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Ecosystem Health of Lake Tamrangabeel, Bongaigaon District, Assam, India with Special Reference to Aquatic Insect Assemblage

R. R. BHAGAWATI and SUSMITA GUPTA*

Department of Ecology and Environmental Science, Assam University, Silchar- 788011, Assam, India.

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ABSTRACT

This study investigated the ecosystem health of a floodplain lake, Tamrangabeel of Bongaigaon district, Assam, India using aquatic insects as bioindicator. The aquatic community of Tamrangabeel was represented by 37 species belonging to 19 families and 5 orders. Shannon –Wiener diversity index (Shannon H') values were recorded less than 1 in all the sites of the lake which indicated perturbed condition of the lake. Order Hemiptera was found to be the largest order with highest number of species. Eudominant species recorded in this lake were *Micronecta siva* (order Hemiptera) and *Cloeon* sp. (order Ephemeroptera). Biological Monitoring Working Party (BMWP) Score, Average Score per taxon (ASPT), and Stream Invertebrate Grade Number-Average Level (SIGNAL) Score reported from the study reflected good ecological potential as well as slightly impacted nature of the water body. The values of different environmental variables of water of all the sites of the lake were found conducive for aquatic life. This study provided an early warning of perturbation of the lake which is to be addressed before it is too late.

Key words: Tamrangabeel, aquatic insect, ecosystem health, biomonitoring score.

INTRODUCTION

Aquatic biodiversity is one of the most essential characteristics of the aquatic ecosystem for maintaining its stability and a means of coping with any environmental change[1,2]. Aquatic insects comprise a taxonomically diverse and ecologically important group of animals. They are also 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, depositor collectors and predators[3]. In recent times they are used as biological tool and also often used to determine the water quality based on type and number of species present, because pollution status of water bodies are expressed in biological and physico-chemical parameters[4]. Data provided by indicator organisms can be used to estimate the degree of environmental impact and its potential dangers for other living organisms[5].

Wetland ecosystems provide many services that contribute to human well-being. Together with energy and nutrients, water is arguably the centrepiece for the delivery of eco-system services to humankind[6] .The Millennium Ecosystem Assessment [7] defines ecosystems as a dynamic complex of plant, animal and microorganism communities and their nonliving environment interacting as a functional unit. The freshwater ecosystem services i.e nature's works free of cost are particularly valuable to the inhabitants who are poor and entirely depend on nature's services directly for their livelihoods.

Percentage of wetland area in India is 18.4% [8] (IUCN, 1989); in Assam it is 9.74% and in Bongaigaon district of Assam it is 2.90 %. [9]. The district is very rich in wetlands (both permanent and seasonal) which are locally known as '*beel*'. Tamrangabeel, a floodplain lake is very rich in fish diversity, density and supports livelihood of

fisherfolk community. Literature review revealed only one study on limnology, fish productivity and fish diversity of Tamrangabeel [10] . No study on the fish food community like plankton and aquatic insects has been carried out till date. Further as a whole studies on aquatic insect community in north eastern region is meager although they are major food for insectivorous fishes and water fowls. In the above back drop this study aimed to investigate the ecosystem health of this important wetland and document the status of diversity and density of aquatic insects. An attempt will also be made to study the use of aquatic insects as bioindicator .

MATERIALS AND METHODS

Tamrangabeel, a floodplain lake latitude 26°19'35'' and longitude 90°34'43'' is situated in the Bongaigaon district of Assam at about 200 km west of the state capital Guwahati and occupies a total area of 160.40 hectare. The lake is surrounded by a number of villages and very much in use for fishery purpose. The source of water of the lake is the excess water of River Brahmaputra. The connecting channel between Tamrangabeel and River Brahmaputra is known as Haripani.

Water samples and insects were collected from four sites (T1, T2, T3 and T4) of Tamranga beel in replicates seasonally viz., winter (December, 2012-February, 2013), pre-monsoon (March-May, 2013), monsoon (June-August, 2013) and post-monsoon (September-November, 2013) for a period of one year. Aquatic insects were collected by kick method whereby the vegetation was disturbed and a circular net (mesh size 60ìm) was dragged around the vegetation for one minute[11,12]. Three such drags constituted a sample. Collected insects were immediately sorted and preserved in 70% ethyl alcohol. They were later identified using a Motic stereozoom microscope using standard keys [13-20] . Diversity indices were worked out by using package of Biodiversity Professional Version 2. Different biotic indices like Biological Monitoring Working Party (BMWP) Score, Average Score Per Taxon (ASPT), Stream Invertebrate Grade Number – Average Level (SIGNAL) were determined using the number and abundance of pollutant sensitive animals [21-24] .

