DOI: 10.54083/ResBio/6.2.2024/52-62

Res. Bio., 2024, 6(2):52-62

Research Biotica

e-ISSN: 2582-6743

April-June, 2024

Article ID: RB184

Research Article

Composition and Diversity of Aquatic Insects of Majuli River Island of Assam

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Open Access

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Conflict of interests: The author has declared that no conflict of interest exists.

How to cite this article?

Borkataki, S., Bhattacharyya, B., Taye, R.R., 2024. Composition and Diversity of Aquatic Insects of Majuli River Island of Assam. *Research Biotica* 6(2), 52-62. DOI: 10.54083/ResBio/6.2.2024/52-62.

Abstract

The composition and diversity of aquatic insect was studied at Majuli river island during 2016-18. The occurrence of 48 species under 6 orders and 20 families was observed during surveys conducted in pre monsoon, monsoon, post-monsoon and winter seasons covering 3 locations, 15 villages and 60 sampling sites. Odonata (47.92%) was the most dominant order with 23 species followed by 9 species of Coleoptera and Hemiptera with 18.75% abundance and Ephemeroptera (3 species, 6.25% abundance). While studying the diversity indices, the highest aquatic insect species were registered in Lower Majuli (29 species) followed by Upper Majuli (24 species) and Central Majuli (17 species). Highest Shannon-Weiner Index (H'=3.156), Simpson Index of Diversity (1-D=0.983) and Evenness (E_H=0.983) were recorded during monsoon season in Upper Majuli, whereas the lowest Shannon-Weiner Index (H'=2.341), Simpson Index of Diversity (1-D=0.913) and Evenness (E_H=0.860) were registered during winter in Central Majuli.

Keywords: Aquatic, Composition, Diversity, Majuli

Introduction

Aquatic insects are generally considered as an excellent model organism in investigating the structure and function of the freshwater ecosystem due to their high abundance, high birth rate with short generation period, large biomass and quick colonization in freshwater environments (Choudhary and Ahi, 2015). Associated with water for most part, these insects can detect any fluctuation in the water quality by showing changes in their population and composition at a particular time and location. They are considered as an integral part of the aquatic ecosystem because of their ecological and economical values. They are considered as a primary tool for studying ecology, growth of population, evolution, genetics and several other areas of biology (Choudhary and Ahi, 2015). Majuli, the largest fresh water mid-river deltaic island provides every possibility of exploring the aquatic insect fauna of the island. However, perusal of literature has shown less number of publications and hence the present study was carried out with a view to assess the composition and diversity of these insects in Majuli.

Materials and Methods

Study Area

Majuli, the largest fresh water mid-river deltaic island in the world, is situated between 26°45' N to 27°12' N latitude and 93°39' E to 94°35' E longitudes. To assess the composition and diversity of aquatic insects, three locations *viz.*, upper, central and lower Majuli were selected. Five different villages were chosen from each location, and four different water bodies were selected from each village for collection of samples during pre-monsoon (March-May), Monsoon (June-August), post-monsoon (September-November) and winter (December-February) of 2016-2017.

Aquatic Insect Collection and Identification

The method of Menke (1979) was followed for sample collection. Aquatic bugs were collected by observing their behaviours. They were dragged through debris, floating vegetations and tangled roots. The aquatic insects that were found clinging to the vegetations were picked manually. Insects inside crevices were flushed out by splashing water on the bank. Aquatic net with a dimension of 30×30 cm frame, 250 µm, 50 cm length was used for sample collection in open areas. Habitat sampling was done during early hours

Article History

RECEIVED on 15th November 2023 RECEIVED in revised form 21st May 2024 ACCEPTED in final form 30th May 2024

of the day (6:00-9:00 AM) as these insects have a tendency to migrate deeper into water during late hours of the day. White trays were used to keep the collected samples. Further, sorting and categorization were done. The samples were preserved in absolute alcohol and thereafter taxonomic treatment was carried out under stereozoom microscope (4X and above) by using standard taxonomic keys (Subramanian and Sivaramakrishnan, 2007). Confirmation was done in consultation with expert taxonomists.

Results and Discussion

Altogether 48 aquatic insect species under 6 orders and 20 families were recorded from Majuli during 2016-2017. The abundance of aquatic insect fauna recorded in Majuli River Island is presented in table 1. Odonata was found to be the most dominant order (47.92%) with the highest numbers of species (23) followed by Coleoptera and Hemiptera (18.75% abundance with 9 species each). Comparatively, only few aquatic insect species were registered under Ephemeroptera (6.25%, 3), Tricoptera (4.17%, 2) and Diptera (4.17%, 2). The present information is in conformity with Takhelmayum *et al*. (2013), who reported that although relative abundance of the order Hemiptera was higher than that of Odonata but the number of species of Odonata was higher than that of the orders Hemiptera and Coleoptera throughout the year in Manipur.

