Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(4): 1253-1257

Received: 01-05-2018
Accepted: 05-06-2018

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Aquatic insect fauna of Majuli river island of Assam

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Abstract
Studies on aquatic insect fauna were carried out at the largest river island of the world, Majuli during 2016-17. Seasonal surveys conducted during pre monsoon, monsoon, post monsoon and winter covering 60 sampling sites revealed the occurrence of a wide array of aquatic insects. Altogether 48 aquatic insect species belonging to 6 orders and 20 families were recorded. At order level, 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).

Keywords: Aquatic Insect Fauna, Coleoptera, Hemiptera, Majuli, Odonata

1. Introduction
Water is one of the most indispensable natural resources and is considered as a service provided by ecosystems [1]. Without water, there is seldom possibility of survival for almost all living organisms on earth for a long period of time. Fresh water has a great role in sustenance of life of human beings, other organisms of the environment and maintaining the balance of nature. Water resources are being used by human being for various purposes like agriculture, industries, hydropower, fisheries and recreational uses [2]. Therefore, focus should be given on surface water quality assessment as the amount of freshwater on the earth is limited. However, it is likely to be observed that because of increasing concern for human health and the habitat of aquatic life, global campaign in the maintenance of a clean water world, many people have come to realize the importance of clean surface water to a nation's economy [3]. Aquatic ecosystems are highly diverse habitats that include ponds, lakes, springs, streams, rivers, wetlands, reservoirs, and ditches. Around the world, aquatic habitats are being subjected to increased levels of human disturbance [4]. This compares with a decline over the years by 35 per cent in 217 marine and coastal species, 15 per cent in 282 terrestrial species [5]. Though, not conclusive, these living forms provide strong indications that aquatic ecosystems are suffering the greatest negative impact from various anthropogenic activities at present. Pertinent to above, it is imperative to identify, monitor and conserve the biodiversity and exploration of indicator species for monitoring water quality of aquatic ecosystems as they are essential elements in lentic and lotic trophic webs, participating in the energy flow and nutrient cycling [6]. Aquatic insects may be considered as an excellent model organism in analyzing the structure and function of the freshwater ecosystem because of their high abundance, high birth rate with short generation period, large biomass and rapid colonization in freshwater habitats [7]. Aquatic insects are found to be associated with water for most part of their life cycle, any change in their number and composition in the population at a given time and space may indicate a change in the water quality and are considered as an integral part of the aquatic ecosystem as they have both ecological and economical value [7, 8]. They have been the primary tool for studying ecology, growth of population, evolution, genetics and many other areas of biology [7]. Majuli, which is marked by its geological alienation from the mainstream Assam state, is known as the largest fresh water mid-river deltaic island in the world which provides every possibility of exploring the aquatic insect fauna of the island. However, practically no concrete information is available on aquatic insect fauna of Majuli river island of Assam. Pertinent to above, the present study was undertaken to study the aquatic insect fauna and their abundance in selected sampling sites of Majuli.

2. Materials and Methods

2.1 Study area

Majuli is the largest fresh water mid-river deltaic island in the world which is situated between 26°45 N to 27°12 N latitude and 93°39 E to 94°35 E longitudes. The total geographical area of Majuli is 577 square km and is situated in the upper reaches of the Brahmaputra, 630 km upstream of the Indo-Bangladesh border and 1,100 km from its mouth. To know the aquatic insect fauna in Majuli, three locations *viz.*, upper, central and lower Majuli were selected. From each location, five different villages were chosen and from each village four different water bodies were selected for collection of aquatic insects during four different seasons *viz.*, pre-monsoon (March-May), Monsoon (June-August), post-monsoon (September-November) and winter (December-February).

2.2 Aquatic insect collection and identification

Specimens were collected according to the method [9], in which the aquatic bugs were collected according to their behaviours and dragged through the organic debrises, floating vegetations, tangled roots and other objects whereas insects clinging on the vegetations were handpicked [9]. Some insects were collected by splashing water on the bank to flush them out of the crevices and small insects that hide in mosses and floating vegetation were exposed by pressing the plant under water [9]. The aquatic insects in open area were collected with the help of an aquatic net with a dimension of 30 × 30 cm frame, 250 µm, 50 cm length. Habitat sampling of the insects and water were made during early hours of the day (6-9 am) since many aquatic insects migrate to deeper water during late hours of the day. The collected specimens were kept in a white tray, thereafter, sorting of individual specimen was done. The insects collected were categorized, recorded and stored in absolute alcohol for preservation [10]. The collected as well as the preserved samples were examined under stereozoom microscope (4X and above) and identified by using standard taxonomic keys [5].