Water temperature (WT), Transparency (Trans) pH, Electrical Conductivity (EC), Dissolved Oxygen (DO), Free CO2 (FCO_2), Total Alkalinity (TA), Nitrate (NO_3) and Phosphate (PO_4) were estimated by standard methods [25,26] .Meteorological data as rainfall (RF) data were obtained from Meteorological Station, Guwahati, Assam.

RESULTS AND DISCUSSION

Macroinvertebrates have served as valuable indicators of degradation of aquatic ecosystems. As there is increasing pressure on our water resources, they should be used for assessing the impact of pollution in aquatic ecosystems[27]. The aquatic community of Tamrangabeel was represented by 37 species belonging to 19 families and 5 orders (Table 1). Similar studies on a lake known as Koyakhujiabeel situated in the same district revealed occurrence of 37 species of aquatic insects [28] .Several studies on aquatic insect diversity in different freshwater systems in North East India such as Loktak Lake, Manipur (Ramsar site); ponds of floodplain wetland of Cachar, Assam; one oxbow lake of south Assam ; another Ramsar site Deeporbeel, Guwahati, Assam; two temple ponds in Silchar, South Assam revealed occurrence of 7 , 8, 9, 31 and 22 species of aquatic insects respectively [29-33]. Compared to all these systems number of aquatic insect species in this lake is remarkable. This study reported 4 genera as new record in India. They are *Trepobates* sp. (family Gerridae), *Plateumaris* sp. (family Chrysomelidae) *Pronoterus* sp (family Noteridae) *Suphisellus* sp. (family Noteridae). Highest number of species was recorded in postmonsoon (Table 1).

During Monsoon along with rainwater branches of trees, leaves, various macrophytes and other debris are deposited in the aquatic systems. During postmonsoon in low water level with the initiation of decomposition process the systems become rich in nutrients and conducive for aquatic insects for both food and shelter. In the present study Hemiptera was found to be the largest order in terms of species richness represented by 16 species and 7 families and highest number of species was recorded from the family Gerridae. In Du river basin in northern Vietnam also Hemiptera was found to be the most diverse order [34] . A study carried out in the

Table 1: Seasonal variations in distribution and dominance status (Engelmann, 1978) of different species of aquatic insect community found in Lake Tamrangabeel

Family	Taxa	Status and RA			
		Winter	Premonsoon	Monsoon	Postmonsoon
Order	*Micronecta siva*(Kirkadly,1897)	Eudominant	Dominant		Recedent (2.13%)
Hemiptera	*Micronecta ludibunda*(Breddin,1905)	(38.01 %)	(25.67%)		
Corixidae	*Micronecta* sp.(Kirkadly,1897)	Subdominant	Subdominant	Recedent	Recedent (1.27%)
		(4.95 %)	(3.37%)	(3.07%)	
	Synaptonecta sp.(Lundblad,1934)	Subrecedent		Recedent	Subrecedent (0.63%)
				(1.53%)	
Gerridae	*Aquarius conformis*(Uhler,1878)	(0.82%)	Dominant	Dominant	Subrecedent (0.42%)
	Gerris sp.(Fabricius, 1794)		(14.18%)	(15.38%)	Subrecedent (0.85%)
	Trepobates sp. (Kittle,1997)	Subdominant	Subdominant		Subdominant (5.33%)
	Limnogonus sp.(Stal,1868)	(4.95 %)	(4.72%)		Subrecedent (0.21%)
	Neogerris sp. (Matsumura, 1913)				Subrecedent (0.85%)
Mesoveliidae	*Mesovelia mulsanti*(White, 1879)		Recedent		Subdominant (4.26%)
Veliidae	*Microvelia* sp.1(Westwood, 1834)		(2.02 %)		Subdominant (3.19%)
	Microvelia sp.2(Westwood, 1834)		Subrecedent		Recedent (2.55%)
Belostomatidae	*Diplonychusrusticus*(Fabricius,1781)		(0.67 %)		Subdominant (3.19%)
Nepidae	*Ranatra sp.*(Fabricius,1790)	Subdominant	Subrecedent	Recedent	Subdominant (3.19%)
		(4.95%)	(0.67%)	(3.07%)	
Pleidae	*Paraplea sp.*(Esaki and China, 1928)	Subrecedent	Subrecedent	Recedent	Subdominant (5.11%)
				(3.07%)	
	Paraplea frontalis(Fieber,1844)	(0.82%)	(0.67%)	Recedent	Recedent (1.27%)
				(1.53%)	
OrderEphemeroptera	*Cloeon sp.*(Leach, 1815)	Eudominant	Dominant	Eudominant	Eudominant (42.64%)
Baetidae		(41.32%)	(25.67%)	(44.61%)	
Caenidae	*Caenis sp.*(Stephens, 1835)			Recedent	Recedent (1.06%)
				(1.53%)	
Order Coleoptera	*Plateumaris* sp.(Thomson,1859)		Dominant	Dominant	Dominant (15.31%)
Chrysomelidae			(12.16%)	(21.53%)	