Table 1: Abundance of aquatic insect fauna at order level in Majuli river island of Assam during 2016-17

Order	No. of species	Abundance (%)
Odonata	23	47.92
Coleoptera	9	18.75
Hemiptera	9	18.75
Ephemeroptera	3	6.25
Tricoptera	2	4.17
Diptera	2	4.17
Total	48	

The highest aquatic entomofauna (29 numbers of aquatic insect species) was registered in Lower Majuli under 6 different orders (Odonata, Coleoptera, Hemiptera, Ephemeroptera, Trichoptera and Diptera) and 18 families (Table 2). The dominant orders recorded were Hemiptera and Coleoptera comprising of 9 species each followed by Odonata (4 species) and Ephemeroptera (3 species). The aquatic bugs recorded were *Diplonychus rusticus*, *Diplonychus* sp., *Lethocerus indicus*, *Lethocerus* sp. (Belostomatidae); *Laccotrephes* sp., *Ranatra* sp. (Nepidae); *Gerris* sp. (Gerridae); *Enithares* sp. (Notonectidae) and *Micronecta* sp. (Corixidae). Similarly, 8 species of aquatic beetles *viz*., *Dineutus* sp. (Gyrinidae); *Cybister fimbriolatus*, *Cybister* sp., *Laccophilus* sp., *Hydaticus* sp., *H. musicus* under the family Dysticidae; *Hydrophilus* sp. (Hydrophilidae); and *Pterostichus* sp. (Carabidae) and only one species of weevil *Bagous* sp. (Curculionidae) were recorded. Apart from the above mentioned species, 3 species of Ephemeroptera *viz*., *Caenis* sp. (Caenidae), *Baetis* sp. (Baetidae), *Isonychia* sp. (Isonychiidae); 2 species each of Trichoptera *viz*., *Glossosoma* sp. (Glossosomatidae) and *D. modesta* (Hydropsychidae) and Diptera *viz*., *Simulium* sp. (Simulidae) and *Chironomus* sp. (Chironomidae) were also found in Lower Majuli.

Table 2: Composition of aquatic insect fauna in Lower Majuli

Order	Family	Species
Odonata	Libellulidae	*Brachythemis contaminata*
		Rhyothemis variegata
		Crocothemis servilia servilia
		Orthetrum pruinosum
Coleoptera	Gyrinidae	*Dineutus* sp.
		Cybister fimbriolatus
		Cybister sp.
	Dysticidae	*Laccophilus* sp.
		Hydaticus sp.
		Herophydrus musicus
	Hydrophilidae	*Hydrophilus* sp.
	Curculionidae	*Bagous sp.*
	Carabidae	*Pterostichus* sp.
Hemiptera	Belostomatidae	*Diplonychus rusticus*
		Diplonychus sp.
		Lethocerus indicus
		Lethocerus sp.
	Nepidae	*Laccotrephes* sp.
		Ranatra sp.
	Gerridae	*Gerris* sp.
	Notonectidae	*Enithares* sp.
	Corixidae	*Micronecta* sp.
Ephemeroptera	Caenidae	*Caenis* sp.
	Baetidae	*Baetis* sp.
	Isonychiidae	*Isonychia* sp.
Trichoptera	Glossosomatidae	*Glossosoma* sp.
	Hydropsychidae	*Diplectrona modesta*
Diptera	Simulidae	*Simulium* sp.
	Chironomidae	*Chironomus* sp.

Likewise, a total of 24 aquatic insect species under 3 different orders (Odonata, Hemiptera and Coleoptera) and 7 families were recorded in Upper Majuli (Table 3).

Table 3: Composition of aquatic insect fauna in Upper Majuli

Order	Family	Species
Odonata	Libellulidae	*Urothemis signata*
		Pantala flavescens
		Aethriamanta brevipennis
		Orthetrum sabina
		Orthetrum brunneum
		Brachydiplax chalybea
		Brechmorphoga mendax
		Neurothemis tullia
		Neurothemis fulvia
		Diplacodes nebulosa
		Acisoma panorpoides
	Aeshnidae	*Gynacantha dravida*
	Coenagrionidae	*Ischnura aurora*
		Ischnura elegans
		Ceriagrion coromandelianum
		Ceriagrion calamineum
		Agriocnemis pieris
		Agriocnemis pygmaea
		Aciagrion hisopa
Coleoptera	Gyrinidae	*Dineutus* sp.
		Cybister sp.
Hemiptera	Belostomatidae	*Diplonychus rusticus*
	Nepidae	*Ranatra* sp.
	Gerridae	*Gerris* sp.

Odonata was the most dominant order and comprised of 19 species (*U. signata*, *P. flavescens*, *A. brevipennis*, *O. sabina*, *O. brunneum*, *B. chalybea*, *B. mendax*, *N. tullia*, *N. fulvia*, *D. nebulosa*, *A. panorpoides* under family Libellulidae; *G. dravida* under family Aeshnidae and *I. aurora*, *I. elegans*, *C. coromandelianum*, *C. calamineum*, *A. pieris*, *A. pygmaea*, *A. hisopa* under family Coenagrionidae) followed by Hemiptera with 3 species, *viz*., D. *rusticus* (Belostomatidae), *Ranatra* sp. (Nepidae) and *Gerris* sp. (Gerridae) and Coleoptera with 2 species (*Dineutus* sp. and *Cybister* sp. under the family Gyrinidae).

