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Aquatic and semi-aquatic Hemiptera of three oxbow lakes of Cachar District, Assam, N. E India and their role as bioindicator

Anupama Saha, Susmita Gupta

Abstract
Aquatic insects comprise taxonomically diverse and ecologically important and interesting group of animals in fresh water systems. Among them the aquatic and semi-aquatic Hemiptera occupies an important position. Over the Cachar plain the River Barak has an extremely meandering course forming large number of oxbow lakes locally known as *anua.* For the present study Gandhinagar *anua*, Bekirpar *anua* and Shibnarayanpur *anua* were selected from the district. Insects were collected seasonally by standard methods from all the possible substrata during 2012-13. The study recorded 8 families of both infra-orders Nepomorpha and Gerromorpha. Nepomorpha families were higher in number which included Corixidae, Nepidae, Notonectidae, Pleidae and Belostomatidae while family Gerridae, Veliidae and Mesoveliidae were recorded from Gerromorpha. Various biomonitoring scoring indices like $BMWP^{THAI}$, $ASPT^{THAI}$ and NLBI were used to assess the ecosystem health of the oxbow lakes. This study finds that Gandhinagar anua is in relatively better condition, but also requires attention as human activity determines the fate of an ecosystem.

Keywords: Gerromorpha, Nepomorpha, Oxbow lake, Biomonitoring

1. Introduction
The oxbow lakes, locally known as '*anua*' are river formed perennial U-shaped wetlands which are generally formed due to change in river course which may or may not retain connection with the original river. Oxbow lakes are recognized for their importance in the maintenance and integrity of regional biodiversity and as natural nurseries of commercially important species [1]. These areas are colonized by several aquatic and marginal flora and various aquatic and semi aquatic fauna which establish strong connection between aquatic and terrestrial ecosystems. These systems are a transitional form between river and lake ecosystems [2]. It implies that the biotope present is a combination of lotic and lentic features and plays an important role in the primary production, nutrient cycling, and preserves rich wildlife of the area.

These Oxbow lakes are home to a great biodiversity of insect fauna. Among them water bugs belonging to the order Hemiptera, sub order Heteroptera are important members of aquatic ecosystem that comprises two infra-orders – (1) Nepomorpha, are truly aquatic and are primarily found under water and (2) Gerromorpha are semi-aquatic and are found on the water surface or at the water margin. Various water bugs have different air-store replenishment methods depending on the family. They are all air breathers and as such are more tolerant to environmental extremes than most other insects [3]. Most aquatic and semi- aquatic Hemiptera bugs are predatory in nature possessing raptorial fore-legs that helps in grasping their prey and feed on them by piercing their rostrum to inject enzyme first to poison them and then internal digested structures are sucked up. Hemiptera families like Corixidae, Notonectidae, Nepidae, and Belostomatidae are reported as predators of fresh water snails and noteworthy feeding on larvae of mosquitoes [4]. They are also known for minimizing pests in the agricultural fields. Thus aquatic and semi-aquatic Hemiptera play an important role as biological control agents in the ecological community. They are also food for higher trophic levels (birds and fishes) in water [5]. Aquatic and semi aquatic water bugs are very significant as bioindicator species that characterize the habitat health [6, 7, 8]. An aquatic insect as bioindicator for water pollution is less expensive than the evaluation of physical and

chemical parameters used in assessing water quality [9, 10, 11]. Some of these bugs are also designated as threatened and vulnerable species in the Red Data Book of Japan [12].

