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Variation in aquatic Insects community in a tropical water body on account of anthropogenic activity

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Abstract
Present work conducted on the upper lake regarding variation in aquatic insect diversity on account of anthropogenic activity revealed a total of 17 different species during premonsoon season. These 17 species of aquatic insects belonged to 6 orders and 17 different families with Coleoptera being the most dominant order while, Ephemeroptera and Megaloptera being the least dominant. Maximum number was recorded during the month of March associated with rich submerged vegetation (mostly with *Ceratophyllum, Najas* and *Potamogeton).* Anthropogenic activities and lake deweeding process disturbed the habitat and rendered oviposition sites of aquatic insects which reduced their diversity greatly.

Keywords: anthropogenic activities, aquatic insects, diversity, deweeding

Introduction
Water bodies with large surface area receive vast input from catchment area and different watersheds. This vast input changes the water quality and puts an effect on the macro invertebrate communities. Aquatic systems are the best sites used for the disposal and recycling of sewage and toxic wastes. however the over exploitation of these water bodies primarily for the demand of portable water supply, irrigation and industrial use reduces the assimilatory capacity of these precious systems, which in turn exerts pressure on the water courses. This stress is mainly faced by the aquatic communities. Increasing global human population rate, rapid expansion in industrial and urban activities along with modernization of agricultural practices result in the high volume of waste materials causing gradual deterioration of water bodies (Subhendu 2000) [14]. The huge amounts of wastes generated in urban cities find their way into surface waters of aquatic systems carried by run-off from rain water, effluent discharges from industries and blocked sewage lines in domestic areas. Water in these systems carry large amounts of matter comprising inorganic, organic and dissolved matter, rendering it unsuitable for direct use. The impact of anthropogenic activities is not unidirectional and may result in either increased or decreased levels of connectivity. These changes pose direct threat to the biota and also create environments that can alter the evolutionary trajectory of populations and species (Allendorf *et al.* 2013) [2].
Living a part of their life in water, aquatic insects are capable of withstanding severe and harsh environment (Polhemus 1979) [12]. Aquatic insects are very important in ecological systems as presence or absence of a particular family of aquatic insects can predict healthy or polluted state of water body by being the primary bio indicator of fresh water bodies besides serving as the food of fishes and other invertebrates and acting as a vector of pathogens to both humans and animals (Foil, 1998; Chae *et al*. 2000) [7, 5]. In the present study the variation of aquatic insects from a tropical water body has been assessed.

Study area
Upper lake renamed as Bhojtal in March 2011 lies on the western side of the Bhopal, capital city of Madhya Pradesh is surrounded by Van Vihar National Park on the south, human settlements on the east and north, and agriculture fields on the west. Located along the geological coordinates of 23.25°N 77.34°E, Upper Lake occupies an area of 31 km^2, and drains a catchment of 361 km^2 with the maximum length and width being 31.5 km and 5 km respectively. It acts as a major source of drinking water, serving around 40 % of the residents with nearly 30 million imperial gallons (140,000 m^3) daily. The watershed of the Upper Lake is mostly rural, with some urbanized areas around its eastern end. The lake was created by Paramara Raja Bhoj during his tenure as a king of Malwa (1005–1055) by constructing an earthen dam across the Kolans River, a tributary of the Halali River. Upper lake and Lower lake are jointly known as Bhoj wetland which has been designated as Ramsar site in November 2002.

Fig 1

Methodology

For the collection and analysis of various water quality parameters standard methods such as Adoni (1985) [1] and APHA (2005) [3] were followed. The sampling of aquatic insects was done mainly on the early hours of the day. Different types of nets and sieves were used for the collection of Aquatic insects. The whole samples were sieved to obtain the insects with the help of forceps and brush and were preserved in 70% ethyl alcohol. The water quality parameters such as air and water temperature, pH, total dissolved solids, electric conductivity, and dissolved oxygen were measured on the field. However the parameters like chlorides, alkalinity, calcium hardness, Total hardness, were calculated in the laboratory. The collected species were identified upto maximum possible classification by using different identification keys viz. Merritt and Cummins (1988), Bal and Basu (1994) [4], Subramanian and Sivaramakrishnan (2007) [15] and Mccafferty (1981) [10].

