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A comparative study of the aquatic insect diversity of two ponds located in Cachar District, Assam, India

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Abstract: Ponds play a vital role in the conservation of aquatic biodiversity at the local level apart from other lakes and rivers. A comparative study was carried out on the aquatic insect diversity of two different ponds, one in an urban area (urban pond, UP) and another in a rural area (Jalinga pond, JP). Two seasonal collections (postmonsoon and winter) were made to check the pollution status of the two ponds based on the aquatic insect community and physicochemical properties of water. Consequently, 29 species, 17 families, and 5 orders of aquatic insects from UP and 17 species, 8 families, and 3 orders from JP were recorded. *Aphelonecta* sp., *Cloeon* sp., and *Micronecta* sp. were the eudominant species recorded. According to the Shannon (H') index, UP was more diverse than JP. Family level biotic indices and scores further proved the better water quality of UP than of JP. Hence, it can be said that urban ponds have an important role to play in biodiversity conservation.

Key words: Aquatic insects, water quality, ponds, biodiversity, comparison

1. Introduction

Ponds are common features of many landscapes and often contribute the bulk of regional freshwater biodiversity (Collinson et al., 1995; Williams et al., 2004; Scheffer et al., 2006). Recent studies, driven both by the need to improve pond conservation strategies and by increasing interest in fundamental aspects of pond ecology (Biggs et al., 2005; McAbendroth et al., 2005), have started to shed interesting new light on pond ecosystem structure and function. As a result, there is growing evidence that ponds are functionally different from larger lakes (Oertli et al., 2002) and that, despite their small size, they are collectively exceptionally rich in biodiversity terms (Williams et al., 2004). Thus, ponds often constitute biodiversity 'hot spots' within a region or a landscape, challenging conventional applications of species-area models ('big is best') in practical nature conservation (Scheffer et al., 2006). Ponds also show greater biotic and environmental amplitudes than rivers and lakes (Davies, 2005).

Aquatic insects are important as fish food, bioindicators, and biocontrol agents. They are known to play a very significant role in the processing and cycling of nutrients as they belong to several specialized feeding groups such as shredders, filter feeders, deposit collectors, and predators (Resh and Rosenberg, 1984). In spite of their importance as biomonitors, bioindicators, predators, and biocontrol agents, conservationists are far from able to list all species under threat. While much attention has been given to large water bodies, the small ones remains neglected, especially ponds, which serve as repositories of local biodiversity. Migration of people from rural to urban areas has increased the population of cities and towns dramatically, thus reducing numbers and also areas of freshwater ecosystems. According to projections by the United Nations, 60% of the world's population will reside in urban areas by 2030. From an ecological perspective, urban ecosystems are highly dynamic (Gilbert, 1989; Adams, 1994).

The Cachar District (24°49′47″N, 92°46′80″E), a major district of South Assam, is located in Northeast India and is rich in wetlands, ponds, streams, and rivers. The present study focuses on aquatic insect diversity and water quality of two ponds, one in an urban area and the other one in a rural area. A comparative study might provide useful insights into the management of biodiversity in the two different landscapes. This study is expected to highlight the importance of both rural and urban ponds in conserving the rich biodiversity in both local and global contexts.

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2. Materials and methods

2.1. Study area

Two ponds were selected in Cachar District, Assam. The urban pond (UP; 24°49.598′N, 92°47.942′E) is an artificial pond located in the center of Silchar city, having residential apartments on two sides and hotels and a shopping complex on the other two sides. The pond belongs to the Silchar Municipality Board and is protected by a wall. The depth of this pond is around 67 cm during the dry period. The sediments are mainly clayey in nature. Macrophytes recorded in UP are *Ipomea aquatica*, *Utricularia* sp., *Nymphoides indica*, *Eichhornia crassipes*, etc. The Jalinga pond (JP; 24°39.725′N, 92°42.507′E), on the other hand, is a rural pond located inside the West Jalinga Tea Estate, an organic tea garden. This pond is surrounded by trees, herbs, shrubs, and a village road. During the dry period the depth of this pond is around 27.95 cm. The sediment of this pond is also clayey in nature. Far fewer macrophytes are available here. They are *Ipomea aquatica*, *Nymphoides indica*, etc. The two ponds are located at a distance of about 33 km from each other (Figure 1).

