Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2016; 4(1): 21-26

Received: 12-11-2015
Accepted: 15-12-2015

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Assessment of ecosystem health of two ponds in district Cachar, Assam, India using aquatic insects

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Abstract
An investigation was carried out to compare the insect diversity and ecosystem health of one man made and one natural pond of Cachar District, Assam. Physico-chemical properties of water in the two systems also have been studied. Dissolved oxygen in site 1 which is a man-made pond, was found very low and showed significant positive correlation with pH. Nitrate concentration of site 1 ranged from 0.26 mg/L to 0.54 mg/L and in site 2 (natural shallow water pond) it ranged from 0.14 mg/L to 0.50 mg/L. All total thirteen species were recorded from these two ponds, nine species from site 1 and twelve species from site 2. Five orders, nine families from site 1 and seven orders, twelve families from site 2 were recorded. Shannon H' less than 1 for each site indicated disturbed condition of water of both the ponds. Shannon H' showed very high significant positive correlation with transparency. Both the sites were found to be dominated by pollution tolerant species. Different biomonitoring scores like BMWP and SIGNAL also revealed stressed condition of these two water bodies. Ecology and anthropogenic impact on the water quality of both the ponds have been discussed in the paper.

Keywords: Aquatic insect diversity, ecosystem health, biomonitoring.

1. Introduction
Freshwater makes up only about 0.01% of world total water body (U. S. Geological survey). The small amount of available fresh water supports the maximum life on the Earth. With the expansion of agricultural and industrial activities in the developing countries sensitive management of the limited available freshwater resources will become increasingly important. If their supply depends completely on ground water, then some water deficit countries could end up by mining a non-renewable resource as it takes many thousands of years to replenish deep fossil groundwater stocks. Conservation and careful husbandry of existing stocks must therefore be carried out if the growing human populations of arid lands are to be protected from famine and poverty. So study and observation of aquatic ecosystem is very much important. Ponds are ubiquitous and comprise a significant proportion of the world's inland waters. They were often destroyed because people were unaware of their significance [1, 2]. Ponds are also collectively more diverse than rivers, lakes, or wetlands [3]. Macroinvertebrates have been recognized as important bioindicators of wetland health [4, 5]. Among macro-invertebrates, aquatic insects hold a huge portion. Different aquatic insects have varying tolerances to a number of water quality parameters, such as dissolved oxygen concentration, pH, temperature, nutrient levels (such as phosphorus and nitrogen) etc. Hence by proper study of aquatic insect diversity of the system, one can determine the status of a pond.
The two types of pond ecosystem i.e. natural and man-made have structural differences. It is felt that ancient man-made ponds are becoming an important source of fresh water. So, an investigation was carried out to compare the insect diversity and ecosystem health of one man made and one natural pond of Cachar District, Assam.

2. Materials and Methods
For this study, two different types of ponds were selected; one man-made ancient pond as site 1 (S1-Ranidghi), situated in a small urban settlement and another natural shallow water pond as site 2 (S2- Moinarbandh) situated in a zone facing high developmental pressure. Both the ponds are located in Cachar district (25.0833˚ N, 92.9167˚ E) of Assam.
Aquatic insects and water samples were collected fortnightly from two sampling sites (S1A, S1B from pond 1 and S2A, S2B from pond 2) with three replicates during January to March, 2013. Physico- chemical parameters like air temperature (AT), water temperature (WT),

transparency (TR), pH, electrical conductivity (EC), dissolved oxygen (DO), free carbon dioxide (FCO_2), total alkalinity (TA), nitrate (NO_3^-) and phosphate (PO_4^{3-}) were analyzed by standard methods [6]. For aquatic insect collection kick method was used where the vegetation was disturbed and a circular net (mesh size 60µm) was dragged around vegetation for a unit time [7]. Three such drags constitute a sample. Insects were then sorted and kept in 70% ethyl alcohol for preservation. They were later identified using a Dewinter advanced stereozoom Microscope and Magnus stereozoom Microscope with the help of standard keys [8-14]. Diversity indices and cluster analysis were worked out using Biodiversity Pro software and statistical analysis were done by using SPSS, Version 16 software. Sensitivity grades for the two ecosystems were calculated by using SIGNAL 2 sensitivity grades [15].