Cachar district (24⁰20/ N and 25⁰10/ N lat. and 92⁰15/ E and 93⁰15/ E long.) in the Barak Valley region of Assam, is a part of Indo-Burma biodiversity hotspot and is rich in wetlands, ponds and tributaries of the River Barak. The river is characterized by several abandoned meandering loops and formed highest number of oxbow lakes in this district. The river appears to have changed its course at several places through space and time [13] giving rise to wide areas as swampy flood plains and oxbow lakes. In India studies on diversity, distribution and abundance of aquatic and semiaquatic Hemipterans are a few, mostly confined to Peninsular India [14, 15, 16, 17, 18, 19]. In North-East India studies are scanty [7, 20, 21]. Against this backdrop. Objectives of this study are to make an inventory and compare aquatic and semi aquatic Hemiptera community of the three oxbow lakes of Cachar district, and to ascertain their role in biomonitoring the health of the aquatic systems.

2. Materials and methods

2.1 Study area

The present work was conducted in the three oxbow lakes of Cachar district namely Site1: Gandhinagar a*nua* at 24˚38′50″ N and 92˚51′52″ E, Site2: Bakirpar a*nua* at 24˚38′43″ N and 92˚51′37″ E and Site3: Shibnarayanpur a*nua* 24˚52′36″ N and 92˚36′36″ E. Locations of the sites are shown in the map (**Fig 1).** Site1 and Site2 are meanders of River Rukni which is a south-bank tributary of River Barak. Site1 shrinks to a great extent during winter and water level remains less than 2 inches. During monsoon it gets directly connected to River Rukni. The system is used for fish culture, and near the junction of the river and the oxbow basin paddy cultivation is also done. Site 2 does not have any connection with the river. The system is surrounded by human habitation on one side and agricultural plot on the other. The lake water is used extensively for washing, bathing, drinking and in agricultural practices. Fishing and duck farming is also practised. In addition the oxbow receives drainage outlets from the nearby houses. Site 3 is an oxbow lake of River Barak on the north-bank. This system is also surrounded by human habitation and is extensively used for domestic use, fishing and agricultural practices.

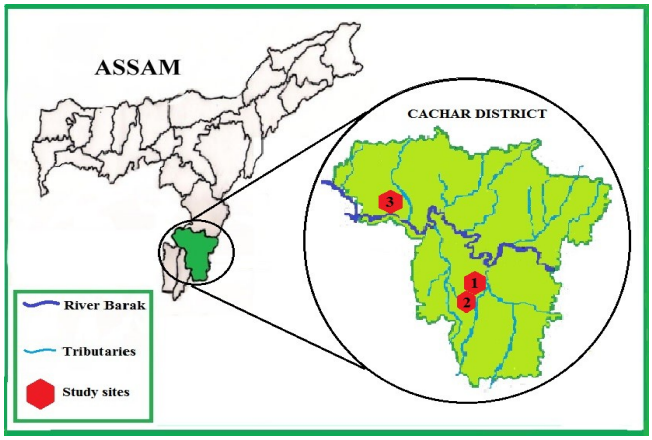

Fig 1: Map of Assam and Cachar district showing three sites (oxbow lakes) and the River Barak (Site1: Gandhinagar *anua*, Site2: Bekirpar *anua* and Site3: Shibnarayanpur *anua*).

2.2 Sampling

Aquatic and *semi aquatic* Hemipterans were collected during 2012-13 during Winter (W) (Dec- Feb.), Pre-monsoon(PRM) (March-May), Monsoon(M) (June-Aug) and Postmonsoon (PSM) (Sep-Nov) seasons in three replicates. No collection was done in site 3 during winter. Samples were collected using a bigger pond net (mesh opening: 500 µm; diameter: 60 cm; depth: 50 cm) with adjustable handle. Samples were preserved in 70% ethanol [22].

2.3 Data analysis

All aquatic and semi aquatic Hemipterans were identified to the lowest potential taxonomic level based on available standard taxonomical keys [23, 24, 25, 26, 27, 28, 29]. Biological Monitoring Working Party ($BMWP^{THAI}$) and Average Score Per Taxon ($ASPT^{THAI}$) score [30] was used to deduce a biotic index of water quality, based on the macro-invertebrates identified. Beside this Nepal Lake Biotic Index (NLBI) [31] was also used to assess the ecosystem health of the aquatic systems. In addition to quantify the diversity of the aquatic and semi aquatic Hemipterans Shannon Diversity index (H′) and Shannon Evenness index (e^H/S), Margaleff index, and Berger-Parker index of dominance were computed using Past software.

