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Original Research Article

Diversity of Aquatic Insects in Lake Pichhola of Udaipur, Rajasthan, India

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ABSTRACT:
The present study conducted on Lake Pichhola with regard to its insect diversity revealed a total of 24 species during the period from October 2019 to March 2020 and these 24 species of insects belonged to 6 orders and 12 families. Maximum insect species were recorded from the littoral zone (vegetation rich site) and minimum insect species from limnetic zone and disturbed sites of the lake. A number of insect species and their immature stages from orders Odonata, Ephemeroptera, Diptera, Hemiptera, Coleoptera and Trichoptera were observed. The insect fauna from the order Odonata dominated over Ephemeroptera and the second most dominant order was Hemiptera. Aquatic insects are best known for their ability to indicate the water quality and monitoring of aquatic insect diversity and abundance can expedite the conservation of these lake ecosystems.

Keywords: Aquatic insects, Diversity, Lake, Pichhola, Water Quality.

INTRODUCTION

Inland water bodies harbour more than 6% of the insect species on Earth. The biological community most dominant in the freshwater bodies is the insects. About 100,000 species (8%) from 12 orders (like Odonata, Plecoptera, Ephemeroptera, Trichoptera, Diptera, Hemiptera, Heteroptera and such others) spend one or more of their life stages in freshwaterhabitat (Balian et al., 2008; KDB Dijkstra et al., 2014). Almost every type of water bodies have some kind of aquatic insects living in it. The most captivating characteristics of the aquatic insects are their different patterns of distribution in aquatic habitat coupled with their adaptability. Aquatic insects are able to tolerate severe and unpredictable environments. Lately, these ecosystems have increasingly been impacted by anthropogenic activities occurring within catchment areas (Liao, Sarver and Krometis, 2018; Vörösmarty et al., 2010; Yoshimura, 2012).

Insects are very good biological indicators of water quality, pollution and ecological health of lakes, rivers and other water bodies (Heliovaara, 2018; Nasirian & Irvine, 2017; Steward et al., 2018). They have different environmental disturbance tolerance levels. Some aquatic insects are

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highly sensitive to water pollution while others can live in disturbed and extremely polluted waters (Hepp et al. 2013).The presence or absence of certain aquatic insect families can indicate whether a particular water body is healthy or polluted.

Worldwide, fresh water resources have been subjected to an increasing pollution load from contaminated runoff water originated from manmade domestic and industrial activities (Benetti and Garrido 2010), agricultural practices with extreme use of fertilizers and pesticides(Garcia-Criado et al. 1999)and urbanization. These disturbances and changes in the chemical composition of water produce alteration in the structure of the communities of organisms living in these environments. Aquatic organisms are adapted to specific environmental conditions, if these conditions change, some insects disappear (intolerant) and are replaced by others (tolerant). Variation in the composition of aquatic organism assemblages in fresh water ecosystem can indicate possible pollution. The most diverse group of fresh water benthic macroinvertebrates are insects. So, as a highly diverse group, insects, inhabiting the benthic environment are valuable indices of environmental conditions. Lake Pichhola is one of the most prominent lakes of Udaipur and is the lifeline of the city. Tourism industry flourishes in this beautiful city of lakes. So does pollution as there is a large number of hotels, guest houses around the lake, and almost whole lake perimeter is surrounded by residential areas. How the aquatic insect biodiversity in this lake is affected would be a study of conservation interest. Hence, investigation was carried out to determine the aquatic insect biodiversity in lake Pichhola of Udaipur, Rajasthan.

MATERIALS AND METHODS

Sampling site: Lake Pichhola was selected to study the aquatic insect diversity. It is a fresh water lake and is the main source of drinking water for Udaipur city. It is situated between latitude 24°34'54" N and longitude 70°40'35" E. This lake covers 6.96 km² and the catchment area of the lake is 127 km².