Comparatively, 17 species under 3 orders *viz*., Odonata, Coleoptera and Hemiptera under 8 families were registered in Central Majuli (Table 4). The dominant order recorded was Hemiptera comprising of 8 species *viz*., *Diplonychus* sp., *D. rusticus*, *Lethocerus* sp., *L. indicus* under family Belostomatidae; *Laccotrephes* sp., *Ranatra* sp. under family Nepidae; *Gerris* sp. (Gerridae) and *Micronecta* sp. (Corixidae) followed by 7 species of Coleoptera *viz*., *Dineutus*

Table 4: Composition of aquatic insect fauna in Central Majuli

Order	Family	Species
Odonata	Libellulidae	*Rhyothemis variegata*
		Crocothemis servilia servilia
Coleoptera	Gyrinidae	*Dineutus* sp.
		Cybister fimbriolatus
		Cybister sp.
	Dysticidae	*Laccophilus* sp.
		Hydaticus sp.
		Herophydrus musicus
	Hydrophilidae	*Hydrophilus* sp.
Hemiptera	Belostomatidae	*Diplonychus rusticus*
		Diplonychus sp.
		Lethocerus indicus
		Lethocerus sp.
	Nepidae	*Laccotrephes* sp.
		Ranatra sp.
	Gerridae	*Gerris* sp.
	Corixidae	*Micronecta* sp.

sp. (Gyrinidae); *Cybister* sp., *C. fimbriolatus, Laccophilus* sp., *Hydaticus* sp., *H. musicus* under Dysticidae and *Hydrophilus* sp. (Hydrophilidae) and 2 species of Odonata namely *R. variegata* and *C. servilia servilia* under family Libellulidae.

The present experimental findings exhibited a similar trend of abundance indicating highest mean abundance of aquatic insect fauna in monsoon whereas lowest was observed during winter season in all the selected villages of Upper, Lower and Central Majuli.

Location wise relative abundance of aquatic insects covering 15 villages is presented in the tables 5, 6 and 7. In Lower Majuli, the dominant [RA(%) = 10.1-31.6] species recorded were *Ranatra* sp. (15.49%), *Gerris* sp. (11.78%) under Hemiptera and *Dineutus* sp. (Coleoptera) (10.11%) in monsoon and *Ranatra* sp. (Hemiptera) (12.68%, 10.32%) in post monsoon and pre-monsoon in Mohorichuk village; *Dineutus* sp. (Coleoptera) (12.93%), *Ranatra* sp. (11.22%) and *Diplonychus* sp. (10.21%) under Hemiptera during monsoon and *Dineutus* sp. (Coleoptera) (10.64%) and *Ranatra* sp. (10.16%) in post monsoon in Podumoni village; *Dineutus* sp. (Coleoptera) (10.44%) in Bebezia village; *D. rusticus* (16.43%), *Ranatra* sp. (10.53%) and *Diplonychus* sp. (10.33%) under Hemiptera during monsoon and *D. rusticus* (10.81%) and *Ranatra* sp. (10.31%) in post monsoon in Kordoiguri village and *C. fimbriolatus* (11.06%) (Coleoptera) followed by *D. rusticus* (Hemiptera) (10.29%) and *Dineutus* sp. (Coleoptera) (10.15%) in monsoon and *C. fimbriolatus* (10.70 and 10.45%) (Coleoptera) in post monsoon and pre-monsoon in Kulichapori village of Lower Majuli (Table 5). Likewise in case of Upper Majuli, the dominant [RA(%) =

10.1-31.6] species recorded were *Dineutus* sp. (Coleoptera) (13.05%), *D. rusticus* (Hemiptera) (11.84%) and *A. pieris* (Odonata) (10.29%) during monsoon and *Dineutus* sp. (12.97%) and *D. rusticus* (10.60%) during post monsoon in Jengraimukh village of Upper Majuli (Table 6). The relative abundance of other species was found in the range between recedent [RA(%) = 1.1-3.1] and subdominant [RA(%) = 3.2-10.0] (Table 6).

Similarly, in Central Majuli, the dominant [RA(%) = 10.1-31.6] species registered during present investigation were *Diplonychus* sp. (Hemiptera) (12.98%), *C. fimbriolatus* (12.85%) and *Dineutus* sp. (10.93%) under Coleoptera during monsoon in Mohkina village; *Dineutus* sp. (Coleoptera) (11.64%), *Ranatra* sp. (Hemiptera) (11.32%) and *C. fimbriolatus* (Coleoptera) (10.32%) during monsoon and *Ranatra* sp. (Hemiptera) (10.69%) during pre-monsoon in