3. Results and discussion

This study recorded 8 families of both infra-orders Nepomorpha and Gerromorpha. Nepomorpha families were higher in number which included Corixidae, Nepidae, Notonectidae, Pleidae and Belostomatidae, while three families were recorded from Gerromorpha: Gerridae, Veliidae and Mesoveliidae. During the study period all the eight families were recorded in site1 and site3 and family Belostomatidae was absent in site2.

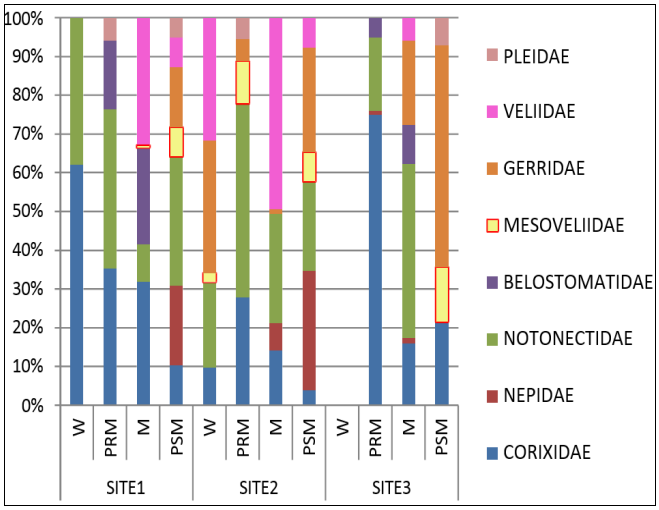

Fig 2: Temporal and spatial variation in relative abundance of aquatic and semi aquatic Hemiptera families.

The family Corixidae was recorded in all the three sites throughout the study period (Fig.2). The number of families, genera and species were recorded highest during postmonsoon season. The highest number of families (7) was recorded in site1, highest number of genera and species (12) were recorded in site2. The lowest number of families (2), genera (2) and species (2) were found in site1 during winter (Fig.3).

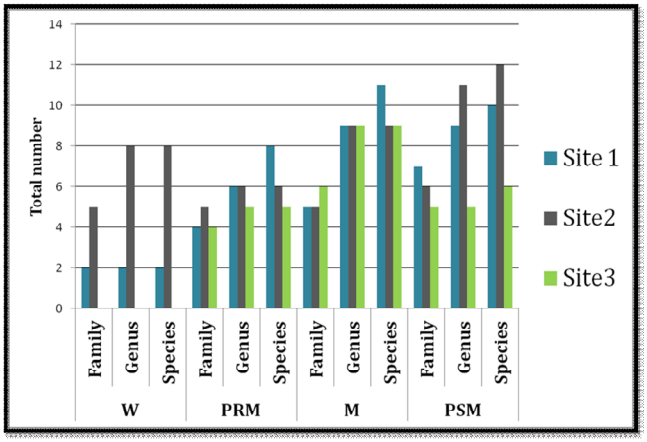

Fig 3: Temporal and spatial variation in number of family, genus and species of Heteropterans in the three oxbow lakes of Cachar District.

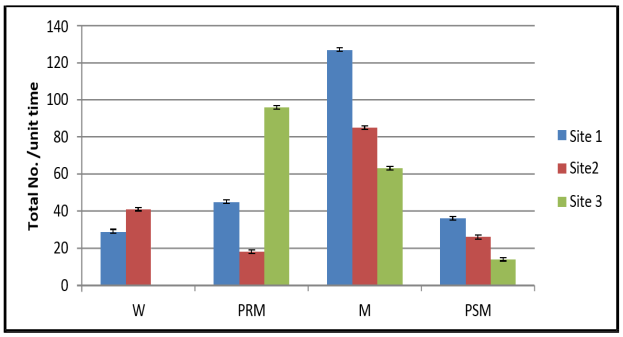

Fig 4: Temporal and spatial variation in the density of Heteropterans in the three oxbow lakes of Cachar District.

