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Biodiversity Assessment of Chironomids (Diptera: Chironomidae) in Rajsamand Lake (Rajsamand, Rajasthan, India)

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Abstract: Present study was performed for taxonomic identification, assemblage, richness, spatial distribution and abundance analysis of chironomid larvae in the benthic and lentic shoreline habitat of Rajsamand Lake, India. Chironomids play an important role in shallow water aquatic ecosystems, so this study will give an idea about ecology of this area. Topographical and environmental factors are strongly correlated with the composition of chironomid communities. No information is available regarding these organisms in this defined area, so this study would provide data for comparison with chironomid community present in nearby and other area, where study on chironomids is already done or will be done. This study on chironomids was conducted for the first time in Rajsamand Lake, India. Specimens were collected at seven sampling sites along shoreline of the Lake. A total of four genera (*viz. Chironomus, Cryptochironomus, Einfeldia* and *Polypedilum*) were reported. *Polypedilum* was the most dominant genus reported followed by *Chironomus, Einfeldia* and *Cryptochironomus*. Genus *Cryptochironomus* was reported for the first time in Rajasthan.

Keywords: Chironomids, Rajsamand Lake, Biodiversity, *Chironomus, Cryptochironomus, Einfeldia, Polypedilum*

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Introduction

Biodiversity is the study of variation of particular clade. However, exact measure of biodiversity in a defined area is difficult to estimate but random sampling always help to assume the ratio of particular taxa.

Biodiversity of taxa is linked with environmental factors and exploitable resources in a defined area (Fesl, 2002). Chironomids are a group of holometabolous cosmopolitan group of aquatic dipterans. They

show metamorphosis with ecdysis and usually have four instars. They are known by many names such as lake flies, blind mosquitoes, muffleheads, chizzywinks, bloodworms, choira *etc.* Their sensitivity to changing environmental conditions makes them potential bioindicators in both lacustrine and riverine habitats (Armitage *et al.*, 1995). These organisms were influenced over time by a range of indirect and direct variables such as human activity, which affect aquatic habitats in many ways (Antczak-Orlewska *et al.*, 2021). Biotic factors are important in determining zoobenthos communities in shallow lakes and chironomids are very good indicators of past changes in primary production (Langdon *et al.*, 2010). Most chironomids are detritivores and feed on phytoplankton, zooplankton and decaying organic matter. Most larvae live in tubes built of sediment (Armitage *et al.*, 1995). They are very considerable diet for fish, aquatic birds and other aquatic invertebrates (Leonard and Ferrington, 2008). Chironomids are ignored by many researchers due to difficulties faced in identification and scarcity of literatures. They can be identified up to species level only by rearing adult males or through DNA barcoding (Brodin *et al.*, 2013). Further documentation and databases of this fauna throughout the globe is also not complete (Armitage *et al.*, 1995). A phylogeny based on cladistic analysis of chironomids subfamilies was proposed by Saether (2000). The chironomids have high adaptability to survive under widely different climatic conditions such as pH, temperature, salinity and low oxygen, where many other organisms cannot (Acosta and Prat, 2010; Cao *et al.*, 2019; Belle and Goldkoop, 2021). Chironomids have also been reported from glacial melt stream at

5600 meter above sea level in Himalaya Mountains (Koshima, 1984). The deformities in mouthparts especially in mentum are used in biomonitoring programmes to obtain information about organic and chemical pollution of aquatic water bodies and their catchments (Morais *et al.*, 2010). Topographical and environmental factors such as altitude, latitude, vegetation, drainage, temperature, area size, eutrophication *etc.* affect their spatial distribution and assemblage (Rossaro, 1991). Their fossils are also used in palaeolimnology to guess past climatic change (Brodersen and Quinlan, 2006). Chironomids have both negative and positive impact on humans. Negative impact includes nuisance species that acts as paddy pest, allergens and host for pathogenic bacteria (Broza and Halpern, 2001). Positive impact includes, essential role in nutrient cycling, energy flow, biofiltering and food for freshwater commercial and sport fisheries (Rawal *et al.*, 2018, 2019; Arkia *et al.*, 2019).

This study was performed for taxonomic identification, assemblage, richness, spatial distribution and abundance analysis of chironomid larvae in the benthic and lentic shoreline habitat of Rajsamand Lake, India.

Materials and Methods

Rajsamand Lake also known as Rajsamudra Lake (Fig. 1) was built in 17th century by Rana Raj Singh. It has shoreline of about 15 km and surface area of approximately 9 km². This is a eutrophic Lake which has shoreline development index of about 1.4102. Maximum depth of this lake is about 18 meters. Lake is on altitude of approximately 550 meter above sea level. Primary inflow is of Gomati River and Nandsamand Dam (Naruka and Sharma, 2017).