3. Results and Discussion

Range of different physico-chemical parameters are shown in Table 1. Significant correlations among the different physico-chemical parameters and diversity indices in site 1 and site 2 are shown in Table 2. In site 1, AT showed significant positive correlation with WT, pH and DO and in site 2, it showed significant positive correlation with WT, pH, EC and DO.WT in site 1 showed significant positive correlation with pH and DO. In site 2, it showed significant positive correlation with pH and EC and significant negative correlation with TR and NO_3^-. The EC of water indicates the availability of free ions and other nutrient elements such as nitrate, chlorides and bicarbonates and input of organic and inorganic waste [16]. In the present study, the EC of site 1 ranged from 68.63 µS/cm to 98.43 µS/cm. In site 2, it ranged from 79.67 µS/cm to 119.33 µS/cm and showed significant positive correlation with pH and negative correlation with TR. Adeleke [17] opined that conductivity levels below 50µS/cm are regarded as low; those between 50-600 µS/cm are medium and above this are high. In this study, both the sites showed medium EC. Range of FCO_2 in site 1 was 30.51 mg/L to 57.57 mg/L and in site 2 it was 14.43 mg/L to 27.06 mg/L. $FCO_2$was much higher in site 1. This might be due to higher respiration of aquatic biota, more decomposition of organic matter and low photosynthesis [16]. In site 1, FCO_2 showed significant negative correlation with nitrate. Nitrate concentration of site 1 ranged from 0.26 mg/L to 0.54 mg/L and in site 2 it ranged from 0.14 mg/L to 0.50 mg/L. It was slightly higher in site 1. Most important source of nitrate is biological oxidation of nitrogenous substances present in sewage, industrial waste, chemical fertilizers, decaying vegetables, leachates etc [18]. In site 1, nitrate showed significant negative correlation with FCO_2 and pH. On the other hand it showed significant positive correlation with TR in site 2.

Macro invertebrates, especially aquatic insects are vulnerable to changes in ecosystem health and for their sensitivity they have served as valuable indicators. Because of having limited habitat and less moving ability, they cannot change their habitat quickly and they respond to any pollutants by changing their community composition [19]. Altogether seven orders, thirteen families and thirteen species were found in Ranidighi and Moinarbandh study sites. In Ranidighi, which is a manmade ancient pond, five orders, nine families and nine species were recorded and in Moinarbandh, which is a natural shallow water pond, seven orders, twelve families and twelve species were recorded (Table 3).

Table 1: Physico-chemical properties of water in site 1 and site 2

Physico-chemical parameters	Range	
	Site 1	Site 2
Air temperature (AT)	17 °C to 32 °C	17 °C to 32 °C
Water temperature (WT)	21 °C to 29 °C	21 °C to 28 °C
Transparency (TR)	35 cm to 38 cm	27 cm to 36 cm
pH	5.51 to 7.43	6.30 to 7.77
Electrical conductivity (EC)	68.63 µS/cm to 98.43 µS/cm.	79.67 µS/cm to 119.33 µS/cm
Dissolved oxygen (DO)	4.36 mg/L to 10.65 mg/L	7.32 mg/L to 14.51mg/L
Free carbon dioxide (FCO_2)	65.1 mg/L to 98.57 mg/L	72.0 mg/L to 88.0 mg/L.
Total alkalinity (TA)	65.1 mg/L to 98.57 mg/L.	72.0 mg/L to 88.0 mg/L
Nitrate (NO_3^-)	0.13 mg/L to 0.54 mg/L	0.14 mg/L to 0.50 mg/L.
Phosphate (PO_4^{3-})	beyond detection level	beyond detection level

Table 2: Significant correlations among the different physico-chemical parameters and diversity indices

Site 1		Site 2	
Variables	R value	Variables	R value
Air Temp. vs. Water Temp.	0.942**	Air Temp. vs. Water Temp.	0.836**
Air Temp.vs. pH	0.906**	Air Temp. vs. Transparency	-0.921**
Air Temp. vs. DO	0.741**	Air Temp. vs. pH	0.948**
Water Temp vs. pH	0.824**	Air Temp. vs. Conductivity	0.774**
Water Temp vs. DO	0.669**	Air Temp. vs. DO.	0.721**
Transparency vs. Shannon	0.489**	Water Temp. vs. Transparency	-0.977**
pH vs. DO	0.698**	Water Temp. vs. pH	0.799**
pH vs. Nitrate	-0.558**	Water Temp. vs. Conductivity	0.620**
Total Alkalinity vs. Free CO2	0.575**	Transparency vs. pH	-0.858**
Free CO2 vs. Nitrate	-0.479**	Transparency vs. Conductivity	-0.683**
Shannon vs. Margalef	0.602**	Transparency vs. Nitrate	0.537**
		Transparency vs. DO	0.503**
		pH vs. Conductivity	0.805**
		pH vs. DO	0.594**
		pH vs. Nitrate	-0.609**
		DO vs. Free CO2	0.529**
		DO vs. Nitrate	-0.646**
		Free CO2 vs. Nitrate	-0.366*
		Nitrate vs. Shannon	-0.545**
		Nitrate vs. Margalef	-0.542**
		Shannon vs. Margalef	0.571**