3. Results and discussion

The aquatic entomofauna of Majuli constituted 48 species categorised under 6 orders and 20 families [11]. The order wise results with description of the aquatic insect species pertaining to the present investigation are presented and discussed below:

3.1 Odonata

During the time of investigation, total of 23 species, including 16 species of dragonflies (sub-order: Anisoptera) belonging to the families Libellulidae and Aeshnidae, whereas 7 species of damselflies (sub-order: Zygoptera) belonging to the family Coenagrionidae were recorded (Table 1). The species belonging to the family Libellulidae was found to be abundant with 15 species followed by the Coenagrionidae with 7 species and Aeshnidae with 1 species. Different species of Odonates recorded were *Brachythemis contaminata*, *Crocothemis servilia servilia*, *Rhyothemis variegata*, *Urothemis signata*, *Pantala flavescens*, *Aethriamanta brevipennis*, *Orthetrum sabina*, *O. pruinosum*, *O. brunneum*, *Brachydiplax chalybea*, *Brechmorphoga mendax*, *Neurothemis tullia*, *N. fulvia*, *Diplacodes nebulosa*, *Acisoma panorpoides* under family Libellulidae and *Gynacantha dravida* under family Aeshnidae (sub-order: Anisoptera). Likewise, 7 species of damselflies *viz*., *Ischnura aurora*, *I. elegans*, *Ceriagrion coromandelianum*, *C. calamineum*, *Agriocnemis pieris*, *A. pygmaea* and *Aciagrion hisopa* under family Coenagrionidae (sub-order: Zygoptera) were identified [12].

Table 1: Checklist of aquatic insect fauna of Majuli river island of Assam during 2016-17

Order	Sub Order	Family	Scientific Name	Habitat
Odonata (23 species)	Anisoptera	Libellulidae (15 species)	*Brachythemis contaminata* (Fabricius, 1793)	Naiads are aquatic found in water bodies with dense, floating and submerged vegetation/seasonal natural streams/periodically managed streams Adults are semi-aquatic in nature
			Crocothemis servilia servilia (Drury, 1773)	
			Rhyothemis variegata (Linnaeus, 1763)	
			Urothemis signata (Rambur, 1842)	
			Pantala flavescens (Fabricius, 1798)	
			Aethriamanta brevipennis (Rambur, 1842)	
			Orthetrum sabina (Drury, 1770)	
			Orthetrum pruinosum (Burmeister, 1839)	
			Orthetrum brunneum (Fonscolombe, 1837)	
			Brachydiplax chalybea (Brauer, 1839)	
			Brechmorphoga mendax (Hagen, 1861)	
			Neurothemis tullia (Drury, 1773)	
			Neurothemis fulvia (Drury, 1773)	
			Diplacodes nebulosa (Fabricius, 1793)	
			Acisoma panorpoides (Rambur, 1842)	
		Aeshnidae (1 species)	*Gynacantha dravida* (Lieftinck, 1960)	
	Zygoptera	Coenagrionidae (7 species)	*Ischnura aurora* (Brauer, 1865)	Naiads are aquatic found in water bodies with dense, floating and submerged vegetation/ seasonal natural streams/periodically managed streams. Adults are semi-aquatic in nature
			Ischnura elegans (Linden, 1820)	
			Ceriagrion coromandelianum (Fabricius, 1798)	
			Ceriagrion calamineum (Lieftinck, 1951)	
			Agriocnemis pieris (Laidlaw, 1919)	
			Agriocnemis pygmaea (Rambur, 1842)	
			Aciagrion hisopa (Sélys, 1876)	