2.2. Methods

The study was carried out during the postmonsoon (2013) and winter (2014) seasons. Water and insect samples were collected from each pond in three replicates in two seasons. Air and water temperature (AT and WT) were measured using a mercury bulb thermometer while transparency (TR) was measured using a Secchi disk. Physicochemical properties of water such as dissolved oxygen (DO), free carbon dioxide (FCO_2), total alkalinity (TA), pH, electrical conductivity (EC), nitrate (NO_3^-), phosphate (PO_4^{3-}), total dissolved solids (TDS), salinity, sodium (Na), and potassium (K) were analyzed. DO was estimated by Winkler's method, while TA and FCO_2 contents were analyzed by titrating with strong acid and alkali (Michael, 1984; Ramesh and Anbu, 1996; APHA, 2005). NO_3^- was estimated by using a UV spectrophotometer (APHA, 2005) and PO_4^{3-} was estimated using a light spectrophotometer (Michael, 1984). Both NO_3^- and PO_4^{3-} were analyzed using a microprocessor UV/VIS spectrophotometer, EI Model-1371. Sodium and potassium were estimated using a flame photometer, Systronics 128 µC (APHA, 2005). Depth was measured following the standard literature (APHA, 2005). pH was measured by digital pH meter, Systronics MK VI. TDS and EC were measured using a microprocessor-based conductivity/TDS meter, ESICO Model-1601.

Aquatic insects were collected by kick method whereby the vegetation was disturbed and a circular net (mesh size: 60 µm) was dragged around the vegetation for a unit of time (Macan and Maudsley, 1968; Brittain, 1974). Three such drags constituted a sample (Subramanian and Sivaramakrishnan, 2007). Collected insects were immediately sorted and preserved in 70% ethyl alcohol. They were later identified using a Dewinter advance stereozoom microscope (Motic SMZ-168 Series) with the

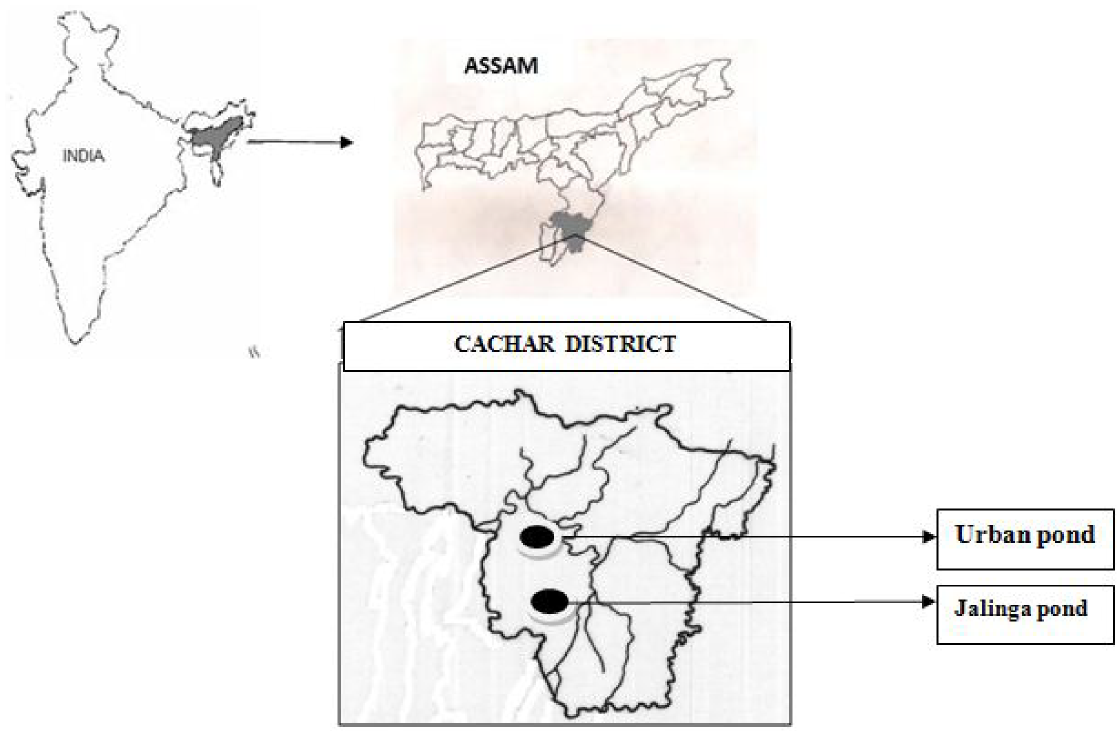

Figure 1. Map of Cachar District, Assam, highlighting the urban pond in Silchar city and Jalinga pond in the West Jalinga tea garden.

help of standard keys (Kumar, 1973a, 1973b; Bal and Basu, 1994a, 1994b; Westfall and Tennessen, 1996; Bouchard, 2004; Epler, 2010). Diversity indices were worked out using the package PAST. For statistical analysis SPSS 20 was used. Canonical correspondence analysis (CCA) was performed using CANOCO for Windows v. 4.5 (ter Braak, 1995). Family level biotic scores and indices were used. Biological monitoring working party (BMWP) scores and average score per taxon (ASPT) were analyzed following Mandaville (2002). The Nepal Lake Biotic Index (NLBI) was analyzed following Shah et al. (2011).