Results and Discussions

The water quality parameters of the Bhoj wetland during the study period are given in Table 1 and the aquatic insects recorded are shown in Table 2. However the Monthly variation of aquatic insect species is shown in Fig. 2.

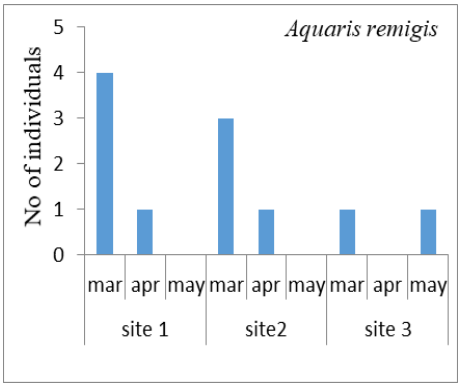
Table 1: Water quality parameters at different sites of Bhoj wetland.

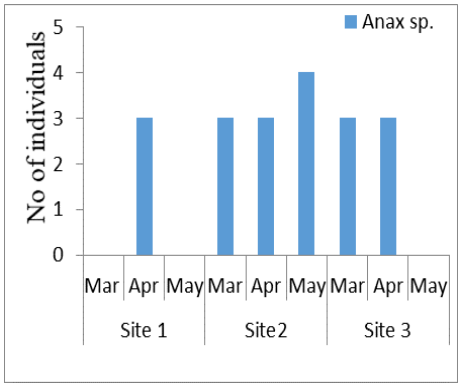
Parameters	Site 1 (Van Vihar)			Site 2 (Boat club)			Site 3 (Khanugaun)		
	Mar	Apr	May	Mar	Apr	May	Mar	Apr	May
Atm. Temperature °C	24	26	33	25	32	35	27.5	32	38
water temperature °C	24	30	30	23	30	32	23	30	32
Ph	7.5	7.5	7.6	7.6	7.6	7.6	7.1	7.5	7.6
EC µScm^{-1}	200	200	200	200	200	200	200	200	200
TDS ppm	100	90	100	80	90	90	90	90	100
DO mgl^{-1}	8.8	4.8	8.4	8.8	6	8	7.2	4.4	4.4
Alkalinity mgl^{-1}	44	46	46	48	48	46	46	48	48
Ca^{++} mgl^{-1}	50.4	48.3	48	46	52.5	52.5	46	46.2	48.3
total hardness mgl^{-1}	94	92	94	92	96	96	92	90	90
chlorides mgl^{-1}	41.95	41.95	39.96	42.95	46.95	41.95	39.96	41.95	31.96

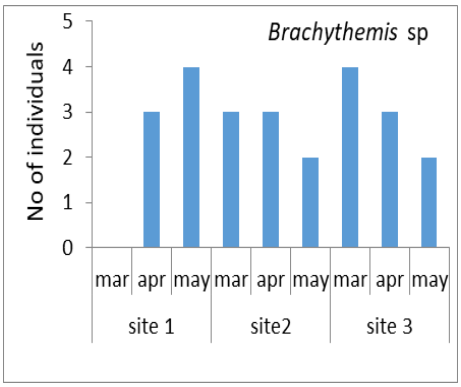
Table 2: List of aquatic insect species recorded/m^2 at Bhoj wetland during Mar- May 2016.

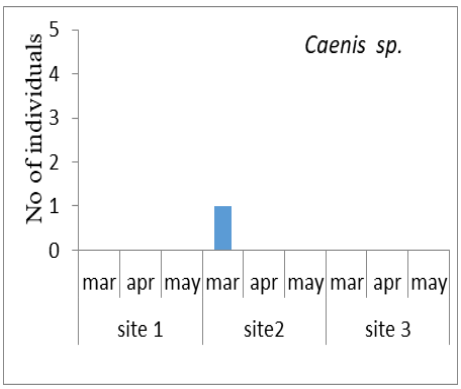
S. No	Taxa	Site 1 (Van Vihar)			Site 2 (Boat club)			Site 3 (Khanugaun)		
		Mar	Apr	May	Mar	Apr	May	Mar	Apr	may
Order Hemiptera										
Family coraxidae										
1	*Sigara alternata*	-	5	4	5	3	3	4	2	-
Family Gerridae										
2	*Aquaris remigis*	4	1	-	3	1	-	1	-	1
Family Naucoridae										
3	Naucoris sp	1	1	2	-	-	-	-	1	-