Coleoptera (9 species)	Adephaga	Gyrinidae (1 species)	*Dineutus* sp. (Macleay, 1825)	Usually on the surface of water bodies with dense, floating and submerged vegetation/seasonal natural streams
		Dysticidae (5 species)	*Cybister fimbriolatus* (Say, 1823)	
			Cybister sp. (Curtis, 1827)	
			Laccophilus sp. (Leach, 1815)	
			Hydaticus sp. (Leach, 1817)	
			Herophydrus musicus (Klug, 1834)	
		Hydrophilidae (1 species)	*Hydrophilus* sp. (Geoffroy, 1762)	
		Curculionidae (1 species)	*Bagous* sp. (Germar, 1817)	
		Carabidae (1 species)	*Pterostichus* sp. (Bonelli, 1810)	
Hemiptera (9 species)	Heteroptera	Belostomatidae (4 species)	*Diplonychus rusticus* (Fabricius, 1871)	Usually on the surface of water bodies with dense, floating and submerged vegetation/Periodically managed streams/ Seasonal natural streams
			Diplonychus sp. (Laporte, 1832)	
			Lethocerus indicus (Lepeletier & Serville, 1825)	
			Lethocerus sp. (Mayr, 1853)	
		Nepidae (2 species)	*Laccotrephes* sp. (Stål, 1866)	
			Ranatra sp. (Fabricius, 1790)	
		Gerridae (1 species)	*Gerris* sp. (Fabricius, 1794)	
		Notonectidae (1 species)	*Enithares* sp. (Spinola, 1837)	
		Corixidae (1 species)	*Micronecta* sp. (Kirkaldy, 1897)	
Ephemeroptera (3 species)	Pannota	Caenidae (1 species)	*Caenis* sp. (Stephens, 1835)	Nymphs or imagos are found in benthic zone of clean water bodies. Adults are land dwellers and short lived.
	Pisciformia	Baetidae (1 species)	*Baetis* sp. (Leach, 1815)	
		Isonychiidae (1 species)	*Isonychia* sp. (Eaton, 1871)	
Trichoptera (2 species)	Spicipalpia	Glossosomatidae (1 species)	*Glossosoma* sp. (Curtis, 1834)	
	Annulipalpia	Hydropsychidae (1 species)	*Diplectrona modesta* (Banks, 1908)	
Diptera (2 species)	Nematocera	Simulidae (1 species)	*Simulium* sp. (Latreille, 1802)	Maggots are usually found on the surface or in the benthic zone of lentic water bodies. Adults are land dwellers
		Chironomidae (1 species)	*Chironomus* sp. (Meigen, 1803)	

3.2 Coleoptera

Altogether 9 species of aquatic insects under Coleoptera belonging to 5 families (Dysticidae, Gyrinidae, Hydrophilidae, Curculionidae and Carabidae) were registered (Table 1). The species belonging to the family Dysticidae was found to be abundant with 5 species followed by families Gyrinidae, Hydrophilidae, Curculionidae and Carabidae with 1 species in each family [13-15]. Short descriptions of all 9 species of aquatic beetles (8 numbers) and one weevil are given below:

i. Species: *Dineutus* sp.
Family: Gyrinidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Eyes divided into dorsal and ventral portions; forelegs long and raptorial, mid and hind legs short and paddle-like; antennae stout and club-shaped; lives on water surface.

ii. Species: *Cybister* sp. and *C. fimbriolatus*
Family: Dytiscidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Nymphs with six jointed legs; body segmented with a narrow collar behind the head, legs short and slender, may be adapted for swimming; mandibles sickle shaped.

iii. Species: *Laccophilus* sp.
Family: Dytiscidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Length of the body ranges between 0.3-1 cm; shiny, usually black or brownish-black, but often marked with dull yellow, green, or bronze; antennae 11 segmented, long and threadlike.

iv. Species: *Hydaticus* sp. and *Herophydrus musicus*
Family: Dytiscidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies

Characteristics: Eyes do not protrude; body convex shaped in cross section; hind tarsus with a single claw, mesoscutellum large and exposed.

v. Species: *Hydrophilus* sp
Family: Hydrophilidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies

Characteristics: Head capsule with groups of six ocelli (five lateral and one ventral) or without ocelli; abdominal tip rounded; antennae arise behind the insertion point of the mandibles.

vi. Species: *Bagous* sp.
Family: Curculionidae
Habitat of nymph and adult: Near water bodies, on weeds
Characteristics: Eyes undivided; aquatic or semi aquatic but never found on water surface; head with anterior prolongation or snout.

vii. Species: *Pterostichus* sp.
Family: Carabidae
Habitat of nymph and adult: In moist areas near water bodies, sometimes on weeds
Characteristics: Semi aquatic beetle; about 0.3-1.5 cm in length; two tiny rows of setae located before the end claw.

3.3 Hemiptera
Nine species of aquatic bugs belonging to 5 families (Belostomatidae, Nepidae, Gerridae, Notonectida and Corixidae) were recorded (Table 1) [14, 15]. The species belonging to the family Belostomatidae was found to be abundant with 4 species followed by Nepidae with 2 species.

i. Species: *Diplonychus rusticus* and *Diplonychus* sp.
Family: Belostomatidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Body length 2-3 cm; oval to rounded, medium brown; inner margins of eyes convergent anteriorly; lateral margins of pronotum and hemelytra paler brown.