Figure 1: Satellite map showing study area and sampling sites (Courtesy: Google Earth)

Random sampling was done at seven sites -- S1-S7 (Fig. 1) with three repetitions on each site in the months of November 2019 to March 2020. Since they are ephemeral, univoltine and semelparous, no seasonal sampling were required. Modified partial quadrant method was used to collect larvae in per square meter area. Since chironomids larvae are found in sediment of shoreline, no deep water sampling was required. Latitudes, longitudes and altitudes of sampling sites were measured using GPS of Smartphone. Larval samples were collected by sieving sediment substrate in bucket, then larvae were carried alive in plastic bottles and labeled with sampling site. After carried to the laboratory, they were counted and sorted for further biodiversity analysis. Larvae were preserved in 70% alcohol and mounted on DPX. Then sorting and identification of these mounted larvae was done up to genera level under microscope (50-1000x magnification) using keys (Epler, 2001). In order to examine significant difference in larval density among sampling sites standard deviations and standard errors of means were calculated for each sampling sites. For comparison of

biodiversity among seven sampling sites, Shannon-Weiner and Simpson indices were calculated. Shannon index is an informative index which considers all taxa randomly but Simpson index focuses more on dominant taxa. Evenness index were calculated for assessment of equitability and Dominance index for assessment of Dominance among sampling sites. Statistical analyses were done using *Microsoft Excel* and *Past* software (Version 4.05). Shannon-Weiner, Simpson indices and Pielou's Evenness index were calculated as ---

Shannon-Weiner diversity index (H) = $-\sum [(p_i) * \ln (p_i)]$
where, Σ =summation; p_i = ratio of samples upon total sum of samples

Simpson diversity index (D) = $1 - [\sum n(n-1)/N(N-1)]$
where, Σ =summation; N = total number of individuals of all taxa; n =number of individuals in particular taxa

Pielou's Evenness index (E) = H/H_{max}
where, H = Shannon-Weiner index; H_{max} = maximum diversity possible

Dominance index = $1-D$
where D is Simpson diversity index

Results and Discussion

Chironomids larvae were sorted among other aquatic larvae using distinguished features such as red color, absence of spiracles, prolegs on first thoracic and terminal abdominal segments. Larval mouthparts are adapted to their diet. Mentum, mandibles and ventromental plates are key features for morphological identification in our study. Subfamily Chironominae was confirmed using distinguished features such as presence of mentum with 12 teeth, one or two pair of eye spots, striated ventro-mental plates and antennae with five segments. However, taxonomic species identification of larval chironomids is time consuming and difficult due to morphological similarities in them.

Table 1: Data of sampling and mean larval density

Sampling Sites	Sampling 1	Sampling 2	Sampling 3	mean density (n/m ²)	S. D.	S. E.
Site 1	116	94	106	105.33	11.02	4.16
Site 2	214	132	181	175.66	41.26	15.59
Site 3	106	83	94	94.33	11.50	4.35
Site 4	93	75	86	84.66	9.07	3.43
Site 5	41	20	31	30.66	10.50	3.97
Site 6	64	48	57	56.33	8.02	3.03
Site 7	103	83	91	92.33	10.07	3.80

DNA barcoding using COI (cytochrome oxidase I) gene is useful for species confirmation but due to their abundance and absence of available GenBank database, it is also not feasible for all collected larvae. Chironomid species identification and confirmation using chromosomes is also not possible due to chromosomal polymorphism amongst members of same species. So in this study identification of larval chironomids is limited up to genera level. At site 2 larval chironomid densities was reported maximum and at site 5, it was reported minimum. Overall mean density of larval chironomids along shoreline of Rajsamand Lake is 91.32/m² (Table 1).