3. Results

3.1. Physicochemical properties of water

Physicochemical parameters of both UP and JP are shown in Table 1. Both the highest and the lowest amount of DO was found in winter, with the highest in JP (10.17 mg L^{-1}) and lowest in UP (3.40 mg L^{-1}). FCO_2 ranged from 9.32 mg L^{-1} to 11.05 mg L^{-1} in UP and 5.99 mg L^{-1} to 11.98 mg L^{-1} in JP. TA ranged from 109.73 mg L^{-1} to 127.07 mg L^{-1} in UP and 15.33 mg L^{-1} to 19.53 mg L^{-1} in JP. NO_3^- and PO_4^{3-} were found highest in JP (NO_3^- in postmonsoon and PO_4^{3-} in winter) and were lowest also in JP (NO_3^- in winter and PO_4^{3-} in postmonsoon). EC ranged from 164.43 µS cm^{-1} to 195.27 µS cm^{-1} in UP and 19.77 µS cm^{-1} to 38.31 µS cm^{-1} in JP. Na was found highest in UP (9.66 mg L^{-1} in winter) and lowest in JP (2.93 mg L^{-1} in winter).

3.2. Pearson's correlation (two-tailed)

Pearson's correlations between physicochemical variables of water and aquatic insects of UP and JP for postmonsoon and winter seasons are shown in Table 2. In UP no correlation was established between aquatic insects and physicochemical variables of water in the postmonsoon season, but in winter the number of species had positive correlations with pH and Na as well as negative correlations with K and TA. In the case of JP, species density had positive correlations with Na, AT, WT, and depth as well as negative correlation with only TR in the postmonsoon season. In winter, only the number of species had a negative correlation with Na. Other than this, in UP salinity had a positive correlation with pH while EC had a positive correlation with TDS in the postmonsoon season. In JP, EC had a positive correlation with TDS in winter.

3.3. Aquatic insects

A total of 5 orders, 17 families, and 29 species from UP and 3 orders, 8 families, and 17 species from JP were recorded during the two seasons. The values of the Shannon index of diversity ranged from 1.5 to 1.9 in JP and 1.7 to 2.1 in UP. Evenness values ranged from 0.52 to 0.56 in JP and 0.40 to 0.44 in UP. The values of Margalef's index ranged from 1.3 to 2.3 in JP and 2.5 to 3.8 in UP. The Berger–Parker index of dominance values ranged from 0.41 to 0.43 in UP and 0.35 to 0.46 in JP (Table 3).

Table 1. Physicochemical variables of water of the two ponds, UP and JP, during postmonsoon and winter seasons (2013–2014) (mean ± SD).

Seasons	UP			JP		
	Postmonsoon	Winter	Mean ± SD	Postmonsoon	Winter	Mean ± SD
AT (°C)	30.2 ± 0	27 ± 0	28.60 ± 1.75	30 ± 0	25 ± 0	27.5 ± 2.74
WT (°C)	25.1 ± 0	22 ± 0	23.55 ± 1.70	24 ± 0	23 ± 0	23.5 ± 0.55
TR (cm)	81.5 ± 0	34.75 ± 0	58.13 ± 25.61	20.5 ± 0	7.25 ± 0	13.88 ± 7.26
Depth (cm)	81.5 ± 0	52.5 ± 0	67 ± 15.88	30.9 ± 0	25 ± 0	27.95 ± 3.23
DO (mg L^{-1})	3.91 ± 0.45	3.4 ± 0.6	3.65 ± 0.55	7.41 ± 0.18	10.17 ± 1.33	8.79 ± 1.73
FCO_2 (mg L^{-1})	9.32 ± 1.15	11.05 ± 1.01	10.18 ± 1.35	5.99 ± 0	11.98 ± 2.0	8.99 ± 3.52
TA (mg L^{-1})	109.73 ± 0.46	127.07 ± 3.32	118.40 ± 9.73	15.33 ± 2.31	19.53 ± 2.16	17.43 ± 3.05
NO_3^-(mg L^{-1})	0.81 ± 0.68	0.48 ± 0.61	0.64 ± 0.61	0.86 ± 0.54	0.18 ± 0.17	0.52 ± 0.52
PO_4^{3-}(mg L^{-1})	0.08 ± 0.09	0.23 ± 0.07	0.16 ± 0.11	0.04 ± 0.04	0.29 ± 0.06	0.17 ± 0.15
pH	7.83 ± 1.37	7.20 ± 0.04	7.52 ± 0.94	6.45 ± 0.38	5.81 ± 0.19	6.13 ± 0.44
EC (µS cm^{-1})	164.43 ± 3.19	195.27 ± 1.85	179.85 ± 17.05	19.77 ± 0.55	38.31 ± 0.88	29.04 ± 10.18
TDS (ppm)	108.50 ± 0.26	126.89 ± 1.15	117.69 ± 10.10	12.92 ± 0.34	24.91 ± 0.54	18.91 ± 6.58
Salinity (ppt)	68.67 ± 6.65	79.03 ± 11.07	73.85 ± 43.11	173.25 ± 91.67	1573.33 ± 42.06	873.29 ± 769.50
Na (mg L^{-1})	7.59 ± 0.40	9.66 ± 0.63	8.62 ± 1.23	6.84 ± 4.36	2.93 ± 1.18	4.88 ± 3.57
K (mg L^{-1})	3.32 ± 0.09	4.25 ± .70	3.78 ± 0.68	3.87 ± 0.11	5.30 ± 0.55	4.58 ± 0.86

Table 2. Significant Pearson's correlations among physicochemical variables of water and aquatic insect density and richness of UP and JP (*=significant at 0.05 level and **= significant at 0.01 level).

