abundance within the community. The presence of rare species, such as *Hydrovatus* sp., *Neogerris* sp., and *Amphiallagma parvum*, suggests that specific pond ecosystems exhibit microhabitat specialization. *Helochares* sp. was not recorded in the P2 study pond, and *Neogerris* sp. was absent from the P1 pond during the study period. Additionally, while *Anisops barbatus* was not found in P2 and P3, *Mesovelia mulsanti* and *Chironomus* sp. were absent in P3, which has the least aquatic vegetation (Fig. 4). The Shannon-Wiener Index (H') ranged from 1.95 to 2.38, indicating moderate to high species diversity. P2 recorded the highest value (2.38), followed by P1 (2.29) and P3 (2.12). These values fall within the

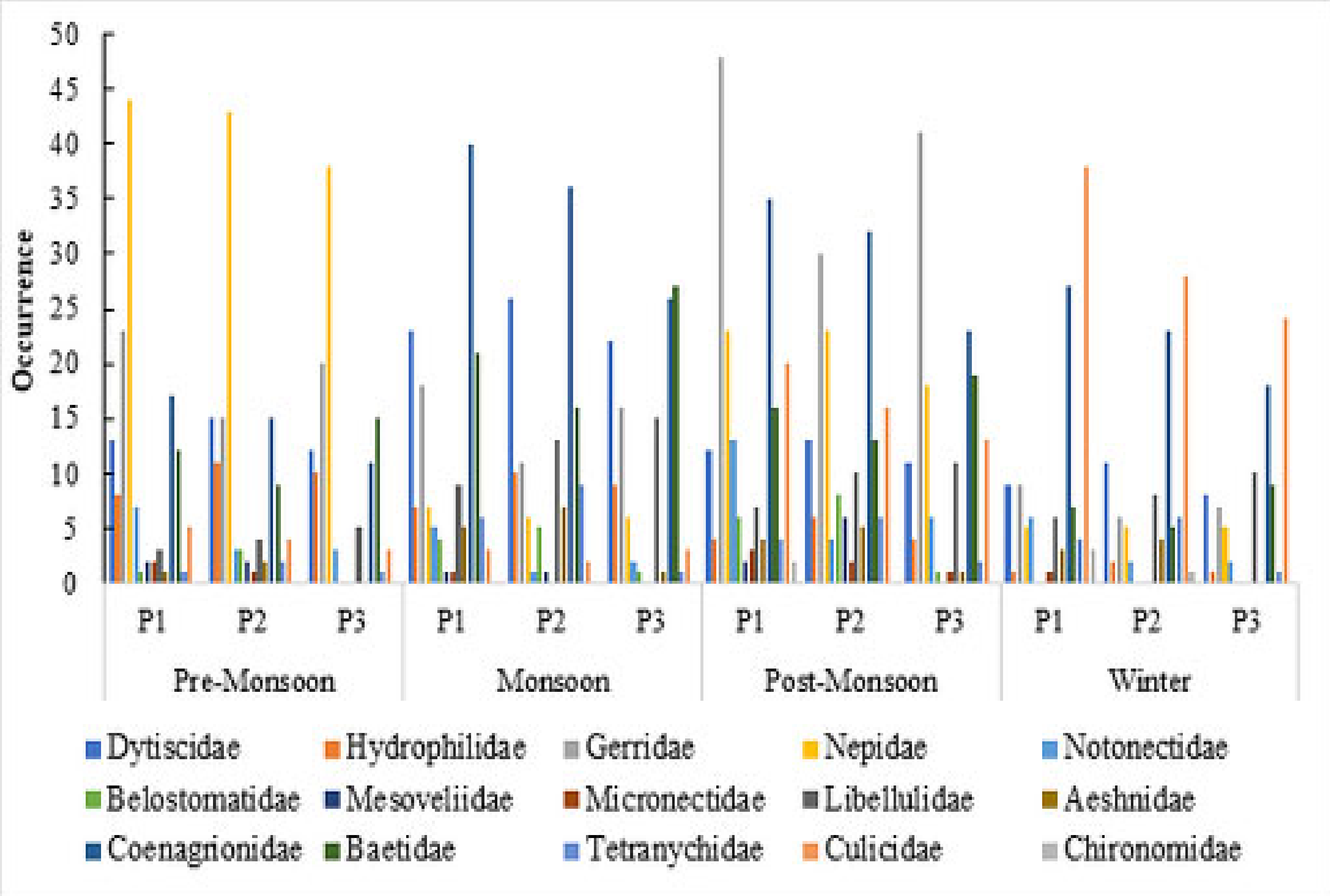

Figure 3. Seasonal occurrence of different insect families in the three study ponds

Table 4. Family-wise distribution of aquatic insects and showing the number and percentage of species and individuals

Order	**Family**	**Species (% occurrence)**	**Individuals (% occurrence)**
Coleoptera	Dytiscidae	5 (17.24)	175 (10.69)
	Hydrophilidae	3 (10.34)	73 (4.46)
Hemiptera	Gerridae	3 (10.34)	244 (14.91)
	Nepidae	2 (6.90)	223 (13.62)
	Notonectidae	2 (6.90)	54 (3.30)
	Belostomatidae	1 (3.45)	29 (1.77)
	Mesoveliidae	1 (3.45)	14 (0.86)
	Micronectidae	1 (3.45)	11 (0.67)
Odonata	Libellulidae	2 (6.90)	101 (6.17)
	Aeshnidae	1 (3.45)	33 (2.02)
	Coenagrionidae	4 (13.79)	303 (18.51)
Ephemerptera	Baetidae	1 (3.45)	169 (10.32)
Prostigmata	Tetranychidae	1 (3.45)	43 (2.63)
Diptera	Culicidae	1 (3.45)	159 (9.71)
	Chironomidae	1 (3.45)	6 (0.37)
	Total	29	1637

Figure 4. a. *Gerris spinolae*; b. *Laccotrephes ruber*; c. *Notonecta indica*; d. *Urothemis signata*; e. *Belostoma minor*; f. *Ranatra filiformis*; g. *Cybister tripunctatus*; h. *Coelostoma fallaciosum*; i. *Anax* sp.; j. *Limnogonus nitidus*; k. *Laccophilus* sp.; l. *Micronecta* sp.; m. *Ischnura senegalensis*; n. *Pseudagrion* sp.; o. *Berosus* sp.