Table 1. Continue

Dytiscidae	*Laccophilus* sp.(Leach,1817)		Subrecedent (0.67%)		
	Cybister sp.(Curlis, 1827)		Subrecedent (0.67%)		Subrecedent (0.63%)
Gyrinidae	*Dineutus* sp.				
Noteridae	*Pronoterus* sp.(Sharp,1882)	Recedent (1.65%)	Subrecedent (0.67%)		Subrecedent (0.42%)
	Suphisellus sp. (Crotch,1873)	Subrecedent (0.82%)			Subrecedent (0.21%)
	Laccobius sp.(Erichson, 1837)	Subrecedent (0.82%)			Subrecedent (0.42%)
	Berosus sp. (Leach,1817)				Subrecedent (0.21%)
Curculionidae	*Sphenophorus* sp.(Schoenherr,1838)			Recedent (1.53%)	Subrecedent (0.42%)
Order Diptera	*Culex* sp.(Linnaeus,1758)				
Culicidae	*Anopheles* sp. (Meigen)		Subrecedent (0.67%)	Recedent (3.07%)	Subrecedent (0.21%)
Psychodidae	*Psychoda* sp. (Latreille)		Recedent (1.35%)		Subrecedent (0.21%)
Muscidae	*Musca* sp. (Linnaeus)				Subrecedent (0.21%)
OrderOdonata	*Orthetrum sabina* (Drury, 1770)				Subrecedent (0.21%)
Libellulidae	*Rhodothemis lieftincki*(Fraser, 1954)				Subrecedent (0.21%)
	Leucorrhinia sp.(Brittinger,1850)		Subdominant (4.72%)		Subrecedent (0.63%)
Coenagrionidae	*Pseudagrion pruinosum*(Burnmeister,1839)		Subrecedent (0.77%)		Subrecedent (0.42%)
	Pseudagrion australasiae(Selys, 1876)	Subrecedent (0.85%)	Subrecedent (0.876%)		Subrecedent(0.42%)
	Agriocnemis femina(Brauer,1868)				

Relative abundance RAÂ1% = subrecedent; 1.1-3.1% = recedent; 3.2-10 % = subdominant; 10.1-31.6% =dominant and Ã31.7%= eudominant.

River Moirang, Manipur recorded highest relative abundance of order Hemiptera [35] .

According to the Engelmann Scale [36] (1978) eudominant species recorded in this lake were *Micronecta siva* in winter and *Cloeon* sp. in winter and postmonsoon. Eudominance of *Cloeon* sp.was also recorded in one oxbow lake of south Assam[31] and in one floodplain ecosystem of south Assam[37]. The tolerance value play key role in using aquatic insects to monitor water [41] and the tolerance value of *Cloeon sp.* is 4[24] . *Cloeon* sp. belonging to

Table 2: Seasonal variations in diversity indices of aquatic insects in the Lake Tamrangabeel

	Winter				Pre-monsoon				Monsoon				Post-monsoon			
	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4	T1	T2	T3	T4
Shannon H' Logbase 10	0.78	0.48	0.24	0.62	0.76	0.73	0.52	0.71	0.63	0.65	0.24	0.50	0.96	0.57	0.66	1.06
Shannon Hmax	0.85	0.7	0.3	0.9	1.04	0.85	0.70	0.90	0.85	0.70	0.30	0.78	1.20	1.18	1.23	1.30
Evenness J	0.92	0.68	0.81	0.69	0.73	0.86	0.74	0.8	0.75	0.93	0.81	0.65	0.80	0.48	0.54	0.82
Berger-Parker Dominance (d)	0.24	0.54	0.75	0.45	0.30	0.32	0.41	0.37	0.37	0.38	0.75	0.67	0.24	0.70	0.63	0.27
Berger-Parker Dominance (1/d)	4.2	1.87	1.33	2.23	3.29	3.13	2.42	2.71	2.69	2.67	1.33	1.5	4.13	1.43	1.58	3.71

Table 3: Seasonal variations in BMWP and ASPT Scores of different sites of Lake Tamrangabeel