<table>
<tr><td colspan="2">UP</td><td colspan="2">JP</td></tr>
<tr><td>Postmonsoon</td><td>Winter</td><td>Postmonsoon</td><td>Winter</td></tr>
<tr><td>Salinity vs. pH (+*)</td><td>No. of species vs. pH (+**)</td><td>Species density vs. Na (+**)</td><td>No. of species vs. Na (-*)</td></tr>
<tr><td rowspan="4">EC vs. TDS (+*)</td><td>No. of species vs. Na (+*)</td><td>Species density vs. AT (+*)</td><td rowspan="4">EC vs.
TDS (+**)</td></tr>
<tr><td>No. of species vs. K (-*)</td><td>Species density vs. WT (+*)</td></tr>
<tr><td rowspan="2">No. of species vs. TA (-*)</td><td>Species density vs. TR (-*)</td></tr>
<tr><td>Species density vs. depth (+*)</td></tr>
</table>

Table 3. Diversity indices of aquatic insects in UP and JP.

Sites	UP		JP	
Seasons	Postmonsoon	Winter	Postmonsoon	Winter
Shannon H′	1.748	2.148	1.505	1.928
Evenness e^H/S	0.4419	0.408	0.563	0.5289
Margalef	2.511	3.782	1.275	2.265
Berger–Parker	0.4118	0.4394	0.4669	0.35

Aphelonecta sp. was the most abundant species in both UP and JP during the postmonsoon season and was marked as a eudominant species according to Engelmann's scale of dominance (1978). During winter, *Cloeon* sp. and *Micronecta* sp. were found most abundantly as well as eudominantly in UP and JP, respectively (Figure 2; Tables 4 and 5).

3.4. BMWP and ASPT

The BMWP is a scoring system up to family level of aquatic insects where each family score is based on its pollution tolerance. ASPT is used to represent the average tolerance score of all taxa within the community and indicate its water quality, and it is calculated by dividing the total score of BMWP by the total number of species counted (Mandaville, 2002). ASPT scores of UP were 5.9 in the postmonsoon season and 5 in winter. JP's scores were 5 (postmonsoon) and 5.1 (winter) (Table 6). Both the ponds indicated 'doubtful quality' as the scores ranged between 5 and 6 (Mandaville, 2002).

3.5. NLBI

The NLBI scores for UP and JP are shown in Table 7. The NLBI is a family-level biotic index for macroinvertebrates for assessing the ecological quality of lakes and reservoirs (Shah et al., 2011). The NLBI score of UP postmonsoon was 4.78 (highest record) and for winter it was 4.21. The NLBI score for JP was 3.5 (lowest record) for the postmonsoon season and 4.25 for winter.

3.6. CCA

CCA shows the relationships between the aquatic insect community and environmental variable data of UP and JP in Cachar District (Figures 3 and 4). Table 8 shows the summary statistics of CCA between aquatic insect species and environmental variables for the first two axes in UP and JP, whereas Table 9 shows the taxa names along with the codes used in the CCA graphs of UP and JP.

CCA showed the following eigenvalues: axis I- 0.67, axis II- 0.306 for UP; and axis I- 0.868, axis II- 0.420 for JP. Species–environment correlations of the two axes were 1.00 and 1.00 for UP and 1.00 and 1.00 for JP, which showed the strong relationship of the aquatic insect community with the environment variables. Cumulative percent variance of species data and cumulative percent variance of species–environment relations for UP were 43.5 for axis 1 and 63.2 for axis 2, while axis 1 and 2 were 48.7 and 78.3 respectively in JP.

4. Discussion

DO was found much lower in UP than in JP. The highest species density in UP might be due to DO being utilized by the aquatic insects. Another factor might be human habitation, which contributed wastewater into the system. Similar low DO amounts were recorded in Seetadwar Lake (3.41 to 6.21 mg L^{-1}) by Tewari and Mishra (2005) and in Kandhar Dam (3 to 6 mg L^{-1}) by Surve et al. (2005). In JP,