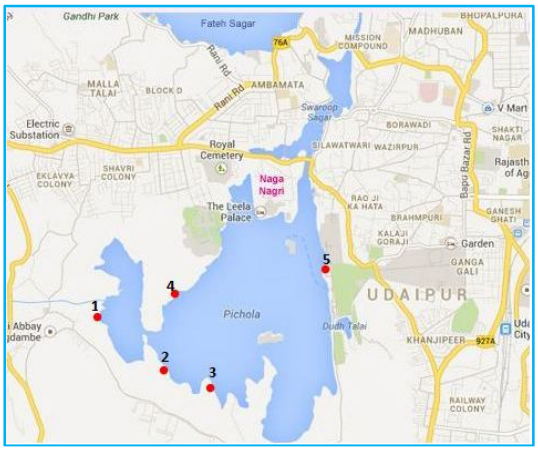

Figure 1: GPS picture of Lake Pichhola
Insect collection sites:
1. Area near Pratap Park
2. Vaidhnath temple area
3. Area near Military Cantt. Sisarma
4. Purbiya colony area
5. Dudh talai

Collection method: Monthly collections were made for the entire period of study from 5 sites of the lake, both limnetic and disturbed. The lake was sampled for availability of insect diversity and immature stages every fortnight for a period of 6 months from October 2019 to March 2020.

Sampling of the aquatic insects was made during the dawning hours (6:00 AM – 9:00 AM) of sunny days because various aquatic insects migrate to deeper water during late hours of the day.

Insects like dragonflies, damselflies, beetles, bugs, etc. were searched along the lake shoreline. Aquatic insects were collected according to their behaviour. Insects were dragged through the mosses, floating vegetation, organic debris and intricate roots (Menke, 1979). Insects clinging on the vegetation were handpicked. In open area, insects were collected with the help of pond net and dip net (Jenila & Nair, 2013). To collect larval stages of aquatic insects, aquatic plants were pulled from the vegetation rich sites of lake. After collection, sorting was done using forceps and droppers for larger insects and larval stages respectively. The larval stages and small specimens were identified under microscope. Adult flying insects were

collected from the water surface using sweep net at sampling sites of Lake Pichhola. The insects were sorted, counted and identified by using standard taxonomic keys Bal and Basu (1994), Bal and Basu (1994a), Subramanian (2005) Mccafferty (1981) and Pennak (1978) and later on released without causing any harm to them.

Analysis of data: Data were analysed by using Microsoft Excel. Diversity and other indices were calculated using the following formulae:

Shannon-Wiener diversity index (H): The diversity index was calculated by using the Shannon-Wiener diversity index (1949). The formula is:

H= $-\sum_{i=0}^{n} pilnpi$

Where, Pi= S/N
S= Number of individuals in species
N= Total number of individuals in all species
ln= Logarithm to base e

Pielou's Evenness Index (E): For calculating the evenness of species, Pielou's Evenness Index (E) was calculated (Pielou, 1966) using the formula:

E=H/lnS

Where,
H= Shannon-Wiener diversity index
S=Total number of species in the sample

Margalef's index (R): Margalef's index was used as a simple measure of species richness (R) (Margalef's, 1958). The formula is-

R= S-1/ lnN
Where,
S**=** Total number of Species
N= Total number of individuals in the sample
ln= Natural logarithm

Relative Dominance Index: The Dominance index was calculated using this formula

Relative Dominance= ni/N×100
Where,
ni= Number of individuals of a particular species
N= Total number of individuals of all species

RESULTS

A total of 881 individuals of aquatic insects belonging to 24 species, 12 families and 6 orders were captured and identified during the study period, between October 2019 and March 2020 from five different locations of lake Pichhola. Maximum individuals (251) of aquatic insects were recorded at locus-1 and minimum individuals were recorded at locus-5 (Table1). Out of these 6 orders, Odonata were most dominant (35.5%) with 313 individuals and second most dominant order was Hemiptera (21.9%) with 193 individuals followed by Diptera (21.6%) with 190 individuals, Ephemeroptera (11.5%) with 101 individuals, Coleoptera (7.3%) with 64 individuals and least one was Trichoptera (2.3%) having 20 individuals (Table 2). Shannon-Wiener diversity index was maximum for order Diptera followed by Coleoptera, Hemiptera, Odonata and minimum for order Trichoptera, these values are 1.56, 1.54, 1.52, 1.51, 1.41 and 1.26 respectively (Table 2).