Table 5: Relative abundance (%) of aquatic insects in Lower Majuli

Taxa	Mohorichuk				Podumoni				Bebezia			
	PrM	M	PoM	W	PrM	M	PoM	W	PrM	M	PoM	W
Odonata												
B.contaminata	0.83	1.68	1.31	0.66	1.37	2.13	1.68	1.11	1.47	1.93	1.63	1.08
R.variegata	1.54	3.37	1.71	0.91	2.98	3.83	3.24	2.61	3.33	5.31	4.89	3.17
C. servilia servilia	2.12	3.03	2.44	2.00	1.53	2.55	1.65	1.08	1.64	2.42	1.74	1.23
O. pruinosum	1.24	2.02	1.42	0.75	0.61	1.00	0.85	0.25	1.07	1.97	1.24	0.94
Coleoptera												
Dineutus sp.	9.49	10.11	9.94	9.09	10.00	12.93	10.64	8.09	9.89	10.44	10.00	5.80
C. fimbriolatus	7.29	8.36	8.00	6.82	7.11	7.69	7.23	5.53	7.42	9.18	8.23	7.13
Cybister sp.	6.63	8.53	7.12	4.38	6.36	7.82	7.07	5.96	6.29	7.12	6.48	3.86
Laccophilus sp.	4.21	4.94	4.66	3.37	3.83	5.08	4.77	3.00	4.61	4.94	4.78	3.86
Hydaticus sp.	1.01	1.48	1.22	0.75	1.10	2.55	1.53	1.02	1.01	3.86	2.18	0.80
H. musicus	0.50	1.19	0.90	0.00	0.74	1.59	1.24	1.00	0.94	1.52	1.38	0.17
Hydrophilus sp.	3.03	3.70	3.42	2.90	2.52	3.83	2.88	2.65	2.63	3.15	3.05	1.94
Bagous sp.	0.38	0.68	0.51	0.14	0.68	0.94	0.71	0.43	0.84	1.24	1.13	0.00
Pterostichus sp.	0.50	0.85	0.67	0.35	0.43	3.40	1.68	0.85	0.58	0.79	0.63	0.00
Hemiptera												
D. rusticus	7.62	9.53	9.09	6.75	7.96	9.44	8.01	7.00	7.98	9.28	8.93	6.49
Diplonychus sp.	7.13	8.65	7.73	6.41	8.32	10.21	8.85	7.68	7.25	9.15	8.37	6.81
L. indicus	6.22	8.42	6.79	5.69	6.31	8.09	6.31	5.66	5.62	6.76	5.81	5.09
Lethocerus sp.	3.52	3.98	3.75	2.41	3.83	4.71	4.42	3.12	4.78	5.23	5.09	1.93
Laccotrephes sp.	1.35	2.05	1.99	1.08	1.70	2.83	2.54	0.68	3.26	6.28	3.71	2.65
Ranatra sp.	10.32	15.49	12.68	9.84	9.55	11.22	10.16	8.36	8.21	9.73	9.10	7.37
Gerris sp.	7.50	11.78	8.70	7.05	7.69	8.93	8.09	7.07	5.46	6.67	6.41	4.35
Enithares sp.	1.00	1.19	1.08	0.87	0.94	2.13	1.00	0.53	0.87	1.24	1.01	0.00
Micronecta sp.	2.37	2.79	2.49	1.68	2.98	3.43	3.18	2.05	1.77	3.26	2.61	0.48
Ephemeroptera												
Caenis sp.	0.31	0.91	0.77	0.00	0.60	0.94	0.82	0.00	0.53	1.12	0.88	0.00
Baetis sp.	0.42	0.75	0.61	0.00	0.26	0.65	0.55	0.00	0.31	0.84	0.69	0.00
Isonychia sp.	0.27	0.68	0.51	0.00	0.31	0.59	0.48	0.00	0.65	1.01	0.82	0.00
Trichoptera												
Glossosoma sp.	0.50	0.80	0.71	0.00	0.43	0.94	0.62	0.00	0.36	0.67	0.50	1.45
D. modesta	0.41	0.97	0.63	0.00	0.17	0.82	0.51	0.00	0.25	0.79	0.61	0.00
Diptera												
Simulium sp.	1.98	2.18	2.07	1.01	0.67	1.24	0.82	0.05	0.36	0.90	0.54	0.00
Chironomus sp.	1.26	1.68	1.41	0.34	0.54	0.94	0.89	0.24	0.22	0.56	0.32	0.00

Table 5: Continue...

Taxa	Kordoiguri				Kulichapori			
	PrM	M	PoM	W	PrM	M	PoM	W
Odonata								
B.contaminata	0.84	2.82	1.22	0.64	1.45	1.89	1.65	0.51
R.variegata	1.36	4.57	1.51	1.15	2.23	3.55	3.02	1.94
C. servilia servilia	2.00	3.29	2.32	1.43	1.22	2.03	1.38	0.87
O. pruinosum	0.84	1.94	1.04	0.24	1.36	3.01	2.83	0.00
Coleoptera								
Dineutus sp.	8.10	10.03	9.68	6.10	9.00	10.15	9.63	8.36
C. fimbriolatus	7.34	9.31	8.84	5.16	10.45	11.06	10.70	8.12
Cybister sp.	6.95	7.45	7.23	2.82	6.05	6.61	6.25	5.08
Laccophilus sp.	5.94	7.80	6.78	4.75	5.79	8.63	6.11	5.00
Hydaticus sp.	1.00	1.39	1.17	0.94	1.69	2.01	1.87	1.02
H. musicus	1.12	1.33	1.25	0.47	1.25	1.83	1.44	0.00
Hydrophilus sp.	3.42	5.16	4.42	3.05	5.89	6.11	6.09	5.03
Bagous sp.	0.40	1.50	0.93	0.00	0.30	0.57	0.43	0.00
Pterostichus sp.	0.55	1.04	0.93	0.00	0.48	0.63	0.57	0.00
Hemiptera								
D. rusticus	8.33	16.43	10.81	7.88	8.27	10.29	9.60	7.00
Diplonychus sp.	8.59	10.33	9.31	8.17	7.61	8.63	8.00	7.17
L. indicus	5.16	6.20	6.03	4.56	7.36	8.54	7.97	6.61
Lethocerus sp.	4.00	4.49	4.35	3.37	3.45	4.57	3.78	2.47
Laccotrephes sp.	1.79	2.20	2.13	0.94	0.73	1.13	0.93	0.51
Ranatra sp.	9.73	10.53	10.31	6.10	7.99	8.72	8.33	6.09
Gerris sp.	6.89	7.38	7.10	3.76	8.68	9.93	9.34	7.11
Enithares sp.	1.07	1.45	1.23	0.00	0.43	0.76	0.32	0.00
Micronecta sp.	2.29	2.61	2.42	0.00	0.36	0.57	0.24	0.00
Ephemeroptera								
Caenis sp.	0.94	1.16	1.03	0.79	0.73	1.15	1.07	0.00
Baetis sp.	0.64	1.41	0.98	0.20	0.22	0.50	0.43	0.00
Isonychia sp.	0.71	1.88	1.27	0.35	0.24	0.57	0.36	0.07
Trichoptera								
Glossosoma sp.	0.23	0.68	0.39	0.07	0.34	0.63	0.57	0.11
D. modesta	0.43	0.81	0.65	0.00	0.23	0.56	0.32	0.00
Diptera								
Simulium sp.	1.36	2.35	1.91	0.71	0.41	0.63	0.50	0.00
Chironomus sp.	0.94	1.16	1.03	0.39	0.00	0.38	0.07	0.00