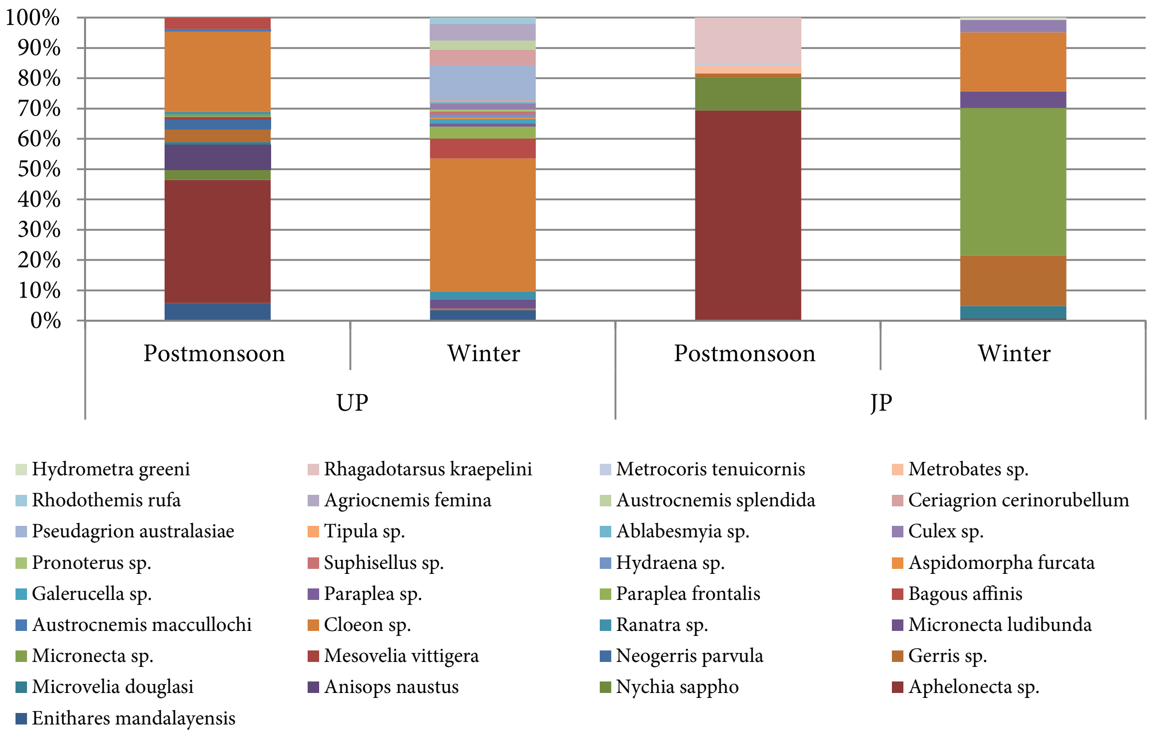

Figure 2. Relative abundance of the species gathered from UP and JP in postmonsoon and winter seasons.

Table 4. Engelmann's scale of dominance of aquatic insects in UP (Engelmann, 1978).

Postmonsoon			Winter		
Taxa	Relative abundance (%)	Dominance status	Taxa	Relative abundance (%)	Dominance status
Enithares mandalayensis Distant, 1910	5.88	Subdominant	*Enithares mandalayensis* Distant, 1910	3.54	Subdominant
Aphelonecta sp. Lansbury, 1965	41.18	Eudominant	*Gerris* sp. Fabricius, 1794	0.51	Subrecedent
Nychia sappho Kirkaldy, 1901	3.36	Subdominant	*Paraplea frontalis* Fieber, 1844	4.04	Subdominant
Anisops naustus Fieber, 1851	8.40	Subdominant	*Paraplea* sp. Esaki & China, 1928	1.01	Subrecedent
Microvelia douglasi Scott, 1874	0.84	Subrecedent	*Ranatra* sp. Fabricius, 1790	2.53	Recedent
Gerris sp. Fabricius, 1794	4.20	Subdominant	*Micronecta ludibunda* Breddin, 1905	3.03	Recedent
Neogerris parvula Stal, 1859	3.36	Subdominant	*Cloeon* sp. Linnaeus, 1761	43.94	Eudominant
Mesovelia vittigera Horvath, 1895	0.84	Subrecedent	*Bagous affinis* Hustache, 1926	6.57	Subdominant
Micronecta sp. Kirkaldy, 1897	0.84	Subrecedent	*Galerucella* sp. Crotch, 1873	1.52	Recedent
Ranatra sp. Fabricius, 1790	0.84	Subrecedent	*Aspidomorpha furcate* Thunb, 1979	0.51	Subrecedent
Cloeon sp. Linnaeus, 1761	26.89	Dominant	*Hydraena* sp. Kugelan, 1794	1.01	Subrecedent
Austrocnemis maccullochi Tillyard, 1926	0.84	Subrecedent	*Suphisellus* sp. Crotch, 1873	1.01	Subrecedent
Bagous affinis Hustache, 1926	2.52	Recedent	*Pronoterus* sp. Sharp, 1882	0.51	Subrecedent
			Culex sp. Linnaeus, 1758	2.02	Recedent
			Ablabesmyia sp. Johannsen, 1905	0.51	Subrecedent
			Tipula sp. Linnaeus, 1758	0.51	Subrecedent
			Pseudagrion australasiae Selys, 1876	11.62	Dominant
			Ceriagrion cerinorubellum Baruer, 1865	5.05	Subdominant
			Austrocnemis splendida Martin, 1901	3.03	Recedent
			Agriocnemis femina Brauer, 1868	5.56	Subdominant
			Rhodothemis rufa Rambur, 1842	2.02	Recedent

RA < 1 = Subrecedent; 1.1–3.1 = recedent; 3.2–10 = subdominant; 10.1–31.6 = dominant; >31.7% = eudominant.