expected range for diverse aquatic communities (Turkmen and Kazanci 2010, Kerkhoff 2010). Simpson's Index (D) values were relatively low (0.111–0.178), suggesting an even distribution of species with low dominance by any single species. The values approach zero, indicating a stable and balanced ecosystem (Warwick et al. 2008). Margalef's Richness Index ranged from 4.72 (P3) to 5.55 (P2), indicating high species richness. The observed values suggest clean water conditions in all three ponds, as values above 3 indicate good water quality (Lenat et al. 1981, Akindele and Liadi 2014). The Berger-Parker Dominance Index values ranged between 0.092 (P2) and 0.319 (P1) (Table 5). The relatively low values suggest a well-balanced community structure, with no single species dominating the ecosystem (Berger and Parker 1970).

CONCLUSIONS

This study on aquatic insect diversity in three perennial rural ponds in the Ramnagar-I block of East Midnapore, West Bengal, India, has provided valuable insights into the composition and distribution of insect species within these freshwater ecosystems. The findings indicate that all selected sites supported relatively diverse aquatic insect communities, suggesting that the water quality was adequate to sustain the recorded species. Pond ecosystems are crucial for preserving aquatic biodiversity, as insects often dominate freshwater habitats. Interestingly, more minor and temporary water bodies harbour more species than larger, permanent ones. Aquatic insects have adapted to life in water by developing various morphological and physiological traits. The rich assemblage of aquatic insects observed across the studied sites indicates a relatively healthy and stable ecosystem supported by good water quality. These findings enhance our understanding of biodiversity in rural pond ecosystems and lay the groundwork for future regional ecological and conservation efforts. Continued monitoring and research in these ponds can further inform sustainable management practices and help preserve the area's aquatic biodiversity.