Table 3: List of insect species recorded at Site 1 and Site 2

Order	Species with family	Order	Species with family
Site 1		**Site 2**	
Hemiptera	*Ranatra varipes* (Nepidae), *Rhopalosiphum nymphaeae* (Aphididae), *Mesovelia* sp. (Mesoveliidae), *Gerris*sp. (Gerridae), *Micronecta* sp. (Corixidae).	Hemiptera	*Ranatra varipes* (Nepidae), *Rhopalosiphum nymphaeae* (Aphididae), *Mesovelia* sp. (Mesoveliidae), *Micronecta* sp. (Corixidae), *Anisops* sp.(Notonectidae)
Odonata	*Pseudagrion* sp. (Coenagriidae), *Leucorrhinia* sp. (Libellulidae	Odonata	*Pseudagrion*sp. (Coenagriidae), *Leucorrhinia* sp. (Libellulidae)
Ephemeroptera	*Cloeon* sp. (Baetidae)	Ephemeroptera	*Cloeon* sp. (Baetidae)
Collembola	*Siminthurus* sp. (Sminthuridae)	Collembola	*Siminthurus* sp. (Sminthuridae)
Trichoptera	*Fabria* sp. (Phyganeadae)	Trichoptera	*Fabria* sp. (Phyganeadae)
		Coleoptera	*Sitophilus* sp. (Curculionidae)
		Diptera	*Parapalaeosepsis* sp.(Sepsidae)

The figures 1, 2, 3 and 4 have clearly depicted that *Cloeon* sp. is the most abundant species in both the ponds. Presence of order Ephemeroptera, one of the sensitive groups of aquatic insects EPT (Ephemeroptera, Plecoptera and Trichoptera) indicated that both the systems are having good water quality. However, the order Ephemeroptera is represented by the genus *Cloeon,* whose tolerance value is relatively high and it can survive well in moderately polluted water [20]. This agreed to the findings of a study made on aquatic insects of an oxbow lake in Cachar, Assam [21]. According to Alba-Tercedor *et al.* [22] *Cloeon* sp. showed a high significance level of association with moderately polluted water as they inhabit medium and lower courses. Thus, these findings have challenged the traditional concept of EPT as sensitive group.

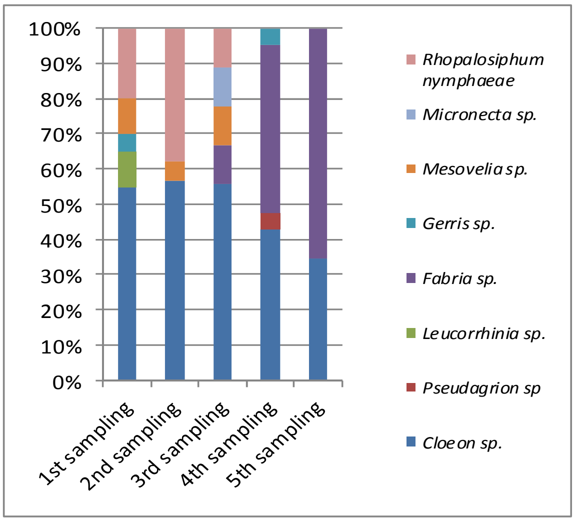

Fig 1: Relative abundance (%) of species of aquatic insects in Site 1A.