	T1		T2		T3		T4	
BMWP								
Winter, 2012	26	M	19	PM	9	P	21	M
Premonsoon, 2013	26	M	14	P	26	M	32	M
Monsoon,2013	26	M	14	P	9	P	21	M
Postmonsoon,2013	51	G	44	M	34	M	19	M
ASPT								
Winter, 2012	5.2	D	4.75	PMP	4.5	PMP	5.25	D
Premonsoon, 2013	5.2	D	4.67	PMP	5.2	D	5.33	D
Monsoon,2013	4.33	PMP	4.67	PMP	4.5	PMP	5.25	D
Postmonsoon,2013	6.37	C	5.5	D	5.67	D	4.75	PMP

BMWP score: 0-16=Poor water quality, 17-50=Moderate water quality, 51-100=Good water quality; ASPT score: >6= Clean water, 5-6= Doubtful quality, 4-5 = Probable moderate pollution, <4 = Probable severe pollution

Table 4: Seasonal variations in SIGNAL 2 Scores of the different sites of Lake Tamrangabeel

SIGNAL 2 score	T1		T2		T3		T4	
Winter, 2012	3.4	SP	3.27	SP	3.87	SP	3.54	SP
Premonsoon, 2013	2.85	SP	3.36	SP	3.83	SP	3.31	SP
Monsoon,2013	3.2	SP	3.8	SP	4.33	MP	3.4	SP
Postmonsoon,2013	2.94	SP	3.08	SP	3.03	SP	2.68	SP

Signal 2 scores: > 6= healthy habitat, 5-6= mild pollution, 4-5= moderate pollution, < 44. = severe pollution

Table 5 a: Environmental variables of water of Lake Tamrangabeel during Winter and Premonsoon, 2012 (n=3)

Variables	Winter				Premonsoon			
	T1	T2	T3	T4	T1	T2	T3	T4
RF (mm)	0	0	0	0	25.2± 0	25.2±0	25.2±0	25.2±0
DO (mgL^{-1})	13.7±0.86	14.1±0.39	13.44±0.83	13.89±0.49	12.02± 0.19	13.87± 0.24	12.77±0.61	12.10±0.45
FCO_2 (mgL^{-1})	3.14±0.24	3.38±0.00	3.63±0.24	3.79± 0.27	3.01±0.20	3.06±0.22	3.28±0.20	3.50±0.07
TA (mgL)	24.67±1.73	27.44±2.36	29.44± 1.92	26.44± 0.19	27.78±2.31	29.33±0.98	29.22±0.41	27.67±0.81
EC (µSiemens cm^{-1})	41.74±6.27	39.86±9.13	31.46± 0.79	32.35± 1.29	34.85±2.40	37.38±6.35	31.74±0.76	31.74±0.65
pH	6.46±0.15	6.56±0.02	6.66± 0.05	5.61± 0.89	6.03±0.18	5.81±0.37	6.29±0.06	6.33±0.01
WT (°C)	21.83 ± 0.28	21.46 ± 0.45	21.16 ±0.28	21.46 ± 0.45	25.33±0.94	27.33±0.94	28±2.16	29.33±0.94
Trans (cm)	107.33±6.0	116.16±6.25	125± 19.52	105.33± 5.48	110.17±8.99	117.17±17.51	63.5±8.84	79.17±16.76
PO_4(µgL^{-1})	0.048± 0.008	0.064±0.024	0.040± 0.028	0.046±0.005	0.070±0.026	0.122±0.021	0.095±0.005	0.078±0.033
NO_3 (mg L^{-1})	0.016±0.015	0.002±0.004	BDL	0.005±0.004	0.123±0.059	0.062±0.048	0.177±0.044	0.150±0.080

Rainfall (RF) ,Water temperature (WT), Transparency (Trans), Electrical conductivity (EC), Dissolved oxygen (DO), free CO2 (FCO_2) , Total alkalinity (TA), Nitrate (NO_3) and Phosphate (PO_4), BDL= Below detection level

Table 5 b: Environmental variables of water of Lake Tamrangabeel during Monsoon and Postmonsoon, 2012 (n=3)