Table 5. Diversity indices of aquatic insect communities in three sampling ponds

Ponds	**Shannon Weiner Index (H')**				**Simpson Index (D)**				**Margalefs richness index**				**Berger-Parker Dominance Index**			
	Prm	**Ms**	**Pom**	**Wn**	**Prm**	**Ms**	**Pom**	**Wn**	**Prm**	**Ms**	**Pom**	**Wn**	**Prm**	**Ms**	**Pom**	**Wn**
P1	2.098	2.222	2.294	2.073	00.167	00.142	00.131	00.178	5.472	5.389	5.290	5.022	0.180	0.140	0.101	0.319
P2	2.134	2.205	2.383	2.097	00.168	00.138	00.111	00.161	5.556	5.239	5.234	5.200	0.186	0.112	0.092	0.277
P3	1.952	2.055	2.129	1.963	00.178	00.15	00.148	00.17	4.821	5.144	5.182	4.727	0.178	0.209	0.126	0.282

Prm: Premonsoon, **Pom**: Post monsoon, **Ms**: Monsoon, **Wn**: Winter

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REFERENCES

Akindele, E.O. and Liadi, A.A. 2014. Diversity and Response of Benthic Macroinvertebrates to Natural and Induced Environmental Stresses in Aiba Stream, Iwo, Southwestern Nigeria. West African Journal of Applied Ecology, 22 (1), 101-111. https://www.ajol.info/index.php/wajae/article/view/108003

Amaravathi, D., Sekhar, P.S.R. and Rao, R.K. 2018. Entomofaunal diversity in Kondakarla freshwater lake ecosystem at Visakhapatnam, Andhra Pradesh, India. Journal of Entomology and Zoology Studies, 6(6), 880-886. https://www.entomoljournal.com/archives/2018/vol6issue6/PartO/6-6-37-128.pdf

Bal, A. and Basu, R.C. 1994. Insecta: Hemiptera: Mesoveliidae, Hydrometridae, Veliidae and Gerridae, Belostomatidae, Nepidae, Notonectidae and Pleidae. Records of the Zoological Survey of India, Fauna of West Bengal, State Fauna Series, 3(Part 5), 535-558.

Barbour, M.T., Barbour, M.T., Gerritsen, J., Snyder, B.D. and Stribling, J.B. 1999. Rapid Bioassessment Protocols for Use in Wadable Streams and Rivers: Periphyton, Benthic Macroinvertebrates and Fish, 2nd ed. United States Environmental Protection Agency, Washington, DC. 337 pages. https://www3.epa.gov/region1/npdes/merrimack station/pdfs/ar/AR-1164.pdf

Berger, W.H. and Parker, F.L. 1970. Diversity of Planktonic Foraminifera in Deep Sea Sediments. Science, 168(3937), 1345-1347. https://doi.org/10.1126/science.168.3937.1345

Bhattacharya, D.K. and Gupta, B. 1991. Freshwater wetland-inhabiting insects of West Bengal. Environment and Ecology, 9, 995-998.

Bhattacharya, D.K. 2000. Insect fauna associated with large water hyacinth in freshwater Wetlands of West Bengal. Pp. 165-169, In: Aditya, A.K. and Haldar, P. (Eds.) Biodiversity and Environment: Proceedings of the National Seminar on Environmental Biology, Daya Publishing House, Delhi.

Biswas, S. and Mukhopadhyay, P. 1995. Insecta: Coleoptera: Hydrophilidae. State fauna (Series 5): Fauna of West Bengal, (Part 6a), Zoological Survey of India, Calcutta, 143-168.