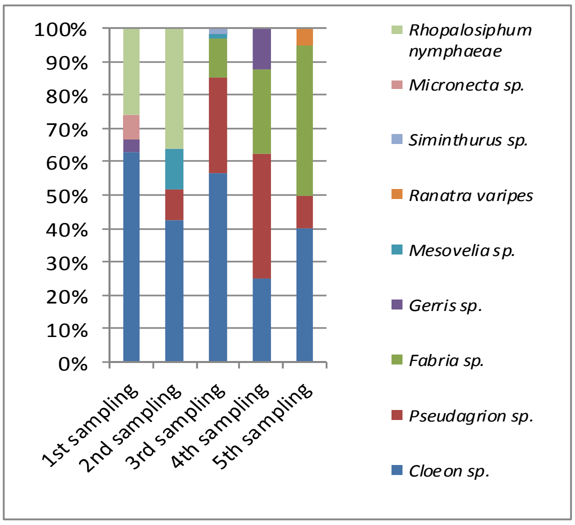

Fig 2: Relative abundance (%) of species of aquatic insects in Site 1B

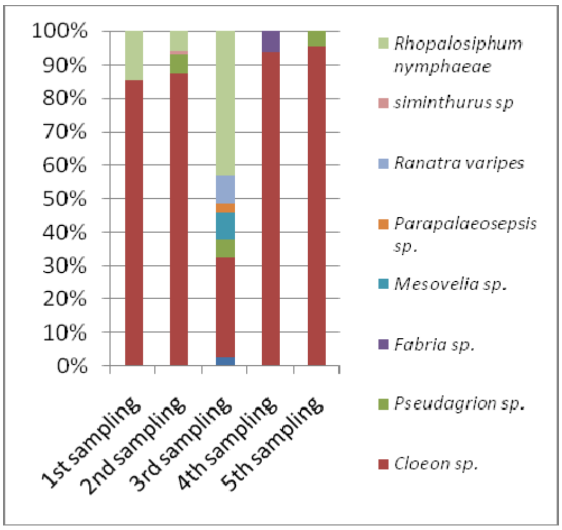

Fig 3: Relative abundance (%) of species of aquatic insects in Site 2A.

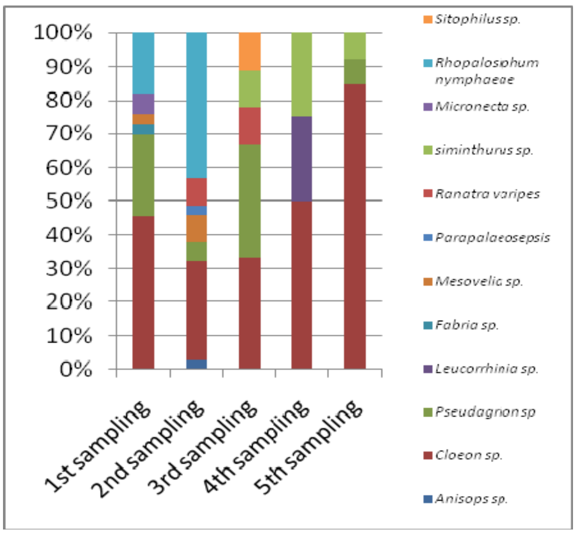

Fig 4: Relative abundance (%) of species of aquatic insects in Site 2B

The values of Shannon diversity index at Site 1A are from 0.28 to 0.56 and Site 1B from 0.42 to 0.57. In Site 2A it ranged from 0.08 to 0.18 and Site 2B from 0.45 to 0.64 (Table 4). Shannon H' being less than 1 for each site indicated disturbed condition of water [19]. Shannon index showed very high significant positive correlation with transparency in pond 1. Bray- Curtis (Single link) cluster analysis based on aquatic insect community revealed that S1-A& S1-B has highest similarity (77.4%) (Figure 5).

Table 4: Variations in Shannon Weiner diversity index (H/), Berger Parker index of dominance (d) and Margaleff index (M) during the study period in different sites

1st collection					
	Shannon H'	Shannon Hmax	**Shannon J'**	**Berger-Parker Dominance (d)**	**Margaleff M**
Site 1- A	0.55	0.70	0.78	0.55	13.35
Site 1- B	0.42	0.60	0.69	0.63	11.53
Site 2- A	0.18	0.30	0.60	0.86	2.94
Site 2- B	0.61	0.78	0.78	0.46	10.56
2nd collection					
	Shannon H'	Shannon Hmax	**Shannon J'**	**Berger-Parker Dominance (d)**	**Margaleff M**
Site 1- A	0.37	0.48	0.78	0.57	8.82
Site 1- B	0.52	0.60	0.87	0.43	10.56
Site 2- A	0.22	0.60	0.36	0.87	2.61
Site 2- B	0.64	0.85	0.76	0.43	10.08
3rd collection					
	Shannon H'	Shannon Hmax	**Shannon J'**	**Berger-Parker Dominance (d)**	**Margaleff M**
Site 1- A	0.56	0.70	0.81	0.56	23.13
Site 1- B	0.46	0.70	0.65	0.57	8.08
Site 2- A	0.00	0.00	0.00	0.00	0.00
Site 2- B	0.64	0.85	0.76	0.33	23.13
4th collection					
	Shannon H'	Shannon Hmax	**Shannon J'**	**Berger-Parker Dominance (d)**	**Margaleff M**
Site 1- A	0.44	0.60	0.73	0.48	13.03
Site 1- B	0.57	0.60	0.95	0.38	25.79
Site 2- A	0.10	0.30	0.34	0.94	3.89
Site 2- B	0.64	0.70	0.91	0.50	88.82
5th collection					
	Shannon H'	Shannon Hmax	**Shannon J'**	**Berger-Parker Dominance (d)**	**Margaleff M**
Site 1- A	0.28	0.30	0.93	0.65	11.73
Site 1- B	0.48	0.60	0.80	0.45	13.35
Site 2- A	0.08	0.30	0.27	0.95	3.43
Site 2- B	0.45	0.48	0.94	0.85	17.28