The family Chironomidae is one of the most abundant dipterans group present in all zoogeographical regions (Leonard and Ferrington, 2008). Review of records and species accounts confirms a total of eleven subfamilies (*viz.* Aphroteniinae,

Buchonomyiinae, Chilenomyiinae, Chironominae, Diamesinae, Orthoclaadiinae, Podonominae, Prodiamesinae, Tanypodinae, Telmatogetoninae and Usumbaromyiinae), which further grouped in 22 tribes and 339 genera and more than 4000 reported species but it estimates that more than 10000 species may be present (Ashe, 1983). In oriental region total 105 genera and more than 350 species are reported. In India there are four reported subfamilies (*viz.* Chironominae, Diamesinae, Orthoclaadiinae and Tanypodinae) with 313 species under 60 genera (Chaudhuri *et al.*, 2001). Few recent studies have been done on chironomids in Rajasthan, India. First chironomid species reported in Rajasthan (Jaipur) was *Chironomus circumdatus* (Sharma and Gupta, 2014). Later we also reported a new species *Einfeldia pritiensis* in Udaipur (Singh and Rawal, 2016 a). We also reported three genera (*viz.* *Chironomus*, *Einfeldia* and *Polypedilum*) from lakes (Fatehsagar, Pichola and Udaisagar) of Udaipur region (Singh and

Table 2: Genera recorded along sampling site

Genera	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7	Total
<i>Polypedilum</i> (Kieffer)	105	188	95	93	40	70	103	692
<i>Chironomus</i> (Meigen)	89	158	87	82	26	50	80	572
<i>Einfeldia</i> (Kieffer)	81	130	76	62	21	40	69	479
<i>Cryptochironomus</i> (Kieffer)	27	32	15	9	3	4	14	104
Not identified	14	19	10	8	2	5	11	69
Total	316	527	283	254	92	169	277	1918

Fig. 2: Bar graph showing relative abundance of chironomid genera (site wise)

Rawal, 2016 b), which are about 55 km (straight distance) away from present study site. Four genera (viz. *Chironomus*, *Clinotanypus*, *Einfeldia* and *Polypedilum*) were also reported recently from Jaisamand Lake which is 90 km (straight distance) from current study area (Verma and Rawal, 2021). A total of four genera (viz. *Chironomus*, *Cryptochironomus*, *Einfeldia* and *Polypedilum*) were reported. *Polypedilum* was the most dominant genus reported followed by *Chironomus*, *Einfeldia* and *Cryptochironomus*

(Table 2; Fig. 2). Genus *Cryptochironomus* was reported for the first time in Rajasthan. All four reported genera belong to subfamily Chironominae and Tribe Chironomini.

Study on chironomids of Rajasthan is very rare. This study will also help to understand the taxonomic diversities of chironomids in Rajsamand Lake. A total of four genera (viz. *Chironomus*, *Cryptochironomus*, *Einfeldia* and *Polypedilum*) were identified with dominant genus *Polypedilum*. *Polypedilum* was found to be most dominant (36%) among four

■ Polypedilum ■ Chironomus ■ Einfeldia ■ Cryptochironomus ■ Not identified

Figure 3: Pie graph showing relative abundance of chironomid genera (overall)

Table 3: Diversity indices obtained for sampling sites

Diversity Indices	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	Site 7
Individuals	302	508	273	246	90	164	266
Shannon index (H)	1.296	1.254	1.247	1.202	1.172	1.16	1.234
Simpson index (D)	0.7123	0.6969	0.6968	0.6811	0.6635	0.6648	0.6896
Dominance index (1-D)	0.2877	0.3031	0.3032	0.3189	0.3365	0.3352	0.3104
Evenness index (E)	0.9139	0.8761	0.8701	0.832	0.8072	0.7977	0.8585

reported genera. *Chironomus* (30%) was found second most dominant genus. *Einfeldia* (25%) was at third place in dominance and least reported genus was *Cryptochironomus* (5%) (Fig. 3). The maximum diversity of chironomid genera was reported at site 1 and minimum at site 6 (Shanon-Weiner Index) and site 5 (Simpson index). Maximum dominance of chironomids was reported at site 5 and minimum at site 1. Maximum evenness index was reported at site 1 and minimum at site 6 (Table 3).

Conclusion

Four genera were identified in this Lake, (viz *Chironomus*, *Cryptochironomus*, *Einfeldia* and *Polypedilum*). *Polypedilum* was the most dominant genus reported followed by *Chironomus*, *Einfeldia* and *Cryptochironomus*. All four reported genera belong to subfamily Chironominae and Tribe Chironomini. Three genera (viz. *Chironomus*, *Einfeldia* and *Polypedilum*) were also previously reported in Udaipur region, which is about 50 km

(straight distance) away from this site. Genus *Cryptochironomus* was reported for the first time in Rajasthan. This study proposes a general pattern of biodiversity, distribution and abundance of chironomids along shoreline of Rajsamand Lake. This study will also give an idea about ecology of this area because environmental factors are strongly correlated with the composition of chironomid communities. This study will provide basic data for comparison of chironomid community present in nearby and other areas as well as their use as potential bioindicators in this water body.

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