Biswas, S., Mukhopadhyay, P. and Saha, S.K. 1995a. Fauna of West Bengal. Insecta: Coleoptera: Adephgaga: Family Gyrinidae and Haliplidae. State Fauna Series 3(Part 6A), Zoological Survey of India, Calcutta, 121-141.

Biswas, S., Mukhopadhyay, P. and Saha, S.K. 1995b. Fauna of West Bengal. Insecta: Coleoptera: Adephgaga: Family Dytiscidae. State Fauna Series 3(Part 6A), Zoological Survey of India, Calcutta, 77-120.

Butler, R.G. and Demaynadier, P.G. 2008. The significance of littoral and shoreline habitat integrity to the conservation of lacustrine damselflies (Odonata). Journal of Insect Conservation, 12, 23-36. https://doi.org/10.1007/s10841-006-9059-0

Cheng, L. 1985. Biology of Halobates (Heteroptera: Gerridae). Annual Review of Entomology, 31, 111-135. https://doi.org/10.1146/annurev.en.30.010185.000551

Choi, J.Y., Kim, S.K., Kim, J.C. and Kwon, S.J. 2020. Habitat preferences and trophic position of *Brachydiplax chalybea flavovittata* Ris, 1911 (Insecta: Odonata) larvae in Youngsan River wetlands of South Korea. Insects, 11, 273. https://doi.org/10.3390/insects11050273

Choudhury, D. and Gupta, S. 2015. Aquatic insect community of Deepor beel (Ramsar site), Assam, India. Journal of Entomology and Zoology Studies, 3(1), 182-192. https://www.entomoljournal.com/vol3Issue1/3-1-17.1.html

Daly, H.V., Doyen, J.T. and Purcell, A.H. 1998. Introduction to Insect Biology and Diversity, 2nd Ed. Oxford University Press, Inc., New York. 734 pages.

Das, K. and Gupta, S. 2012. Seasonal variation of Hemiptera community of a temple pond of Cachar District, Assam, northeastern India. Journal of Threatened Taxa, 4, 3050-3058. https://doi.org/10.11609/JoTT.o2724.3050-8

Das, S.K., Basu. S., Ghosh, S. and Mitra, B. 2014. Preliminary studies on the aquatic insect diversity of Acharya Jagadish Chandra Bose Indian Botanic Garden (AJCBIBG), West Bengal. Records of the Zoological Survey of India, 114(Part-3), 453-466. https://recordsofzsi.com/index.php/zsoi/article/download/121660/83575

Debnath, R., Ghosh, L. K. and Debnath, N. 2013. A preliminary study on the aquatic insects in freshwater wetlands of North Eastern Kolkata. Records of the Zoological Survey of India, 113 (Part-4), 255-275. https://recordsofzsi.com/index.php/zsoi/article/view/121790

Declerck, S.A., Bakker, E.S., van Lith, B., Kersbergen, A. and van Donk, E. 2011. Effects of nutrient additions and macrophyte composition on invertebrate community assembly and diversity in experimental ponds. Basic and Applied Ecology, 12, 466-475. http://dx.doi.org/10.1016/j.baae.2011.05.001

DeNeiff, A.P. and Carignan, R. 1997. Macroinvertebrates on Eichhornia crassipes roots in two lakes of the Paran River floodplain. Hydrobiologia, 345, 185-196. https://doi.org/10.1023/A:1002949528887

Dey, P.K. 2016. The seasonal distribution of litter Coleopteran population and its relationship with edaphic factors in a tropical evergreen forest of West Bengal, India. International Journal of Advanced Research in Biological Sciences, 3, 123-134. http://dx.doi.org/10.22192/ijarbs.2016.03.12.016

Dubey, T.P. 2015. The Biological Diversity of Village Ponds and its Crucial Role in Sustainable Development. 22 May 2015, International Day for Biological Diversity, Biodiversity for sustainable development. Uttar Pradesh State Biodiversity Board. 7 pages. https://www.upsbdb.org/pdf/Souvenir2015/ch-21.pdf

Dudgeon, D. 1999. Tropical Asian Streams: Zoobenthos, Ecology and Conservation. Hong Kong University Press, Hong Kong. 830 pages.