[NB: RA(%)<1 = Subrecedent; 1.1-3.1 = Recedent; 3.2-10 = Subdominant; 10.1-31.6 = Dominant; and >31.7 = Eudominant]

Pohadia village; *Dineutus* sp. (Coleoptera) (11.40%) and *Ranatra* sp. (Hemiptera) (10.57%) in Juginidhari village; *L. indicus* (Hemiptera) (10.31%) in Doriagaon village; *C. fimbriolatus* (Coleoptera) (13.06%) and *D. rusticus* (Hemiptera) (11.43%) in Borbari village during monsoon in Central Majuli (Table 7). The relative abundance of other aquatic insect species was in the range between subrecedent [RA(%) ≤ 1.0] and dominant [RA(%) = 10.1-31.6] (Table 7).

The above information clearly reflects that there was location wise variation in total species composition of aquatic insect fauna. The probable reasons of getting more numbers of species in Lower Majuli (29) and Upper Majuli (24) than Central Majuli (17) might be due to the fact that the areas surveyed in both Lower and Upper Majuli were covered with more numbers of lotic aquatic systems with abundant vegetation. Moreover, the Central Majuli location was found

Table 6: Relative abundance (%) of aquatic insects in Upper Majuli

Taxa	Jengraimukh				Kumarbari				Koliagaon			
	PrM	M	PoM	W	PrM	M	PoM	W	PrM	M	PoM	W
Odonata												
U. signata	2.97	3.43	3.25	2.23	2.62	4.83	2.88	1.67	3.76	4.85	4.15	2.90
P. flavescens	4.98	6.00	5.16	3.35	4.20	5.15	4.58	2.73	4.35	5.78	5.53	4.08
A. brevipennis	4.12	4.65	4.40	2.41	4.75	7.13	5.78	2.96	3.47	4.74	4.25	3.13
O. sabina	3.76	4.32	4.19	3.32	4.25	5.31	4.96	3.83	4.83	6.46	5.68	3.45
O. brunneum	3.26	5.95	4.20	2.95	3.33	4.20	3.49	2.88	4.56	5.78	5.67	3.70
B. chalybea	4.04	5.20	4.46	3.54	3.95	4.47	4.20	3.52	4.85	5.80	5.44	4.08
B. mendax	4.29	4.87	4.60	3.72	4.58	5.16	5.03	4.12	4.08	4.39	4.23	3.82
N. tullia	1.03	1.86	1.38	0.72	3.82	4.96	4.25	3.01	2.79	5.96	3.67	2.17
N. fulvia	0.86	1.49	1.21	0.51	2.69	5.73	3.38	2.43	3.13	5.02	4.22	2.79
D. nebulosa	1.27	1.43	1.39	1.00	3.57	4.47	3.82	2.88	4.08	4.61	4.45	3.88
A. panorpoides	5.48	6.52	6.00	4.98	4.96	5.45	5.16	4.20	4.08	5.14	4.85	3.13
G. dravida	1.54	2.97	1.53	1.55	2.29	3.15	3.03	1.98	2.51	3.02	2.72	2.11
I. aurora	2.40	2.10	2.23	2.60	5.92	3.49	4.80	5.73	2.79	3.51	3.03	2.43
I. elegans	1.54	1.88	1.67	1.49	2.84	5.34	3.64	2.46	3.43	3.82	3.76	2.99
C. coromandelianum	1.37	1.66	1.53	2.60	2.69	4.96	3.73	2.28	3.26	4.70	4.54	3.03
C. calamineum	3.09	3.32	3.91	4.83	3.57	5.73	3.82	1.52	2.50	5.64	4.35	2.37
A. pieris	5.49	10.29	7.16	2.86	5.73	6.37	6.18	4.91	3.30	5.44	4.70	1.71
A. pygmaea	1.03	2.11	1.49	0.63	3.49	4.10	3.60	3.14	3.81	4.74	4.54	2.82
A. hisopa	0.61	1.12	0.86	0.17	2.67	3.65	3.38	2.21	2.99	5.02	4.69	1.71
Coleoptera												
Dineutus sp.	10.01	13.05	12.97	5.58	4.37	6.42	4.80	3.05	4.44	5.54	5.14	3.76
Cybister sp.	6.97	8.40	7.81	5.42	4.47	5.47	5.31	3.44	4.61	5.96	5.31	4.14
Hemiptera												
D. rusticus	9.73	11.84	10.60	6.32	4.86	5.31	5.02	2.29	5.33	6.19	5.92	4.02
Ranatra sp.	4.54	8.55	5.16	3.97	4.69	6.02	5.61	3.82	4.23	4.83	4.61	3.45
Gerris sp.	6.14	9.26	7.03	4.00	4.47	5.55	5.23	2.67	4.17	5.01	4.42	2.98

Table 6: Continue...