Table1: Structure of Aquatic Insect Diversity of Lake Pichhola

S. No.	Taxa	Common Name	Locus 1	Locus 2	Locus 3	Locus 4	Locus 5	Total No. of insects
Order: Coleoptera								
Family: Dytiscidae								
1.	*Laccophillus sp.*	Spotted diving beetle	10	24	2	13	15	64
Order: Odonata								

Family: Libellulidae								
2.	*Acisoma panorpoides*	Asian pintail	4	_	6	2	1	13
3.	*Sympetrum meridionale*	Autumn meadowhawk	5	3	5	1	_	14
4.	*Diplacodes lefebvrii*	Black percher	1	7	8	_	_	16
5.	*Trithemis pallidinervis*	Dancing dropwing	17	10	9	6	8	50
6.	*Trithemis aurora*	Crimson marsh glider	15	12	7	9	4	47
7.	*Tholymis tillarga*	Foggy winged twister	12	17	11	8	2	50
Family: Coenagrionidae								
8.	*Pseudagrion decorum*	Three strip blue dart	24	15	20	13	5	77
9.	*Pseudagrion malabaricum*	Malabar sprite	2	2	_	1	_	5
10.	*Amphiallagma parvum*	Little blue	3	5	4	6	_	18
11.	*Ichnura sengalensis*	Senegal golden darter	4	8	-	6	3	21
Family: Aeshnidae								
12.	*Anax guttatus*	Blue tailed green darter	2	_	_	_	_	2
Order: Ephemeroptera								
Family: Baetidae								
13.	*Baetis* sp.	Small minnow mayfly	30	21	20	14	`16	101
Order: Trichoptera								
Family: Hydropsychidae								
14.	*Hydropsyche pellucidula*	Net-spinning caddisfly	7	4	5	_	_	16
15.	*Cheumatopsyche lepida*	Net-spinning caddisfly	2	1	_	_	1	4
Order: Hemiptera								
Family: Nepidae								
16.	*Ranatra linearis*	Water stick insect	13	15	12	12	8	60
17.	*Ranatra elongata*	Water stick insect	10	8	7	8	6	39
Family: Gerridae								
18.	*Gerris lacustris*	Common water strider	6	8	6	2	_	22
Family: Corixidae								
19.	Corixa sp. (*Corixa punctata*)	Water boatman	18	10	10	5	3	46
Family: Notonectidae								
20.	Notonecta sp.	Water back swimmer	7	6	8	2	3	26
Order: Diptera								
Family: Chironomidae								
21.	*Chironomus pulmosus*	Non biting midge	29	22	10	7	6	74
Family: Culicidae								
22.	*Culex sp.*	_	10	8	13	9	15	55
23.	*Anopheles sp.*	_	15	20	4	6	4	49
24.	*Aedes sp.*	_	5	4	2	1	_	12
Total individuals			251	230	169	131	100	881

Table 2: Relative Dominance and Diversity of different insect orders in Lake Pichhola

Order	Relative Dominance	Shannon weiner Index (H)
Odonata	35.5%	1.41
Hemiptera	21.9%	1.51
Diptera	21.6%	1.56
Ephemeroptera	11.5%	1.26
Coleoptera	7.3%	1.54
Tricoptera	2.3%	1.52

Table3: Diversity, Evenness and Richness Indices of insects at study site (Lake Pichhola)

Index	Value
Shannon-Weiner Species Diversity (H)	2.87
Margalef Richness Index (e)	3.32
Pielou's Evenness Index (R)	0.91

Table 4: Diversity of insects at different loci of Lake Pichhola

Locus No.	L-1	L-2	L-3	L-4	L-5
Shannon-Weiner Species Diversity (H)	2.79	2.88	2.80	2.74	2.48
Margalef Richness Index (e)	4.16	3.85	3.71	4.51	3.26
Pielou's Evenness Index (R)	0.88	0.93	0.94	0.87	0.89