The density of the Heteropterans in site1 and site2 was found highest during monsoon and in site3 during premonsoon season (Fig.4). However during winter, density in site2 was found higher than site1 although in premonsoon it dwindled. It could be attributed to the fact that this particular *anua* (Site2) retained sufficient amount of water in winter that invited the bugs of the local dried up systems.With the onset of drizzling rain in premonsoon those Heteropterans might have migrated back to the nearby pools to colonise habitat avoided by stability loving species. Aquatic insects have strong relationship with the water surface fluctuations [32]. Thus in site1 during winter density of these Heteropterans was much less due to decreased water level that rose up exponentially with the drizzling drops of rain in premonsoon and attained peak with the shower of monsoon. The fresh flow of water rejuvenates these bugs to breed in large numbers and thus new generation gets colonised [33]. On the other hand the situation of site3 was different. Here Hemiptera density was lower in monsoon than that of pre-monsoon and was recorded lowest during postmonsoon. The Site3 is the meander of River Barak and connected by a channel to the River. Predation pressure might have played a significant role here because during monsoon fishes from the rivers migrate to the connecting lentic systems for breeding and spawning.

Based on Engelmann's scale (1978) [34] as shown in Table1, *Micronecta scutellaris, Anisops breddini, Aphelonecta* sp., *Diplonychus* sp. and *Trapobates* sp., were found eudominant in the sites.

Shannon-Wiener diversity index (H′) of the three oxbow lakes (Table 2) ranged between 0.663- 2.215 during the study period. In site1, H′ was recorded lowest during winter otherwise the score was always greater than 1. During winter due to very low water level Hemipterans with their capacity of taking small flights might have migrated to the nearby systems where water level is higher with more chance of availability of food. In site2 it ranged between 1.6 – 2.25 throughout the collection period. In site 3 the score recorded less than 1 during premonsoon indicating stressed and degraded habitat structure and was found greater than 1 during monsoon and postmoonsoon season. This improved situation in monsoon and postmonsoon might be attributed to the fresh flow of water from the river which reduced the pollution status of water and increased species richness. According to Wilhm (1970) [35], "H"' usually varies between 3 and 4 in clean-water aquatic systems and is usually less than 1 in polluted one. Margalef's index values indicated moderate polluted condition in all the three sites during monsoon and premonsoon, and during premonsoon in site1 and site2, and during winter in site2. Margalef's index values more than 3 indicate clean condition; values less than 1 indicate severe pollution and intermediate value indicate moderate pollution of water [36]. Margalef's index indicated severely polluted condition of site1 and site3 during winter and premonsoon respectively. Berger-Parker index of dominance was recorded highest in site3 during premonsoon (0.75) followed by site1 during winter (0.62).

Table 1: Temporal and spatial variation of dominance status of aquatic and semi-aquatic Hemiptera of the three oxbow lakes of Cachar District using 'Engelmann's scale(1978): RA <1.0% = Subrecedent (SR);1.1% – 3.1% = Recedent (R);3.2% – 10.0% = Subdominant (SD); 10.1% – 31.6% = Dominant (D); 31.7% – 100% = Eudominant (E)