Taxa	Karkichuk				Raidongia			
	PrM	M	PoM	W	PrM	M	PoM	W
Odonata								
U. signata	4.17	4.59	4.22	2.83	3.25	3.85	3.62	1.33
P. flavescens	3.72	4.40	3.83	3.14	3.60	4.52	3.94	2.43
A. brevipennis	4.96	5.30	5.12	4.25	4.71	5.10	4.92	1.77
O. sabina	4.62	5.34	4.96	4.05	3.25	3.85	3.67	1.99
O. brunneum	4.51	5.75	5.24	3.67	3.04	3.94	3.31	2.21
B. chalybea	4.17	6.07	4.87	3.98	3.83	4.34	4.20	2.76
B. mendax	4.49	5.67	4.62	3.94	3.49	4.29	3.67	2.65
N. tullia	4.40	5.67	4.78	4.01	2.09	3.17	2.86	1.77
N. fulvia	4.43	5.22	4.74	3.45	4.87	5.57	4.92	2.21
D. nebulosa	3.29	4.28	3.75	2.05	3.49	3.94	3.71	2.88
A. panorpoides	2.90	3.64	3.04	2.65	2.78	3.08	2.86	2.23

Table 6: Continue...

Taxa	Karkichuk				Raidongia			
	PrM	M	PoM	W	PrM	M	PoM	W
G. dravida	2.71	3.28	3.08	2.23	2.17	2.68	2.50	2.05
I. aurora	2.82	3.24	3.18	2.04	3.90	4.52	4.03	2.37
I. elegans	2.83	3.72	3.56	2.43	3.50	4.14	3.76	2.30
C. coromandelianum	2.83	5.07	4.15	2.15	3.54	4.30	3.94	3.08
C. calamineum	4.02	4.86	4.62	3.65	3.63	4.18	3.85	2.75
A. pieris	3.84	4.94	4.45	2.61	5.19	5.57	5.36	4.19
A. pygmaea	3.00	4.79	3.64	2.93	4.64	5.53	5.32	4.00
A. hisopa	4.00	4.86	4.43	3.61	4.04	4.41	4.21	3.54
Coleoptera								
Dineutus sp.	4.49	5.67	5.34	4.00	5.28	5.53	5.46	4.42
Cybister sp.	4.00	4.94	4.32	3.05	4.36	4.95	4.73	3.64
Hemiptera								
D. rusticus	4.06	4.96	4.55	3.24	4.99	5.37	5.04	4.59
Ranatra sp.	3.61	4.56	3.85	2.86	5.00	5.92	5.28	4.35
Gerris sp.	3.49	4.01	3.84	3.24	3.74	4.42	4.29	3.45

[NB: RA(%)<1 = Subrecedent; 1.1-3.1 = Recedent; 3.2-10 = Subdominant; 10.1-31.6 = Dominant; and >31.7 = Eudominant]

to be densely populated by humans as compared to Lower and Upper Majuli areas. It is obvious that anthropogenic activities, directly or indirectly, are responsible for causing perturbations and changes in aquatic biodiversity particularly through fishing, boating, bathing, disposal of wastes and also exploration of some aquatic weeds like water hyacinth, bush morning glory, *etc.* as mulching materials.

The findings are in conformity with the results of Wahizatul

Table 7: Relative abundance (%) of aquatic insects in Central Majuli

Taxa	Mohkina				Pohadia				Juginidhari			
	PrM	M	PoM	W	PrM	M	PoM	W	PrM	M	PoM	W
Odonata												
R. variegata	3.61	4.27	3.82	3.45	4.56	7.16	6.69	2.96	3.26	5.80	3.57	2.73
C. servilia	4.45	5.54	4.85	3.93	1.95	2.89	2.19	1.79	3.97	6.21	4.93	2.88
Coleoptera												
Dineutus sp.	9.68	10.93	9.88	8.37	5.64	11.64	7.45	5.11	8.34	11.40	9.66	8.00
C. fimbriolatus	6.58	12.85	7.68	4.43	8.79	10.32	9.93	7.46	6.44	7.48	6.87	5.31
Cybister sp.	5.89	7.60	6.99	2.46	6.00	7.19	6.41	5.37	8.55	9.55	9.62	6.28
Laccophilus sp.	6.70	9.69	9.14	6.40	4.31	5.67	4.60	3.28	6.29	8.21	7.50	4.87
Hydaticus sp.	2.24	2.53	2.46	1.50	1.18	2.39	1.67	0.89	1.93	2.23	2.00	0.83
H. musicus	0.78	1.97	1.15	0.42	8.63	9.75	9.48	6.27	1.45	2.65	1.74	0.95
Hydrophilus sp.	8.06	9.58	8.57	5.42	6.77	9.31	7.39	6.04	6.67	9.38	7.23	6.00
Hemiptera												
D. rusticus	8.01	9.36	8.20	6.84	7.24	9.90	8.27	6.57	8.42	9.59	8.81	4.04
Diplonychus sp.	7.85	12.98	8.76	6.90	7.36	8.66	7.60	6.04	6.41	9.25	8.34	6.00
L. indicus	5.91	9.12	7.07	3.17	5.84	7.67	7.43	2.69	6.97	9.98	8.42	5.80
Lethocerus sp.	3.53	6.40	4.94	1.96	3.82	5.97	4.20	3.00	2.02	3.94	3.25	0.97
Laccotrephes sp.	1.96	2.96	2.15	1.66	1.00	1.90	1.49	0.59	0.97	2.90	1.65	0.12
Ranatra sp.	7.85	8.57	8.29	5.42	10.00	11.32	10.69	9.55	8.64	10.57	9.43	7.25
Gerris sp.	8.28	9.36	8.79	7.53	8.11	9.55	8.52	7.28	8.00	9.66	8.24	7.51
Micronecta sp.	0.69	2.96	1.75	0.36	0.90	1.49	1.10	0.36	0.83	1.93	0.73	0.21

Table 7: Continue...