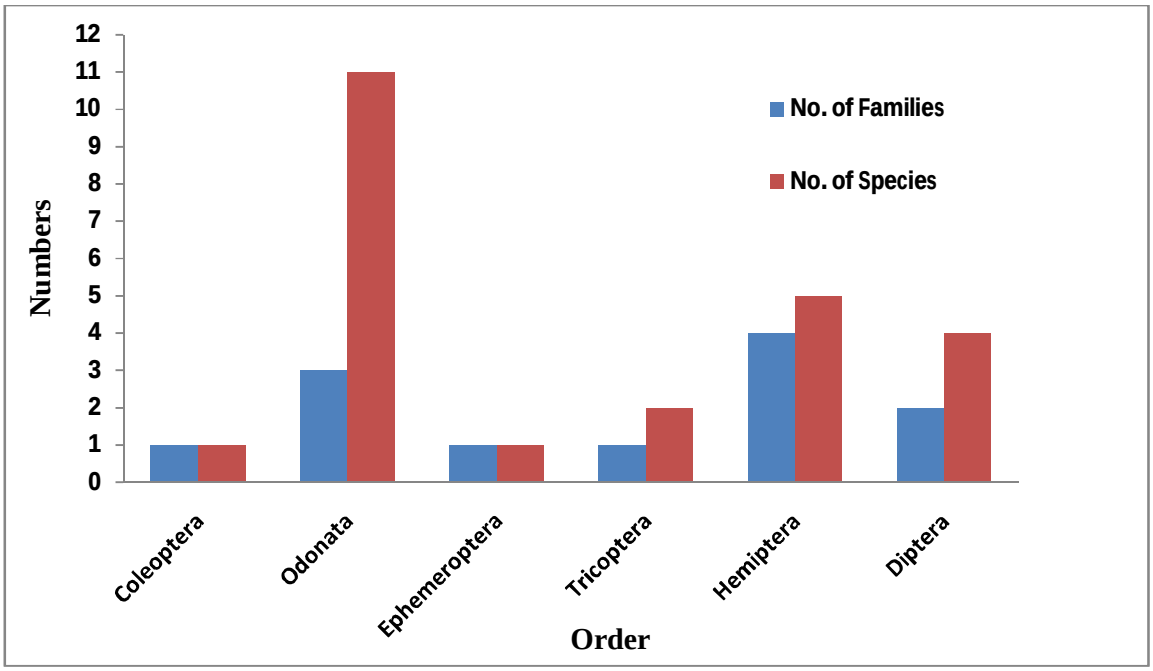

Figure1: No. of insect species and their families from various insect orders from Lake Pichhola