ii. Species: *Lethocerus indicus* and *Lethocerus* sp.
Family: Belostomatidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Adults about 5-7 cm in length; shiny, usually black or brownish- black, often marked with dull yellow, green, or bronze; a pair of short, strap-like appendages at the tip of the abdomen; eyes protrude from margin of the head; mid and hind legs somewhat flattened.

iii. Species: *Laccotrephes* sp.
Family: Nepidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Body elongated; about 4-5 cm in length; sub-oval and flattened; hind coxae widely separated from each other.

iv. Species: *Ranatra* sp.
Family: Nepidae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Adults about 3-4 cm; respiratory siphon 1.6-2 cm in length; colouration medium brown; head with vertex slightly raised above the eyes.

v. Species: *Gerris* sp.
Family: Gerridae
Habitat of nymph and adult: Upper surface of slow moving waters bodies
Characteristics: Body length 1-2 cm; dorsal inner margins of eyes sinuate; pronotum hiny with a single central stripe or no apparent margin; hind tibia not more than 3.2 times length of first tarsal segment.

vi. Species: *Enithares* sp.
Family: Notonectidae
Habitat of nymph and adult: Benthic region and upper surface of water bodies
Characteristics: Forelegs and femora not flattened; elongate or hemispherical; hind legs long and oar-like and fringed with hairs; body elongated.

vii. Species: *Micronecta* sp.
Family: Corixidae
Habitat of nymph and adult: Benthic region and upper surface of water bodies
Characteristics: Mouthparts blunt and triangular or beak-like; tarsus of forelegs modified into a scoop-like structure; lateral margins of the hemelytra with an unbroken brown stripe.

3.4 Ephemeroptera
Three species of Mayflies were recorded and the dominant families were Caenidae (*Caenis* sp.), Baetidae (*Baetis* sp.) and Isonychiidae (*Isonychia* sp.) (Table 1) [5, 16, 17].
Mayfly (*Caenis* sp., *Baetis* sp. and *Isonychia* sp.)
Habitat of Imago : Benthic region/fresh running water bodies
Habitat of Adult : Short lived or live for a day in land
Characteristics: Imago up to 0.25-0.32 cm long; seven pairs of gills along the abdomen used for absorption of dissolved oxygen (4 to 10 ppm) from water and three tails at the base of the abdomen; three pairs of segmented legs with one claw at the end of each leg; wing pads visible on the imago; feed on live and decaying vegetation.

3.5 Trichoptera
During survey a total of 2 species under this order belonging to the families Glossosomatidae (*Glossosoma* sp.) and Hydropsychidae (*Diplectrona modesta*) were recorded (Table 1) [5, 10].
Caddishfly (*Glossosoma* sp. and *Diplectrona modesta*)
Habitat of Larvae: Benthic region of running and static water bodies (ponds and streams)
Habitat of Adult : Land dwellers.
Characteristics: Larvae up to 4 cm in length; soft bodied covered by tube like cases that the larvae build from twigs, leaves, sand, etc.; two small fleshy extensions at the end of the abdomen that end in a small hook; filamentous gills on the underside or the end of the abdomen; oxygen absorbed through the body surface; feed on dead leaves and decaying matter, plants; some prey on other organisms.

3.6 Diptera
Only two dominant families (Simulidae & Chironomidae) under Diptera were observed. These species were *Simulium* sp (Family: Simulidae) and *Chironomus* sp. (Chironomidae) (Table 1) [13].
Midges (*Simulium* sp. and *Chironomus* sp.)
Habitat of maggots : Usually at the benthic zone of lentic water bodies
Habitat of Adult : Small flying insect
Characteristics: Maggots up to 1.5-2.8 cm in length; usually

thin, slightly curved, and segmented; one pair of tiny fleshy prolegs below the head and one pair at the back end; eighth abdominal segment with finger like ventral tubules; feed on smaller larvae, decaying matter, and microorganisms; important component of the aquatic food web; food source for fishes.

The aforementioned descriptions of the identified aquatic insect fauna of Majuli river island were tallied with the descriptions given in the field guide [5] and found authentic resemblances. The present findings also corroborate the earlier reports [15, 19].

4. Conclusion

The study revealed the occurrence of a wide array of aquatic entomofauna in Majuli. However, there is lack of concrete information on aquatic insect fauna of Majuli river island of Assam. Therefore, it could be successfully concluded that there is every possibility of exploring the aquatic insect fauna of the island and proper documentation of aquatic insect fauna by both molecular and conventional taxonomy which would further help in creating a digital database on aquatic insect fauna of North East India.

5. Acknowledgements

Authors would like to express their sincere thanks and gratefulness 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 their eruditely guidance and affectionate encouragement during the course of the study.

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