Taxa	Doriagaon				Borbari			
	PrM	M	PoM	W	PrM	M	PoM	W
Odonata								
R. variegata	3.50	4.49	3.88	3.04	2.07	3.53	2.35	1.91
C. servilia	2.28	3.31	2.49	1.99	2.65	5.71	3.44	1.57
Coleoptera								
Dineutus sp.	8.60	9.97	9.32	5.06	7.17	11.43	9.49	6.88
C. fimbriolatus	7.89	8.35	8.00	7.46	8.71	13.06	9.58	7.51
Cybister sp.	7.30	9.22	7.94	5.57	7.75	9.06	8.95	6.94
Laccophilus sp.	4.03	4.68	4.40	3.41	3.77	4.27	4.00	2.04
Hydaticus sp.	2.08	3.29	2.43	1.74	2.00	2.45	2.33	1.57
H. musicus	4.56	6.37	5.52	4.05	7.75	8.64	8.00	3.63
Hydrophilus sp.	5.32	9.47	7.41	2.53	6.97	8.89	8.23	4.08
Hemiptera								
D. rusticus	6.42	9.63	7.05	6.58	8.89	11.50	9.06	7.43
Diplonychus sp.	5.82	9.60	8.70	4.82	8.36	10.16	9.67	8.12
L. indicus	7.06	10.31	9.74	4.56	7.39	8.69	8.18	3.67
Lethocerus sp.	3.40	5.02	4.80	1.25	3.71	4.29	4.00	3.08
Laccotrephes sp.	2.17	3.54	2.61	1.80	2.21	4.90	2.64	1.92
Ranatra sp.	6.00	9.05	6.94	4.81	8.09	10.37	8.58	4.49
Gerris sp.	7.72	8.55	8.12	5.06	5.00	6.12	5.27	4.83
Micronecta sp.	0.61	1.27	0.88	0.35	0.40	1.23	0.77	0.22

[NB: RA(%)<1 = Subrecedent; 1.1-3.1 = Recedent; 3.2-10 = Subdominant; 10.1-31.6 = Dominant; and >31.7 = Eudominant]

et al. (2011), who reported that there was a significant difference in species composition, between the upstream and downstream stations in Sungai Peres and Sungai Bubu streams of Hulu Terengganu, Malaysia. The individual species was more at upstream stations due to domination of rivers with relatively clean environment than downstream stations (conversely, polluted streams, caused by various anthropogenic activities, with fewer numbers of invertebrate taxa) in both the streams. Fadilah *et al*. (2017) carried out a similar kind of study which revealed the occurrence of 30 species representing 16 families under 5 orders. Occurrence of same species under the order Odonata was also observed by Kalita and Ray (2015) in Deepor *beel* Bird Sanctuary, Kamrup, Assam and they reported a total of 39 species. Choudhury and Gupta (2015) reported *D. rusticus*, *R. longipes longipes*, *R. varipes*, *Gerris* sp. under Hemiptera and *Dineutus* sp. and *Laccophilus* sp. under Coleoptera from Deepor *beel*. In a similar study, the occurrence of *Dineutus* sp., *Laccophilus* sp., *H. triangularis*, *L. indicus*, *D. rusticus*, *G. lacustris*, *R. elongate* and *R. varipea* was reported by Majumder *et al*. (2013) from Tripura. The results also corroborated with Sharma and Chowdhary (2011), who reported 2 species of Ephemeroptera *viz*., *Caenis* sp. and *Baetis* sp. from Tawi, a Central Himalayan river in Jammu and Kashmir. Subramanian and Sivaramakrishnan (2007) registered *Glossosoma* sp. (Glossosomatidae) in Western Ghats and Suhaila *et al*. (2014) reported *Diplectrona* sp. (Hydropsychidae) from Malaysia. Balachandran *et al*. (2012) reported all 3 Ephemeropterans (*Caenis* sp., *Baetis* sp. and *Isonychia* sp.) from Aghanashini river of Central Western Ghats. *Chironomus* sp. under the family Chironomidae of the order Diptera was registered by Majumder *et al*. (2013) in urban fresh water lakes of Tripura.

Experimental findings on season wise composition and abundance of aquatic insect fauna of Majuli are in conformity with Jenila and Nair (2013), who observed that the population of aquatic insects was high in June due to onset of South West monsoon followed by November due to heavy rainfall in a permanent pond of Kanyakumari district. Similarly, Takhelmayum *et al*. (2013) recorded higher density of aquatic insects in June and distinct variation in the density was observed in dry and wet months in Manipur. Payakka and Prommi (2014) also recorded lower individuals in dry season and increase in number during June that remained high up to July. The abundance was higher during rains and decreased during dry period. Lowest population was also observed during December by Jana *et al*. (2009).