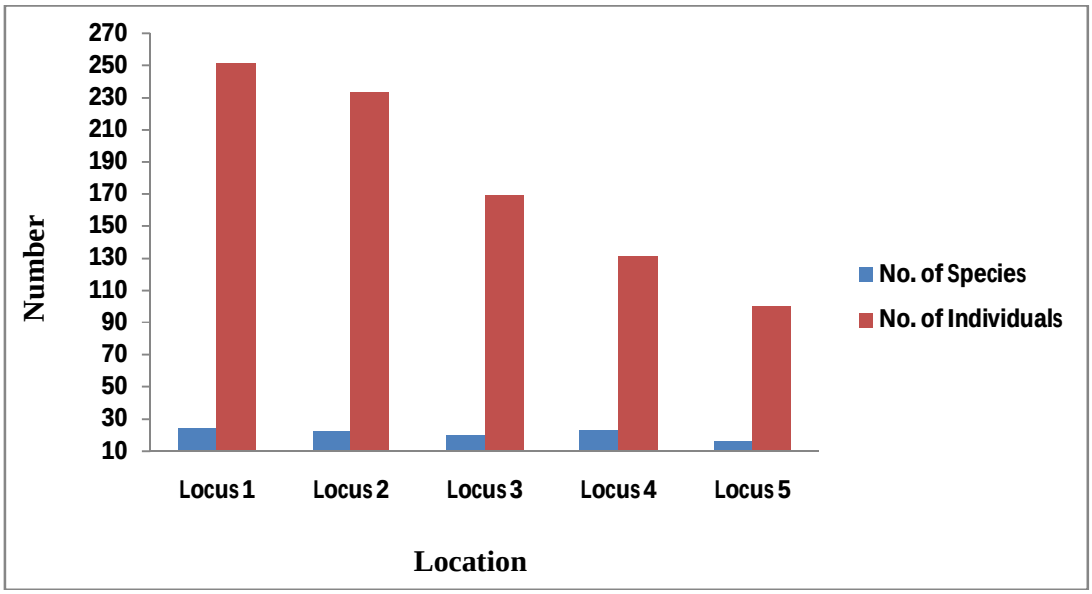

Figure 2: No. of Species and No. of Individual insects at five different loci of Lake Pichhola

Out of 13 identified families Libellulidae was most dominant with respect to number of individuals followed by Coenagrionidae, Culicidae, Baetidae, Nepidae, Chironomidae, Dytiscidae, Corixidae, Notonectidae, Gerridae, Hydropsychidae and Aeshnidae respectively.

The most dominant insect species in study area was Small minnow mayfly, *Baetis* sp. followed by *Pseudagrion, Chironomus pulmosus, Thermonectus marmoratus, Ranatra linearis, Culex sp., Trithemis pallidinervis* and *Tholymis tillarga, Anopheles* sp., *Trithemis aurora,* Corixa sp. (*Corixa punctata*), *Ranatra elongate,* Notonecta sp., *Gerris lacustris, Amphiallagmaparvum, Diplacodes lefebvrii* and *Hydropsyche pellucidula* and *Hydrachnidia sp.*, *Sympetrum meridionale, Acisoma panorpoides, Ades sp., Pseudagrion malabaricum, Cheumatopsyche lepida* and *Anax guttatus* respectively (Table1). Diversity, evenness and richness indices of insects at study site are as given in Table 3.

Species Richness was maximum for locus-4 followed by locus-1, locus-2, locus-3 and least for locus-5, whereas Evenness was maximum for locus-3 followed by locus-2, locus-5, locus-1 and least for locus-4 (Table 4). But Shannon-weiner diversity index (H) was maximum for locus-2 followed by locus-3, locus-1, locus-4 and least for locus-5 (Table 4),because diversity depends on both components - Richness and Evenness.

DISCUSSION

Aquatic insect orders Ephemeroptera, Hemiptera, Diptera, Odonata, Trichoptera and Coleoptera showed high species richness and abundance. In contrast, insect order Plecoptera was completely absent in the studied lake. The absence of Plecoptera suggests that the Lake Pichhola is disturbed and polluted lake.

Sensitive insect species slowly excluded during unfavorable conditions, resulting in a community structure which was noticeably different from undisturbed sites. Chironomidae are indicative of poor water quality from various anthropogenic activities (Yakub, 2004) and dominated in heavily organic polluted water bodies (Ali et al., 2003).

Overall species richness and relative abundance show that insects of the orders Odonata and Hemiptera were the most dominant and order Trichoptera was the least dominant in the lakes of Pichhola. With this work, we have been

able to present a baseline insect diversity data of this freshwater lake, Pichhola.

Recreational activities like boating and water sports in the lake are likely to affect the abundance of aquatic insects. Other environmental influences have not been considered which might possibly affect the biodiversity of aquatic insects in this lake.

Plunge in biodiversity is widespread in freshwaters than in other aquatic environments (Sala et al., 2000). There are multiple reasons for plight in freshwater biodiversity (Reid et al., 2019). Factors like pollution, global climate change, overexploitation of freshwater resources and invasive species in freshwater bodies are accountable for depletion in biodiversity.

CONCLUSION

Lake Pichhola is a fairly large and deep lake with good amount of organic and inorganic material, dissolved oxygen and high concentrations of mineral nutrients. These characteristics make this lake propitious for supporting aquatic hexapods. The biodiversity of aquatic insects in lake Pichhola is indicative of the polluted waters of the lake. Dumping of solid, liquid wastes from residential as well as tourism based industries and over exploitation of lake waters are a major cause of lake degradation. Remedial measures need to be implemented strictly to ameliorate the situation.

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