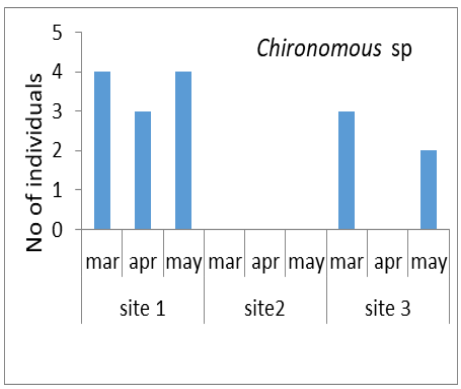
Order Coleoptera										
Family Dysticidae										
4	*Dysticus* sp.	-	-	-	2	2	1	1	2	1
Family Dryopidae										
5	*Dryops sp.*	1	-	2	-	-	-	-	-	-
Family Gyrinidae										
6	*Gyrinus* sp.	1	-	2	-	-	-	2	1	-
Family Brachyceridae										
7	*Lissorhoptrus*	-	2	-	1	2	-	-	-	-
Family Haliplidae										
8	*Haliplus* sp.	1	-	1	-	-	-	2	1	1
Order odonata										
Family Lestidae										
9	*Lestes* sp.	-	-	-	2	-	3	-	-	-
Family Aeshinidae										
10	*Anax* sp.	-	3	-	3	3	4	3	3	-
Family Libellulidae										
11	*Brachythemis sp*	-	3	4	3	3	2	4	3	2
Family Coenogranidae										
12	*Enallagma* sp.	-	2	-	-	3	-	-	1	-
Order Diptera										
Family Simulidae										
13	*simulium* sp	-	-	-	2	2	-	-	2	-
Family Chironomidae										
14	Chironomous sp.	4	3	4	-	-	-	3	-	2
Family Culicidae										
15	Culex sp.	2	-	-	-	-	-	2	3	-
Order Ephemeroptera										
Family Caenidae										
16	Caenis sp.	-	-	-	1	-	-	-	-	-
Order Megaloptera										
Family Corydalidae										
17	Corydalus sp	-	-	-	2	-	-	-	-	-
Total		14	23	19	24	19	13	22	19	7