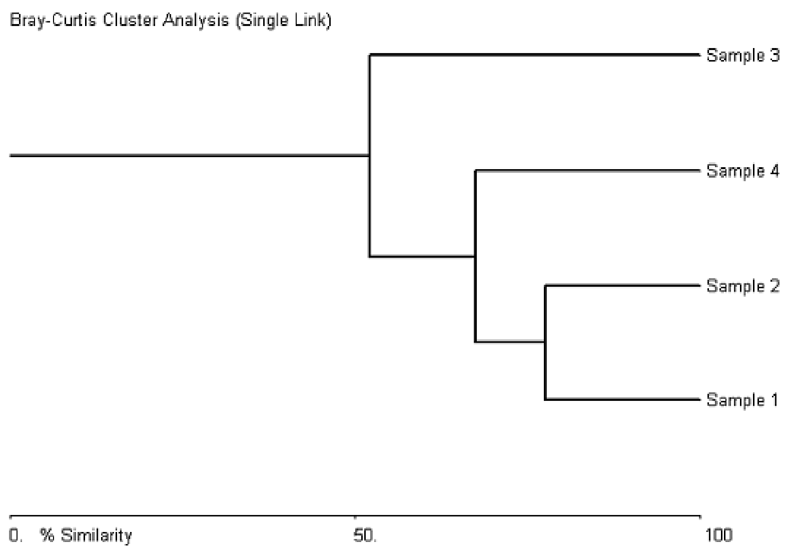

Fig 5: Bray- Curtis (Single link) cluster analysis of aquatic insects. Sample 1, 2, 3 and 4 represents S 1A, S 1B, S 2A and S 2B respectively

A SIGNAL score developed by Chessman [15] gives an indication of water quality in the river. Each type of macroinvertebrate has a 'grade number' between 1 and 10. A low grade number means that the macroinvertebrate is tolerant of a range of environmental conditions, including common forms of water pollution. A high number means that the macroinvertebrate is sensitive to most forms of pollution. Higher the number, greater the average sensitivity. Depending upon this, the SIGNAL 2 sensitivity grades of the study sites were calculated. Some of the macroinvertebrate orders that have the highest SIGNAL 2 sensitivity grades are naturally rare in wetlands, for example stoneflies. Therefore, wetlands are likely to have naturally lower scores than streams in the same region. Naturally low SIGNAL 2 sensitivity grades were found for the study sites. Among all the sites Site 2A was found to have the highest SIGNAL grade (3.9) and on the other hand Site 2B has the lowest grade (3) (Table 5).

Table 5: SIGNAL 2 scores for the study sites S1A, S1B, S2A and S2B

Sites	Site 1A	Site 1B	Site 2A	Site 2B
Signal 2 score	3.6	3.2	3.9	3

This study clearly stated that both the ponds are facing stress. In urban areas, man-made ancient ponds are the last source of fresh water. As a result these ponds are subjected to immense anthropogenic pressure. Ranidighi, which is situated in an urban set up is facing problems of developmental activities in nearby area associated with disposal of solid waste in the pond. The natural shallow water bodies in a particular area are the habitat for large number of flora and fauna which conserve freshwater biodiversity of the place. Moinarbandh is such a natural aquatic ecosystem and a good source of water for the place and it holds a large amount of water in rainy seasons minimizing flood in that area. This study found that inspite of its natural background and least disturbance, the system is showing the signs of pollution.

4. Conclusions
Pollution in freshwater ecosystem is a global problem. Regaining health of any such system is a challenge. This process can be initiated only through proper monitoring of its water quality. This study confirmed that aquatic insects can be very good bio-indicators which is cost effective and reliable. Understanding their response to environmental changes should be of help to the planners or policy makers to put into practice a scientific-based management of water quality.

5. Acknowledgements
Authors are thankful to the Head, Department of Ecology and Environmental Science, Assam University, Silchar, Assam, India for providing laboratory facilities. The first author thanks all the research Scholars of the aquatic biodiversity laboratory for their help during this study.
The authors declare that they have no conflict of interest.

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