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# Biodiversity analysis of chironomids (Diptera: Chironomidae) in Jaisamand Lake (Udaipur, Rajasthan)

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**Abstract**
The objective of this study was to examine biodiversity, taxonomic identification and abundance of chironomid larvae in the benthic and lentic habitat of Jaisamand Lake. This study will give idea about ecology of this area because environmental and topographic factors are strongly correlated with the composition of chironomid communities and would also provide data for comparison with chironomid community present in nearby and other areas, where study on chironomids is already done or will be done. No information is available about diversity and abundance of these organisms in this defined area, so this novel study on chironomids was conducted for the first time in Jaisamand Lake. A total of four genera (*viz. Chironomus, Clinotanypuus, Einfeldia* and *Polypedilum*) were identified with dominant genus *Polypedilum* followed by *Einfeldia*, *Chironomus* and *Clinotanypus*. Genus *Clinotanypus* under subfamily Tanypodinae was reported for the first time in Rajathan.

**Keywords:** chironomids, Jaisamand Lake, biodiversity, *Chironomus, Clinotanypus, einfeldia, Polypedilum*

## Introduction

Biodiversity is the study of variation of particular taxa. However exact measure of biodiversity in a defined area is difficult to estimate but random sampling always help to assume the proportion of particular taxa. Biodiversity of taxa is linked with environmental factors and exploitable resources in a defined area. Taxa richness is also influenced by niche partitioning and other communities available in defined area. Pattern of taxa abundance may also indicate the degree of disturbance to which that taxa are exposed (Fesl, 2002) [12]. Chironomids are a group of holometabolous flies also called lake flies and blind mosquitoes. In vernacular local language they are called "choira". Adults are morphologically similar to mosquitoes (Culicidae) but distinguished from them by absence of elongated mouthparts like them. Etymological meaning of chironomids is "pantomimist". Chironomids are very famous and are widely used for study of polytene chromosomes derived from their salivary glands. These non biting midges are common in aquatic habitats and shoreline niches. They also dominate as aquatic insect communities in both taxa richness and abundance (Bitusik *et al*, 2020) [6]. Chironomids are important components of aquatic food webs with estimated more than 10,000 species worldwide (Armitage *et al*, 1995; Cranston, 1995) [2, 9]. Recently their uses as bioindicators is become prominent (Rawal *et al*, 2018; 2019) [17, 18] because they are good indicators of eutrophication and oxygen depletion (Johnson *et al*, 1993) [14]. These benthic midges are among the best bioindicators of organic enrichment since their community structure and abundance change rapidly in response to the change in environment (Bazzanti, 2000) [5]. The use of littoral chironomids in Lake classification is prominent because besides Oligochaeta, they are only major invertebrates group of benthos inhabiting littoral zones of lentic habitats like lakes. Larval chironomids consume smaller benthic organism, periphyton and detritus (Brodersen & Quinlan, 2006) [7]. At a local level, climate change affects biodiversity through taxa expansion or contraction of their range in response to climate change (Korhonen *et al*, 2010) [15]. Inland water covers less than 1% of the earth's surface but provide habitat for 10% of known organisms. 60% of them are aquatic insects (Dijkstra *et al*, 2014) [10]. Production of benthic chironomid larvae is exported to terrestrial consumers via adult midges hence linking aquatic to terrestrial ecosystems (Gratton & Vander Zanden, 2009) [13].

## Study Area

Jaisamand Lake also known as Dhebar Lake (Figure 1) is India's second largest artificial lake surrounded by Jaisamand Wildlife Sanctuary. It was built by Maharana Jai Singh in 1685. It has a surface area of about 48 km$^2$ and shoreline of approximately 81 km and maximum depth of 31meters. It is a mesotrophic lake, which has shoreline development index of 3.29414. Lake is on altitude of about 290 meter above sea level. Primary inflow and outflow of Jaisamand Lake is Gomati River (Balai *et al*, 2015; 2017) [3, 4].