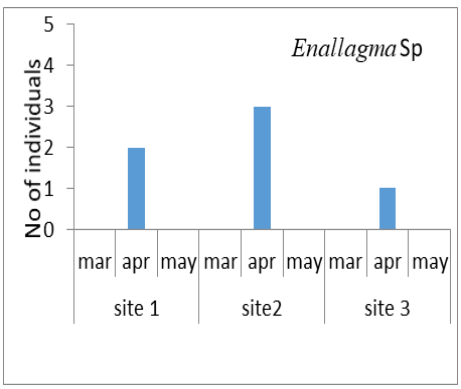












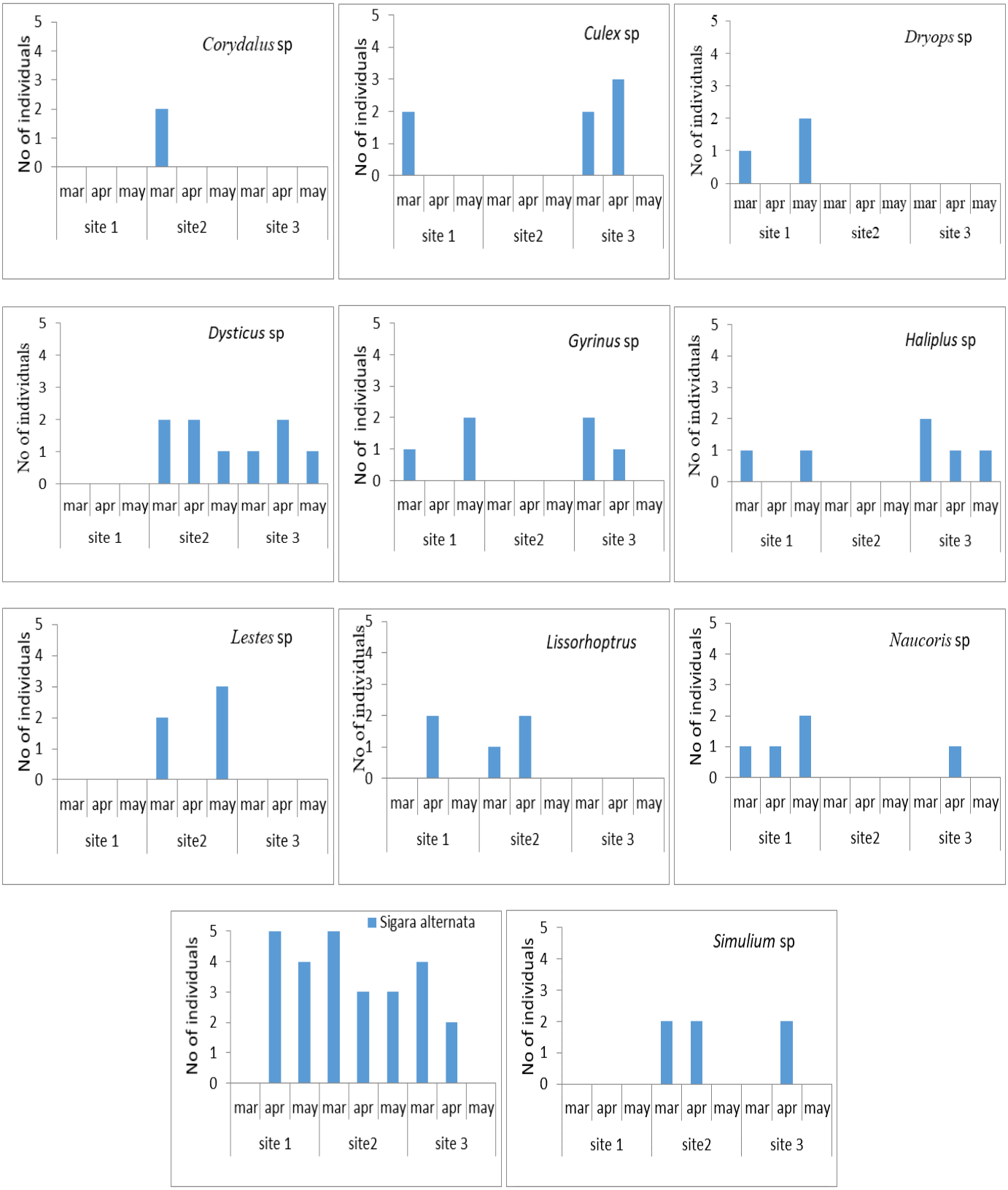


Fig 2: Monthly variation of aquatic insects at different sites.

During the present study a total of 160 individuals of aquatic insects were collected from the three sampling sites of the Bhoj wetland comprising of 17 species under 6 orders and 17 different families. Majority of the insects belonged to the order Coleoptera accounting for 5 species from 5 different families followed by order Odonata which comprised 4 species from 4 different families of aquatic insects. The two orders viz. Diptera and Hemiptera shared an equal number of

insect sps both constituting of 3 species of aquatic insects. However, the least contributors were order Ephemeroptera and Megaloptera both of which represented 1 species only.

The maximum number of species was recorded (10 in number) during the month of March at site 2 (Boat club) and April at site 3 (Khanugaun) (Table 2) during the period of abundant growth of Macrophytes (*Ceratophyllum, Najas, Pistia* and *Potamogeton*) while the least number of insects recorded during the study period was in the month of May at sites 2 (Boat club) and 3 (Khanugaun) each accounting for only 6 species of aquatic insects. The lower diversity of aquatic insects during the month of May at site 3 (Khanugaun) was primarily due to deweeding process which rendered the habitat and oviposition sites of organisms. However, the lower diversity of insects at site 2 (Boat club) can be attributed to the anthropogenic activities mainly boating being done on large scale which disturbs the water column and can reduce the suitability of oviposition sites of organisms.