Variables	Monsoon				Postmonsoon			
	T1	T2	T3	T4	T1	T2	T3	T4
RF (mm)	473.5±0	473.5±0	473.5±0	473.5±0	0	0	0	0
DO (mgL^{-1})	13.48±0.40	12.73±0.85	13.10±1.40	14.78±0.53	9.42±3.39	8.82±2.38	9.15±3.10	10.29±3.32
FCO_2 (mgL^{-1})	4.08±0.42	3.76±0.42	3.54±0.13	4.67±0.26	4.78±0.53	3.87±0.22	4.73±0.67	4.03±0.57
TA (mgL)	66.66±23.09	41.44±0.83	45.22±1.34	41.55±1.54	28±1.08	27.44±4.90	28.44±2.93	28.44±1.49
EC (µSiemens cm^{-1})	53.84±7.85	47.71±1.19	45.63±0.30	46.5±0.31	36.93±2.07	33.6±0.33	32.82±0.53	31.95±0.39
pH	6.90±0.11	7.07±0.03	7.11±0.00	7.12±0.00	6.71±0.27	7.00±0.00	7.01±0.01	6.32±0.96
WT (°C)	32.66±0.47	32±0.81	32.66±0.47	33.33±0.47	25±0	23.67±0.47	25±0	24.33±0.47
Trans (cm)	121.33±74.53	163.66±9.28	148±28.08	135.67±14.81	123±6.37	133.66±11.44	121.33±9.03	136±3.74
PO_4(µgL^{-1})	0.035±0.018	0.040±0.029	0.029±0.026	0.010±0.004	0.032±0.028	0.040±0.014	0.372±0.589	0.027±0.023
NO_3 (mg L^{-1})	0.074±0.032	0.086±0.025	0.105±0.045	0.238±0.002	0.317±0.275	0.144±0.020	0.105±0.018	0.163±0.082

Rainfall (RF) ,Water temperature (WT), Transparency (Trans), Electrical conductivity (EC), Dissolved oxygen (DO), free CO2 (FCO_2) , Total alkalinity (TA), Nitrate (NO_3) and Phosphate (PO_4)

the sensitive order, Ephemeroptera [38], is generally recorded in moderately polluted water [39]. Another eudominant species recorded was *Micronecta siva* only in winter season.

Several biotic indices have been developed to assess water quality in the field[40]. Diversity index can be used to measure environmental stress and high species diversity is an indication of fine distribution of resources among individuals of many species of a community[41] .In the present study the Shannon –Wiener diversity index (Shannon H') values were recorded less than 1 in all the sites of the lake which indicated perturbed condition of the water [42]. (Table 2) The Biological Monitoring Working Party (BMWP) Score was computed by summing the individual scores of all families present in the system. High BMWP score indicates pollution intolerant families, while low scores mean pollution tolerant families[24] .The Average Score per taxon (ASPT) is calculated by dividing the BMWP score by the total number of scoring taxa. In the present study, BMWP ranged from 9 to 51 across the sites and seasons. In most of the sites in most of the seasons water quality was interpreted as probable moderate pollution. Only once in post monsoon water quality was recorded good in site 1. According to ASPT Score also in the same season in the same site water quality was interpreted clean. ASPT Score ranged from 4.33 to 6.47 where except site 1 post monsoon all the scores were either in doubtful or in probable moderate pollution category. (Table 3) Again according to AWBS[43] ,an ASPT score greater or equal to the value of 4.5 indicate a good ecological potential of water body. SIGNAL (Stream Invertebrate Grade Number-Average Level) a scoring system for Macro-invertebrates[23] was used to monitor the impact of disturbance. It is based on the known tolerances of aquatic macro-invertebrate families to various pollutants. Among all the seasons and all the sites, highest SIGNAL score (4.33) was found in T3 in monsoon indicating moderate pollution of water and rest were considered severely polluted [44] (Table 4). However Chessman[23] opined that in wetlands many sensitive groups like Plecoptera, Trichoptera are not found or rarely found. Therefore, wetlands are likely to have naturally lower scores than streams in the same region .

It is very important to study the physic-chemical factors which influence the biological productivity of the water bodies. The ranges of values of different environmental variables of water such as DO (8.82 to 14.11 mgL^{-1}), EC (31.46 to 53.8 $\mu Siemenscm^{-1}$) , pH (5.81 to 7.07), FCO_2(3.01 to 4.78 mgL^{-1}), TA (24.67 to 66.66 mgL^{-1}), PO_4^{3-} (0.01to 0.12µg L^{-1}) and NO_3^- (0.01 to 0.24 mgL^{-1}) of all the sites of Lake Tamrangabeel in different seasons were found conducive for aquatic life (Table 5 a,b).

CONCLUSIONS

This is the first study on the ecosystem health of Lake Tamrangabeel of Bongaigaon district, Assam using aquatic insects as bioindicator. The number, composition and dominance status of aquatic insect species representing the lake; different biotic indices and scores; and the values of environmental variables tells about the ecological potential of the lake located in the Biodiversity hotspot Himalaya. At the same time this study provided an early warning of perturbation of the lake which is to be addressed before it is too late.

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