Elango, K., Vijayalakshmi, G., Arunkumar, P., Sobhana, E. and Sujithra, P. 2021. Aquatic insect's biodiversity: Importance and their conservation. Pp. 289-303, In: Kumar, V., Kumar, S., Kamboj, N., Payum, T., Kumar P., and Kumari, S. (Eds.) Biological Diversity: Current Status and Conservation Policies. Agriculture and Environmental Science Academy, Haridwar, India. https://doi.org/10.26832/aesa-2021-bdcp-019

Engelmann, H.D. 1978. Zur Dominanzklassi kazierung von Bodenarthropoden. Pedobiologia, 18, 378-380. https://doi.org/10.1016/S0031-4056(23)00612-1

Irma, D. and Sofyatuddin, K. 2012. Diversity of gastropods and bivalves in mangrove ecosystem rehabilitation areas in Aceh Besar and Banda Aceh districts, Indonesia. International Journal of the Bioflux Society, 5, 55-59. https://bioflux.com.ro/docs/AACL_5.2.1.pdf

Jackson, J.K. and Resh, V.H. 1989. Activities and ecological role of adult aquatic insects in the riparian zone of streams. Pp. 342-344. In: USDA Forest Service General Technical Report PSW-110, Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, Washington, D.C.

Jana, S., Pahari, P.R., Dutta, T.K. and Bhattacharya, T. 2009. Diversity and community structure of aquatic insects in a pond in Midnapore town, West Bengal, India. Journal of Environmental Biology, 30, 283-287. https://www.jeb.co.in/journal_issues/200903_mar09/paper_21.pdf

Kerkhoff, A.J. 2010. Measuring Biodiversity of Ecological Communities, Keyon College, USA. http://biology.kenyon.edu/courses/biol229/diversity.pdf

Khan, R.A. and Ghosh, L.K. 2001. Faunal Diversity of Aquatic Insects in Freshwater Wetlands of South Eastern West Bengal. Records of the Zoological Survey of India, (Occ. Paper No. 194). 104 pages. https://archive.org/details/dli.zoological.occpapers.194

Kumar, D. 1992. Fish Culture in Undrainable Ponds. A Manual for Extension. FAO Fisheries Technical Paper No. 325. FAO, Rome. 239 pages.

Lenat, D.R. Pensrose, D.L. and Eagleson, K.W. 1981. Variable effects of sediment addition on stream benthos. Hydrobiologia, 79, 187-194. http://dx.doi.org/10.1007/BF00006126

Macan, T.T. and Maudsley, R. 1968. The insects of the stony substratum of Windermere. Transactions of the Society for British Entomology, 8, 1-18.

Maneechan, W. and Prommi, T.O. 2015. Diversity and distribution of aquatic insects in streams of the Mae Klong watershed, Western Thailand. Psyche: A Journal of Entomology, 2015(1), 912451. http://dx.doi.org/10.1155/2015/912451

McCafferty, P.W. and Provonsha, V.A. 1981. Aquatic Entomology. The Fisherman's and Ecologists' Illustrated. Guide to Insects and Their Relatives. Jones and Bartlett Publishers, Boston, London. 445 pages.

Mitra, K. and Kumar, K. 1988. Common Insects of Freshwater Ponds and their Control. ICAR- Central Inland Capture Fisheries Research Institute, Barrackpore, India. http://www.cifri.res.in/Bulletins/Bulletin%20No.54.pdf

Moss, B. 1980. Ecology of Fresh Waters. Blackwell Scientific Publications, Oxford, UK. 332 pages.