In terms of total insect population recorded during the sampling period lowest insect population was found to be during the month of May at site 3 (Khanugaun) where only 7 individuals from 3 different families were recorded. However, the maximum number of aquatic insects was found during the month of March at site 2 (Boat club) which shows a number of 24 individuals of aquatic insects from 10 different families.

During the present study order Ephemeroptera contributed least and was recorded only during the month of March at site 2 (Boat Club). The most diverse taxa found during the entire study period was found to be Brachythemis species from the order Odonata. However in terms of abundance the insect taxa from order Hemiptera was found dominant over all others.

Comparing the data on site wise basis the diversity of aquatic insects at site 1 (Van Vihar) revealed the following trend:

Chironomous sp. > *Sigara alternata* >*Brachythemis* sp > *Aquarius remigis* > *Naucoris sp* >*Dryops sp* = *Gyrinus* sp = *Anax sp* > *Enallgma* sp = *Culex* sp = *Haliplus* sp = *Lissorhoptrus.*

At site 2 (Boat club) this diversity was found to be in the following order as

Sigara alternata > *Anax* sp > *Brachythemis* sp > *Dysticus* = *Lestes* sp > *Aquarius remigis* = *Simulium* sp > *Enallagma* sp = *Lissorhoptrus.*

However at site 3 (Khanugaun) the diversity of aquatic insects was found to be as

Brachythemis sp > *Anax sp* = *Sigara alternata* > *Chironomous* sp = *Culex* sp > *Dysticus* sp = *Haliplus* sp > *Gyrinus* sp > *Aquarius remigis* > *Enallagma sp*= *Naucoris* sp.

On overall basis at site 1 (Van Vihar) *Chironomous* species were dominant which is due to the decomposing weeds being put there after the process of deweeding. However at site 2 (Boat Club) the most dominant taxa was found to be *Sigara aternata* and *Anax* species. The absence of *Chironomous* species from site 2 is particularly due to the disturbance caused by anthropogenic activities mainly by boating and deweeding due to which the habitat gets rendered and the organisms lost their oviposition sites. *Brachythemi*s species was found to be the most dominant species at site 3 (Khanugaun) which was followed by *Anax* sp and *Sigara alternata*. The dominance of both *Brachythemis* species and *Anax* species is attributed to the aquatic vegetation mostly being *Ceratophyllum*, *Najas, Potamogeton* and *Pistia*. However the least diversity of aquatic insects was also recorded at site 3 (Khanugaun) during the month of May which can be attributed mainly to the process of deweeding and anthropogenic activities.

During the present study it was seen that the disturbance in the habitat reduced the number of aquatic insects, which is in accordance with the earlier studies reported by Hepp *et al*., (2013) [9] suggesting that destruction in habitat and water quality reduces the diversity of aquatic macro invertebrates. The water chemistry of an aquatic environment is determined by disturbance from the local surroundings, land use patterns and other human activities (Sundermann *et al.* 2013) [16]. Mohiuddin *et al.,* (2009) [11] reported 38 species of aquatic insects from Lower Lake Bhopal with greater diversity during summer months. Wanganeo *et al.* (2011) [17] reported the maximum diversity of benthic organisms towards the shallower regions of Bhoj wetland comprising luxurious growth of macrophytes however Ganie *et al.,* 2016 [8] reported 27 species of aquatic insects from the Lower Lake Bhopal during Premonsoon season with maximum diversity at vegetation rich site and lowest diversity from the disturbed sites. Choudhary and Janakahi (2015) [6] reported 12 species of aquatic insects from Lakhabanjara Lake, Sagar. Sharma *et al.*, (2010) [13] reported 12 species of aquatic insects from Kishanpura Lake, Indore.

Conclusion

The present study shows that aquatic insects were diverse during the time of luxurious rmacrophytic growth, showing their dependence on them for habitat, feeding and oviposition sites. Insect species from order Coleoptera were dominant throughout the study period. The lowest diversity of aquatic insects is attributed to the anthropogenic activities and Lake deweeding process which renders the habitat of aquatic insects inhabitable.

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