Table 5. Engelmann's scale of dominance of aquatic insects in JP (Engelmann, 1978).

Postmonsoon			Winter		
Taxa	Relative abundance (%)	Dominance status	Taxa	Relative abundance (%)	Dominance status
Metrobates sp. Uhler, 1871	1.65	Recedent	*Anisops breedini* Kirkaldy, 1901	3.5	Subdominant
Metrocoris tenuicornis Esaki, 1926	0.41	Subrecedent	*Anisops niveus* Fabricius, 1775	0.5	Subrecedent
Gerris sp. Fabricius, 1794	0.82	Subrecedent	*Aphelonecta* sp. Lansbury, 1965	0.5	Subrecedent
Rhagadotarsus kraepelini Breddin, 1905	10.33	Dominant	*Microvelia douglasi* Scott, 1874	3	Recedent
Nychia sappho Kirkaldy, 1901	7.43	Subdominant	*Microvelia* sp. Westwood, 1834	17.5	Dominant
Aphelonecta sp. Lansbury, 1965	46.69	Eudominant	*Micronecta quadristrigata* Breddin, 1905	2	Recedent
Anisops exiguous Horvath, 1919	15.70	Dominant	*Micronecta ludibunda* Breddin, 1905	7.5	Subdominant
Anisops breddini Kirkaldy, 1901	16.94	Dominant	*Micronecta* sp. Kirkaldy, 1897	35	Eudominant
			Gerris sp. Fabricius, 1794	12	Dominant
			Hydrometra greeni Kirkaldy, 1898	0.5	Subrecedent
			Cloeon sp. Linnaeus, 1761	14	Dominant
			Caenis sp. Stephens, 1835	1	Subrecedent
			Culex sp. Linnaeus, 1758	3	Recedent

RA < 1 = Subrecedent; 1.1–3.1 = recedent; 3.2–10 = subdominant; 10.1–31.6 = dominant; >31.7% = eudominant.

Table 6. BMWP and ASPT scores of UP and JP.

UP				JP			
Postmonsoon		Winter		Postmonsoon		Winter	
BMWP	ASPT	BMWP	ASPT	BMWP	ASPT	BMWP	ASPT
35	5	65	5	10	5	31	5.1

BMWP score = 0–10 very poor, 11–40 poor, 41–70 moderate, 71–100 good, >100 very good (Mason, 2002). ASPT score = total of BMWP score / total number of families represented; >6 clean water, 5–6 doubtful quality, 4–5 probable moderate pollution, <4 probable severe pollution (Mandaville, 2002).

Table 7. NLBI of UP and JP.

UP				JP			
Postmonsoon		Winter		Postmonsoon		Winter	
Families	Tolerance scores	Families	Tolerance scores	Families	Tolerance scores	Families	Tolerance scores
Notonectidae	3	Notonectidae	3	Gerridae	4	Notonectidae	3
Veliidae	8	Gerridae	4	Notonectidae	3	Veliidae	8
Gerridae	4	Pleidae	4	Total	7	Corixidae	2
Mesoveliidae	6	Nepidae	4	NLBI	3.5	Gerridae	4
Corixidae	2	Corixidae	2			Hydrometridae	6
Nepidae	4	Baetidae	6			Baetidae	6
Baetidae	6	Curculionidae	5			Caenidae	3
Coenagrionidae	5	Chrysomelidae	8			Culicidae	2
Curculionidae	5	Noteridae	5			Total	34
Total	43	Culicidae	2			NLBI	4.25
NLBI	4.78	Chironomidae	1				
		Tipulidae	7				
		Coenagrionidae	5				
		Libellulidae	3				
		Total	59				
		NLBI	4.21				

Lake water quality class and its degree of pollution: 0–1.99 bad (extremely); 2–3.99 poor (heavily); 4–4.90 fair (moderately); 4.91–6.09 good (slightly); 6.10–10 high (none to minimal) (Shah et al., 2011).