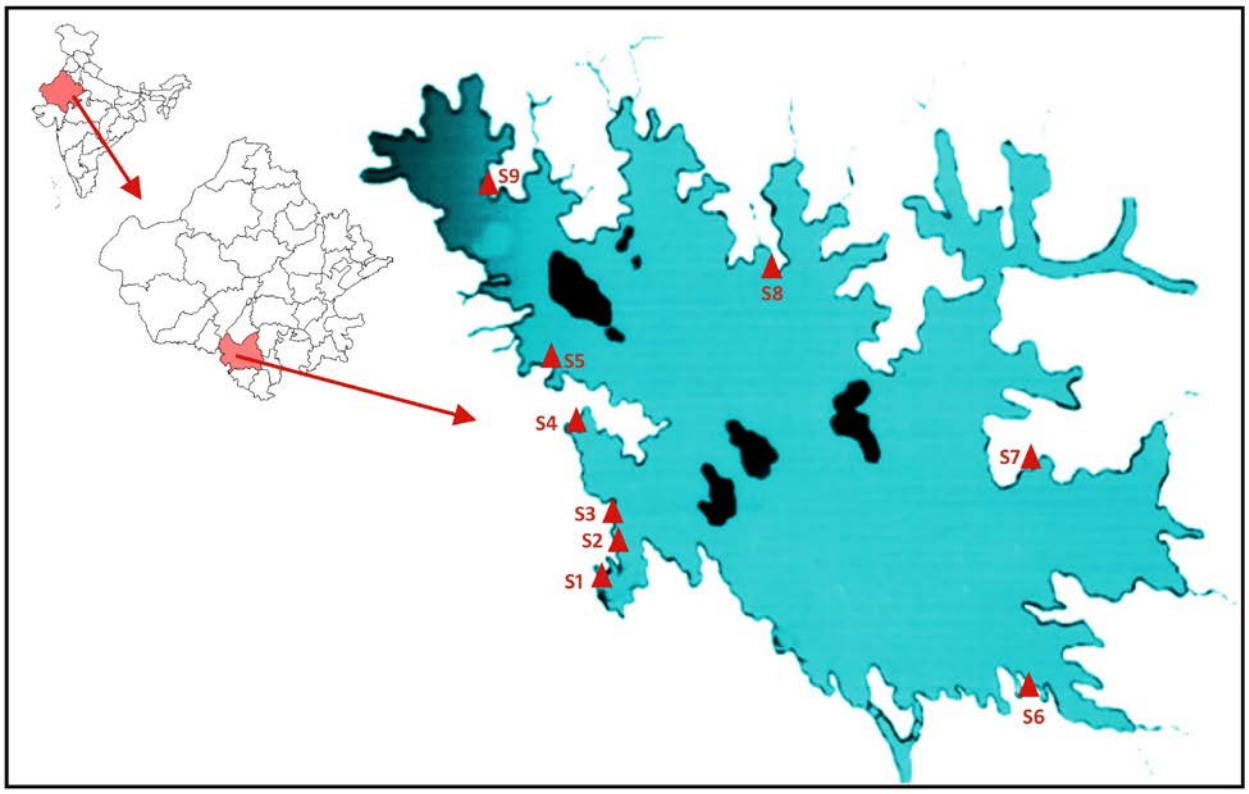


**Fig 1:** Map showing study area and sampling sites.

## Materials and Methods

Random sampling was done at nine sites S1-S9 (Figure 1) with three repetitions on each site in the months of November 2019 to March 2020. Since they are univoltine, ephemeral and semelparous, no seasonal sampling were required. Modified partial quadrant method was used to collect larvae in per meter square area. Since chironomids larvae are found in sediment of shoreline so no need of 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 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) [11]. For comparison of biodiversity among nine sampling sites, Shannon-Weiner and Simpson index 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. In order to examine significant difference in larval density among sampling sites standard deviations and standard errors were calculated for each sampling sites. Biodiversity analysis and statistics was done using *Microsoft Excel* and *Past* software (Version 4.05).

$$\textbf{Standard deviation (SD)} = \sqrt{[\Sigma (xi - x)2 / (n - 1)]}$$

Where, x is the sample mean,
xi = the ith element from the sample,
n = sample size

**Standard error (SE)** = SD /$\sqrt{n}$
Where, SE is standard error,
n = sample size

**Shannon-Weiner diversity index (H)** = -Σ [(pi) * In (pi)]
Where, Σ=summation
pi = ratio of samples upon total sum of samples

**Simpson diversity index (D)** = 1- [Σ 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 Eveness index (E)** = H/Hmax
Where, H= Shannon-Weiner index
Hmax= maximum diversity possible