The present findings on relative abundance are in close proximity with the results of Oku *et al*. (2014), who reported higher abundance of Odonata and Hemiptera followed by Coleoptera in wet season as compared to dry season. A similar type of study carried out by Jana *et al*. (2009), revealed that Odonata was the most common group quantitatively followed by Hemiptera and Coleoptera respectively. Che Salmah *et al*. (2005) also found that riverine

ecosystem has the richest fauna of Odonata as compared to agricultural fields, streams, freshwater and peat swamps. Harun *et al*. (2015) reported that Hemiptera as one of the dominant order during monsoon season and was found in all sampling locations. In a similar kind of study, Takhelmayum *et al*. (2013) also observed domination of *D. rusticus* by 65-80% in the wet season in Manipur. Also, the findings of the present investigation are in agreement with Barman and Gupta (2015), who registered *Dineutus* sp. as one of the most abundant species during monsoon and pre-monsoon in Bakuamari stream, Chakras Hila Wildlife Sanctuary, Assam. Khan and Ghosh (2001) in West Bengal found Coleoptera to be the most common order quantitatively. A similar study was carried out by Sharma and Agrawal (2012) in which the result of dominance of all studied insect species revealed that *Dineutus spinosus* (Coleoptera) had maximum value of dominance followed by *Cybister confuses* in Surha Tal district-Ballia, Uttar Pradesh. Majumder *et al*. (2013) stated that the overall species abundance and richness revealed insects of the order Hemiptera were the most dominant and that of Coleoptera was the least dominant in the urban freshwater lakes of Tripura. Jana *et al*. (2009) registered *Ranatra filiformes* as dominant species followed by *Diplonychus rusticus* in a pond in Midnapore town, West Bengal. Vasantkumar and Roopa (2014) also observed aquatic insects belonging to orders Hemiptera and Coleoptera to be the most common as compared to species belonging to other orders in Karwar.

Results pertinent to the dominance status of aquatic insect fauna corroborate with the findings of Jana *et al*. (2009), who described the dominance status of various species on the basis of relative abundance and most of the species were ranged between subrecedent [RA(%) ≤ 1.0] and subdominant [RA(%) = 3.2-10.0] in a pond of Midnapore town, West Bengal. Sarma and Boruah (2013) also observed that the relative abundance of aquatic insects in Bahini river of Guwahati was ranged between subrecedent [RA(%) ≤ 1.0] and dominant [RA(%) = 10.1-31.6].

The present diversity analyses showed higher species diversity in all the three locations, *viz.*, Upper, Central and Lower Majuli which indicated finely distributed individuals of different species (Table 8). During the period of present investigation, the values of Shannon-Wiener Index (2.5-3.2), Simpson Index of Diversity (0.91-0.95) and Evenness (0.86-0.98) in all the three locations of Majuli were found within proper range (Table 8). The results are supported by the findings of Turkmen and Kazanci (2010), who also recorded that the values of Shannon-Wiener Index (1.50-3.50), Simpson Diversity Index (0.66-0.94) and Evenness (0.52-0.80) were within a proper range.

Table 8: Diversity indices for aquatic insects in sampling locations of Majuli during 2016-17

Location	Season	Taxa	Shannon-Wiener Index (H')	Simpson Index of Diversity (1-D)	Evenness (E_H)
Upper Majuli	Pre-monsoon	24	3.132	0.947	0.951
	Monsoon		3.156	0.955	0.983
	Post Monsoon		3.149	0.951	0.980
	Winter		3.120	0.942	0.911
Central Majuli	Pre-monsoon	17	2.669	0.924	0.942
	Monsoon		2.719	0.927	0.960
	Post Monsoon		2.706	0.925	0.955
	Winter		2.541	0.913	0.860
Lower Majuli	Pre-monsoon	29	2.886	0.932	0.867
	Monsoon		3.015	0.943	0.895
	Post Monsoon		2.952	0.935	0.877
	Winter		2.874	0.930	0.862

Highest Shannon-Wiener Index (H' = 3.156), Simpson Index of Diversity (1-D = 0.955) and Evenness (E_H = 0.983) were recorded during monsoon in Upper Majuli which suggested presence of relatively stable habitats whereas lowest Shannon-Wiener Index (H' = 2.341), Simpson Index of Diversity (1-D = 0.913) and Evenness (E_H = 0.860) were recorded during winter which suggested relatively disturbed habitats in Central Majuli respectively (Table 8). The results corroborated with the observations of Sarma and Baruah (2013) and Turkmen and Kazanci (2010), who concluded that H' value above 3.0 indicated stable and balanced structure and habitat whereas H' under 1.0 indicated pollution and degradation in habitat structure. Further, Dalal and Gupta (2014) revealed that the Evenness being closer to 1 indicated equal distribution of individuals in two temple ponds of Silchar, Assam.

Conclusion

The present study aimed to assess the composition and diversity of aquatic insects of Majuli. The occurrence of a wide array of aquatic entomofauna observed in Majuli exhibited the highest mean abundance of aquatic insect and higher species diversity in monsoon whereas lowest was observed in winter suggesting less environmental

stress and stable environmental conditions contributed to higher species diversity. Also, the study has paved a way on possibility of further exploration of the aquatic insects and their role through more precise biomonitoring programmes.

Acknowledgements

Sincere gratitude is extended to Dr. Hemant V. Ghate, Former Head of the Department of Zoology, Modern College, Pune and Dr. S.K. Dutta, Professor, Department of Entomology, AAU, Jorhat for taxonomic treatments during the present study.

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