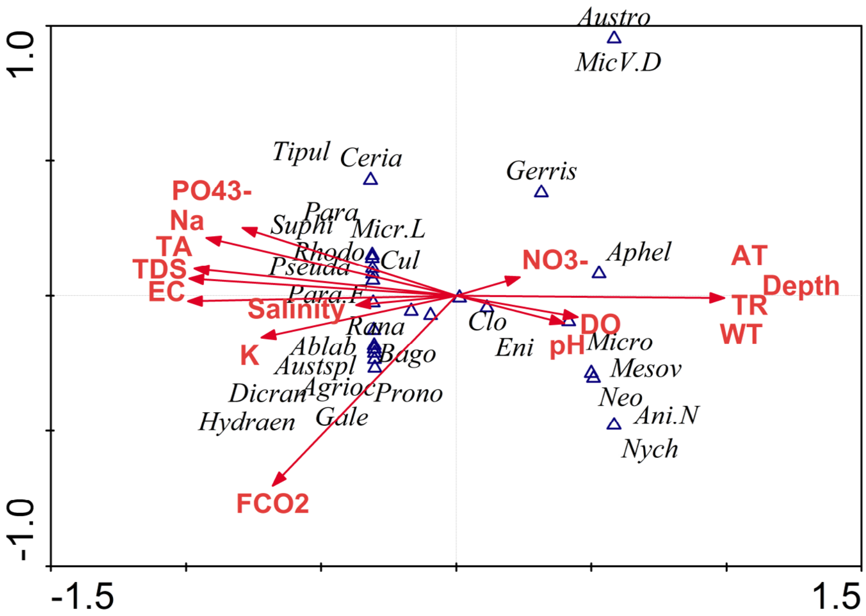

Figure 3. CCA biplot for UP.

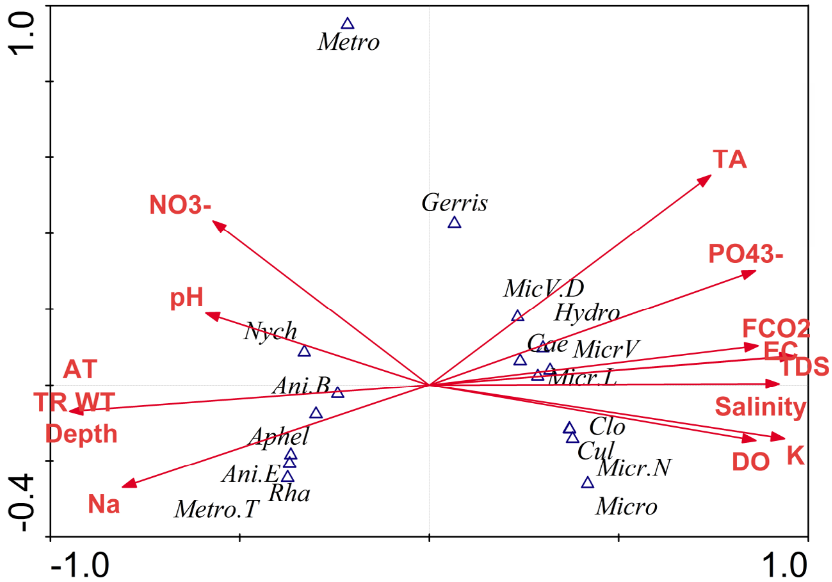

Figure 4. CCA biplot for JP.

pH (5.8–6.4), FCO_2, EC, and TA values were found lower than in UP. Similar low values were also recorded in one wetland and oxbow lake of Cachar District (Laskar and Gupta, 2013; Gupta and Devi, 2014). The concentrations of PO_4^{3-} and NO_3^- in both ponds were found lower than in previous studies conducted in Barak Valley (Bhuiyan and Gupta, 2007; Barman et al., 2014; Dalal and Gupta, 2014). Na concentrations in both ponds were within the desirable limits according to the Bureau of Indian Standards (BIS, 2003) (Table 1).

Pearson's correlation analysis showed species richness to be positively correlated with pH and Na in UP and species density with Na in JP, which indicated the presence of the only tolerant species in both ponds that can thrive in stressed conditions. In JP negative correlation of species density with TR was established. This conformed with the findings of Takhelmayum and Gupta (2015) in the water of Keibul Lamjao National Park, Manipur (Table 2).

Shannon (H') values of both ponds were within the proper range (1.5–3.5) (Turkmen and Kazanci,

Table 8. Summary statistics of CCA between aquatic insect species and environmental variables for first two axes in UP and JP.

	UP		JP	
	Axis 1	Axis 2	Axis 1	Axis 2
Eigen values	0.677	0.306	0.868	0.420
Species–environment correlation	1.000	1.000	1.000	1.000
Cumulative percentage variance of species data	43.5	63.2	48.7	72.3
Cumulative percentage variance of species–environment relation	43.5	63.2	48.7	72.3
Sum of all eigenvalues	1.555		1.782	
Sum of all canonical eigenvalues	1.555		1.782	

Table 9. Taxa name along with its code used in the CCA graph in UP and JP.