	SITE1				SITE2				SITE3			
	W	**PRM**	**M**	**PSM**	**W**	**PRM**	**M**	**PSM**	**W**	**PRM**	**M**	**PSM**
Micronecta siva ***(Kirkaldy,1897)***			12.5%(D)									14.2%(D)
Micronecta haliploides ***(Horvath, 1904)***			13.3%(D)				14.1%(D)				17.4%(D	7.1%(SD)
Micronecta sp2				11.11%(D)				3.8%(SD				
Micronecta scutellaris ***(Stål, 1858)***	*62%(E)*	*20%(D)*			9.7%(SD)	27.7%(D)				*75%(E)*		
Micronecta sp1		20%(D)	2.3%(R)									
Ranatra varipes ***(Stal, 1861)***				2.7%(R)				7.6%(SD		1.0%(SR)	1.5%(R)	
Ranatra gracilis ***(Dallas, 1850)***				11.1 %(D)			7.0%(SD)	23%(D)				
*Anisops breddini****(Kirkaldy, 1901)***	37%(E)	26.6%(D)	10.2%(D)					15.3%(D		9.3%(SD)		
Anisops bouvieri		4.4%(SD)										

(Kirkaldy, 1904)												
Nychia Sappho ***(Kirkaldy, 1901)***		6.7%(SD)			21.9%(D)	22.2%(D)	11.7%(D)	3.8% (SD)		9.3%(SD)	17.4% (D)	
Aphelonecta sp.		8.9%(SD)	2.3%(R)	36.1%(E)		27.8%(D)	14.1%(D)					
Walambianisops sp.			6.2%(SD)				2.3%(R)				22.2% (D)	
Enithares mandalayensis ***(Distant, 1910)***								3.8%(SD				
Diplonychus sp.			33.09%(E)							9.	5%(SD)	
Diplonychus rusticus ***(Fabricius, 1781)***		6.7%(SD)	2.36%(R)							5.2%(SD)	1.5%(R)	
Mesovelia mulsanti ***(White, 1879)***			2.36%(R)	8.3%(SD)	2.4%(R)	11.11% (D)		7.6% (SD)				14.2%(D)
Trapobates sp.					19.5%(D)	5.6%(SD)		3.8% (SD)			14.2% (D)	50%(E)
Aquarius conformis ***(Uhler, 1878)***					12.2%(D)		1.1%(R)	3.8% (SD)		9.	5% (SD)	
Gerris adelaidis				5.5%(SD)	2.4%(R)							
Neogerris parvula ***(Stal, 1859)***								19.2% (D)				7.1%(SD)
Limnogonus nitidus ***(Mayr, 1865)***				11.11%(D)								
Microvelia austrina ***(Torre-Bueno)***			2.36%(R)	2.8%(R)	17%(D)		18.8%(D)					
Baptista sp.(***Andersen et al., 2002)***			22.06% (D)	5.6%(SD)	14.6%(D)		20%(D)	3.8% (SD)				
Pseudovelia sp.			6.37% (SD)				10.5%(D)	3.8% (SD)		6.	3% (SD)	
Paraplea liturata ***(Fieber, 1844)***		6.7%(SD)		5.6%(SD)		5.6%(SD)						7.1%(SD)

Table 2: Temporal and spatial variation in diversity indices viz. Shannon diversity, Evenness index, Margalef index and Berger-Parker dominance index values of the study sites.

	W			**PRM**		
	Site1	**Site2**	**Site3**	**Site1**	**Site2**	**Site3**
Shannon_H	0.6637	1.9		1.891	1.611	0.861
Evenness_e^H/S	0.971	0.8354		0.8286	0.8348	0.4731
Margalef	0.297	1.885		1.839	1.73	0.8764
Berger-Parker	0.6207	0.2195		0.2667	0.2778	0.75
	M			PSM		
	Site1	Site2	Site3	Site1	Site2	Site3
Shannon_H	2.07	2.006	1.976	1.988	2.215	1.468
Evenness_e^H/S	0.6603	0.8261	0.8016	0.7302	0.7636	0.7235
Margalef	2.271	1.801	1.931	2.271	1.801	1.931
Berger-Parker	0.2205	0.2	0.2222	0.2205	0.2	0.2222