Nagendran, A.N. 2007. Stream characteristics and biomonitoring of Perumal Patha Odai, Karanthamalai, Tamil Nadu. Ecology, Environmental and Conservation, 13, 57-62. https://www.envirobiotechjournals.com/issues/article_abstract.php?aid=2201&iid=77&jid=3

Nandi, N.C., Venkataraman, K., Das, S.R. and Bhuinya, S. 2001. Faunal diversity of wetlands in the Indian Botanical Garden, Howrah, West Bengal. Records of the Zoological Survey of India, 99(Part 1-4), 111-129. https://recordsofzsi.com/index.php/zsoi/article/download/159638/110308

Narayan, R., Saxena, K.K. and Chauhan, S. 2007. Limnological investigation of Texi Temple Pond in district Etawah (U.P.). Journal of Environmental Biology, 28, 155-157. http://www.jeb.co.in/journal_issues/200701_jan07/paper_30.pdf

Prommi, T. and Payakka, A. 2015. Aquatic Insect Biodiversity and Water Quality Parameters of Streams in Northern Thailand. Sains Malaysiana, 44, 707-717.

Rao, K.R., Prasanna, D. and Amaravathi, D. 2020. Aquatic entomofauna diversity in lower Manair Dam, Karimnagar Dt. Telangana state, India. Journal of Entomology and Zoology Studies, 8(2), 1144-1149. https://www.entomoljournal.com/archives/2020/vol8issue2/PartT/8-2-148-546.pdf

Rosenberg, D.M. and Resh, V.H. 1995. Introduction to freshwater biomonitoring and Benthic Macroinvertebrates. Pp. 1-9. In: Rosenberg, D.M. and Resh, V.H. (Eds.) Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

Saha, N., Aditya, G., Bal, A. and Saha, G.K. 2007. Comparative study of functional response of common hemipteran bugs of east Calcutta wetlands, India. International Review of Hydrobiology, 92, 242-257. https://doi.org/10.1002/iroh.200610939

Sharma, U.P. and Rai, D.N. 1991. Seasonal variations and species diversity of Coleopteran insects in a fish pond of Bhagalpur. Journal of Environmental Biology, 3, 241-246.

Sivec, I. and Yule, C.M. 2004. Insecta: Plecoptera. Pp. 443-456. In: Yule, C.M. and Sen, Y.H. (Eds.) Freshwater

Invertebrates of the Malaysian Region. Academy of Sciences Malaysia, Malaysia.

Srivastava, V.D. and Sinha, C. 1995. Insecta: Odonata, State fauna (Series 3): Fauna of West Bengal, (Part 4). Zoological Survey of India, Calcutta, 163-224.

Tawfik, M.M., Semida, F.M., Ahmed, R.S.S. and Orabi, G.M. 2013. Biodiversity of the aquatic entomofauna at St. Katherine protectorate and Wadi Feiran, South Sinai, Egypt. Asian Journal of Biological Sciences, 6, 40-53. https://scialert.net/abstract/?doi=ajbs.2013.40.53

Turkmen, G. and Kazanci, N. 2010. Applications of various biodiversity indices to benthic macroinvertebrate assemblages in streams of a national park in Turkey. Review of Hydrobiology, 3, 111-125. http://reviewofhydrobiology.org/page/pdf.asp?pdf=3-2/3-2-2-Fulla.pdf

Vasileva, S.Y., Georgiev, D.G. and Gecheva, G.M. 2011. On the communities of freshwater gastropods on aquatic macrophytes in some water basins of southern Bulgaria. Ecologia Balkanica, 3, 11-17. http://web.uni-plovdiv.bg/mollov/EB/2011/eb.11102.pdf

Warwick, R.M., Somerfield, P.J. and Clarke, K.R. 2008. Simpson Index. Pp. 3252-3255. In: Jørgensen, S.E. and Fath, B.D. (Eds.) Ecological Indicators. Encyclopedia of Ecology, 5. Elsevier, Oxford. http://dx.doi.org/10.1016/B978-008045405-4.00133-6

Wiggins, G.B. 1996. Larvae of the North American Caddisfly Genera (Trichoptera). 2nd ed. University of Toronto Press, Toronto. https://doi.org/10.3138/9781442623606

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