UP		JP	
Taxa	Code name	Taxa	Code name
Enithares mandalayensis	Eni	*Metrobates* sp.	Metro
Aphelonecta sp.	Aphel	*Metrocoris tenuicornis*	Metro.T
Nychia sappho	Nych	*Gerris* sp.	Gerris
Anisops naustus	Ani.N	*Rhagadotarsus kraepelini*	Rha
Microvelia douglasi	MicV.D	*Nychia sappho*	Nych
Gerris sp.	Gerris	*Aphelonect a*sp.	Aphel
Neogerris parvula	Neo	*Anisops exiguus*	Ani.E
Mesovelia vittigera	Mesov	*Anisops breddini*	Ani.B
Micronecta sp.	Micro	*Microvelia douglasi*	MicV.D
Ranatra sp.	Rana	*Microvelia* sp.	MicrV
Cloeon sp.	Clo	*Micronecta maculata*	Micr.N
Austrocnemis maccullochi	Austro	*Micronecta ludibunda*	Micr.L
Bagou saffinis	Bago	*Micronecta* sp.	Micro
Paraplea frontalis	Para.F	*Hydrometra greeni*	Hydro
Paraplea sp.	Para	*Cloeon* sp.	Clo
Micronecta ludibunda	Micr.L	*Caenis* sp.	Cae
Galerucella sp.	Gale	*Culex* sp.	Cul
Hydraena sp.	Hydraen		
Suphisellus sp.	Suphi		
Pronoterus sp.	Prono		
Aspidomorpha furcata	Dicran		
Culex sp.	Cul		
Ablabesmyia sp.	Ablab		
Tipula sp.	Tipul		
Pseudagrion australasiae	Pseuda		
Ceriagrion cerinorubellum	Ceria		
Austrocnemi ssplendida	Austspl		
Agriocnemis femina	Agrioc		
Rhodothemis rufa	Rhodo		

2010), and when compared UP was found to be more diverse than JP with more number of species recorded. However, evenness values were found to be higher in JP, which shows that in JP aquatic insects are more evenly distributed. According to Margalef's water quality index (Lenat et al., 1980), the water of UP is in a clean condition in winter and JP is moderately polluted in both seasons as values greater than 3 indicate a clean condition, values less than 1 indicate severe pollution, and intermediate values indicate moderate pollution. The Berger–Parker index of dominance value was found highest in JP (postmonsoon), followed by UP (winter) (Table 3). This is again confirmed by the eudominant status of *Aphelonecta* sp. in JP in the postmonsoon season and *Cloeon* sp. in UP in winter as per Engelmann's scale of dominance (Engelmann, 1978). *Aphelonecta* sp., *Micronecta* sp., and *Cloeon* sp. were the eudominant species in UP and JP. Earlier studies on temple ponds and village ponds in Cachar District also indicated order Hemiptera as the most abundant group (Barman et al., 2014; Dalal and Gupta, 2014) (Tables 4 and 5).

In the case of the BMWP, the water condition of UP was better than that of JP. ASPT scores of the two ponds in both seasons indicated doubtful water quality (Table 7). The NLBI showed a moderate degree of pollution for both ponds with the highest NLBI score for UP (Table 8).

The CCA ordination diagrams for species–environment relationships of UP and JP are shown in Figures 3 and 4, respectively. The CCA ordination diagram of UP revealed a clear separation of order Hemiptera from Odonata and Coleoptera. *Cloeon* sp. showed a strong positive correlation with DO and pH as *Cloeon* sp. belongs to the sensitive group Ephemeroptera, members of which rely on high DO for survival (Hubbard and Peters, 1978; Resh and Jackson, 1993). Hemipterans are present as a group mainly associated with WT, AT, depth, and TR. They possess the ability of taking atmospheric oxygen through special respiratory appendages and thus can survive in stressed conditions and are less dependent on the DO of water (Usinger, 1968; McCafferty, 1981). Species belonging to the orders Coleoptera and Odonata are found in a single group associated with PO_4^{3-}, Na, TA, TDS, EC, salinity, K, and FCO_2. This shows that they are positively associated with nutrients in water and tolerant to anthropogenic impacts. In the CCA ordination diagram of JP, DO was negatively correlated with FCO_2. In this graph also, *Cloeon* sp. showed a high positive association with DO, as found in UP. All the species belonging to the family Notonectidae, suborder Nepomorpha, which are truly aquatic, were found positively associated with AT, WT, TR, Na, and depth, indicating their preference for water. This is further confirmed by their abundance during the wet season (postmonsoon). *Caenis* sp. and *Hydrometra greeni* showed positive correlation with PO_4^{3-}. Most of the species from Gerromorpha do not rely much on the water of the pond. Hence, where other water-dwelling insects find it unsuitable, they thrive well.

It is well proved from the different diversity indices, BMWP, NLBI, and all the ranges of values of water variables that UP is a better ecosystem than JP. UP, though located in the middle of a commercial and residential area, was found to be well protected by the municipality with minimum disturbance. JP, though located in a rural area, showed signs of disturbance. Fishing is the main activity done here. This study attempts to point out that urban ponds have an important role to play in biodiversity conservation.

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