During the study period of the three *anuas* of the Cachar district (Table 3), the $BMWP^{THAI}$ scores computed by summing the tolerance values of different families of aquatic and semiaquatic Hemiptera indicated good to poor water quality status. During winter, the water quality of the oxbow lakes (Site 1 and Site 2) was found poor which subsequently improved. Water quality was found good in Site1 during monsoon and postmonsoon seasons. Site 2 recorded good $BMWP^{THAI}$ score only during postmonsoon season. Site3 recorded moderately polluted nature throughout the study period. $ASPT^{THAI}$ score was 5 for all the sites in all the seasons, indicating a doubtful water quality of the systems.

Table 3: Temporal and spatial variations in $BMWP^{THAI}$ and $ASPT^{THAI}$ scores and interpretations of three oxbow lakes.

	$BMWP^{THAI}$							
	W		**PRM**		**M**		**PSM**	
Site	Score	Interpretation	Score	Interpretation	Score	Interpretation	Score	Interpretation
1	10	Poor	40	Moderate	55	Good	50	Good
2	10	Poor	30	Moderate	45	Moderate	60	Good
3			25	Moderate	45	Moderate	30	Moderate
	$ASPT^{THAI}$							
	W		PRM		M		PSM	
Site	Score	Interpretation	Score	Interpretation	Score	Interpretation	Score	Interpretation
1	5	Doubtful	5	Doubtful	5	Doubtful	5	Doubtful
2	5	Doubtful	5	Doubtful	5	Doubtful	5	Doubtful
3			5	Doubtful	5	Doubtful	5	Doubtful

Nepal Lake Biotic Index (NLBI), is the score-based method to monitor the quality of lentic water bodies [31]. This index is based on 10 points scoring system. Score values for individual families reflect their pollution tolerance. Pollution intolerant families have high Taxa Tolerance Score (TTS), while pollution tolerant families have low scores. The NLBI scores for Heteropterans can be obtained by summing the individual scores of all families present divided by the total number of scoring taxa. The NLBI value obtained (Table 4), infers the lake water quality class (LWQC) and thus the degree of pollution (DOP) of the aquatic systems can be understood. The NLBI values obtained from the study sites deduced poor water quality in site1 during winter, and in site2 during winter and premonsoon seasons. The water quality was found good only during monsoon season in site1.

Table 4: Temporal and spatial variations in NLBI scores, Lake Water Quality Class (LWQC) and the degree of pollution (DOP) of three oxbow lakes

	SITE1			SITE2			SITE3		
	NLBI	**LWQC**	**DOP**	**NLBI**	**LWQC**	**DOP**	**NLBI**	**LWQC**	**DOP**
W	2.5	POOR	Heavily	2.5	POOR	Heavily			
PRM	4	FAIR	Moderately	3.8	POOR	Heavily	4	FAIR	Moderately
M	5.2	GOOD	Slightly	4.2	FAIR	Moderately	4.66	FAIR	Moderately
PSM	4.66	FAIR	Moderately	4.5	FAIR	Moderately	4	FAIR	Moderately

Relatively low $BMWP^{THAI}$, $ASPT^{THAI}$ and NLBI score in the site 2 and 3 could be attributed to the fact that these two study sites are under anthropogenic stress. They receive a very high amount of domestic wastes and agricultural runoff directly from the local residents and agricultural fields respectively. Further sedimentation could also impute to the low scores as it causes reduction in the depth of the aquatic systems.

4. Conclusion

This study clearly depicted high occurrence of different aquatic and semi aquatic Hemiptera species in the oxbow lakes in different seasons indicating habitat suitability. Their distribution in the three oxbow lakes provided information about the status of the water quality of the lakes and their role as bioindicator. Lack of awareness among the people and improper management of waste disposal have contributed highly to the degradation of the lakes. Site1, Gandhinagar *anua* is relatively in a better condition, but also requires attention as human activity determines the fate of an ecosystem.

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