**Dominance index** = 1-D

## Results and Discussion

Chironomids larvae were sorted among other aquatic larvae using distinguished features such as red color, absence of spiracles, prologs on first thoracic and terminal abdominal segments. 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. Subfamily Tanypodinae was confirmed using distinguished features such as presence of ligula. However taxonomic species identification of larval chironomids is time consuming and difficult due to morphological similarities in them. DNA barcoding using COI (cytochrome oxidase I) gene is useful for species confirmation but due to their abundance and absence of available GenBank/NCBI database, it is also not feasible. 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 7 it was reported minimum. Overall mean density of larval chironomids along shoreline of Jaisamand Lake is reported 57.5/m$^2$ (Table 1). Chironomidae family has been subdivided into eleven subfamilies (*viz.* Aphroteniinae, Buchonomyiinae, Chilenomyiinae, Chironominae, Diamesinae, Orthocladiinae, Podonominae, Prodiamesinae, Tanypodinae, Telmatogetoninae and Usumbaromyiinae). In India there are four subfamilies (*viz.* Chironominae, Diamesinae, Orthocladiinae and Tanypodinae) are reported with 313 species under 60 genera (Chaudhuri *et al*, 2001) [8]. First chironomid species reported in Rajasthan (Jaipur) is *Chironomus circumdatus* (Sharma and Gupta, 2014) [19]. Later we also report a new species *Einfeldia pritiensis* in Udaipur (Singh and Rawal, 2016a) [20]. We also reported three genera (*viz. Chironomus*, *Einfeldia* and *Polypedilum*) from lakes (Fatehsagar, Pichola and Udaisagar) of Udaipur region (Singh and Rawal, 2016b) [21], which are about 50 km (straight distance) away from present study site. Same three genera (*viz. Chironomus*, *Einfeldia and Polypedilum*) were also reported recently from Rajsamand Lake which is about 90 km (straight distance) from this site (Prajapat &Rawal, 2021) [16]. In this study we reported four genera (*viz. Chironomus*, *Clinotanypuus*, *Einfeldia* and *Polypedilum*) were identified with dominant genus *Polypedilum* followed by *Einfeldia*, *Chironomus* and *Clinotanypus* (Table 2 & Graph 1). Genus *Clinotanypus* under subfamily Tanypodinae was reported for the first time in Rajasthan.

**Table 1:** Data of sampling and mean larval density.

| Sampling Site | Sampling 1 | Sampling 2 | Sampling 3 | mean density (n/m$^2$) | S.D. | S.E. |
|---|---|---|---|---|---|---|
| Site 1 | 48 | 60 | 50 | 52.67 | 6.43 | 3.71 |
| Site 2 | 104 | 70 | 79 | **84.33** | 17.62 | 10.17 |
| Site 3 | 90 | 80 | 72 | 80.67 | 9.02 | 5.21 |
| Site 4 | 54 | 68 | 32 | 51.33 | 18.15 | 10.48 |
| Site 5 | 39 | 55 | 69 | 54.33 | 15.01 | 8.67 |
| Site 6 | 88 | 76 | 40 | 68.00 | 24.98 | 14.42 |
| Site 7 | 36 | 41 | 30 | **35.67** | 5.51 | 3.18 |
| Site 8 | 53 | 38 | 43 | 44.67 | 7.64 | 4.41 |
| Site 9 | 67 | 32 | 40 | 46.33 | 18.34 | 10.59 |

**Table 2:** Genera reported along sampling site.

| Genera | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| *Polypedilum* Kieffer | 40 | 118 | 109 | 48 | 55 | 67 | 40 | 38 | 42 | 557 |
| *Einfeldia* Kieffer | 25 | 82 | 83 | 30 | 33 | 65 | 31 | 37 | 39 | 425 |
| *Chironomus* Meigen | 78 | 46 | 45 | 28 | 27 | 36 | 14 | 33 | 35 | 342 |
| *Clinotanypus* Kieffer | 12 | 0 | 0 | 44 | 40 | 34 | 22 | 26 | 23 | 201 |
| Not Identified | 3 | 7 | 5 | 4 | 8 | 2 | 0 | 0 | 0 | 29 |
| Total | 158 | 253 | 242 | 154 | 163 | 204 | 107 | 134 | 139 | 1554 |

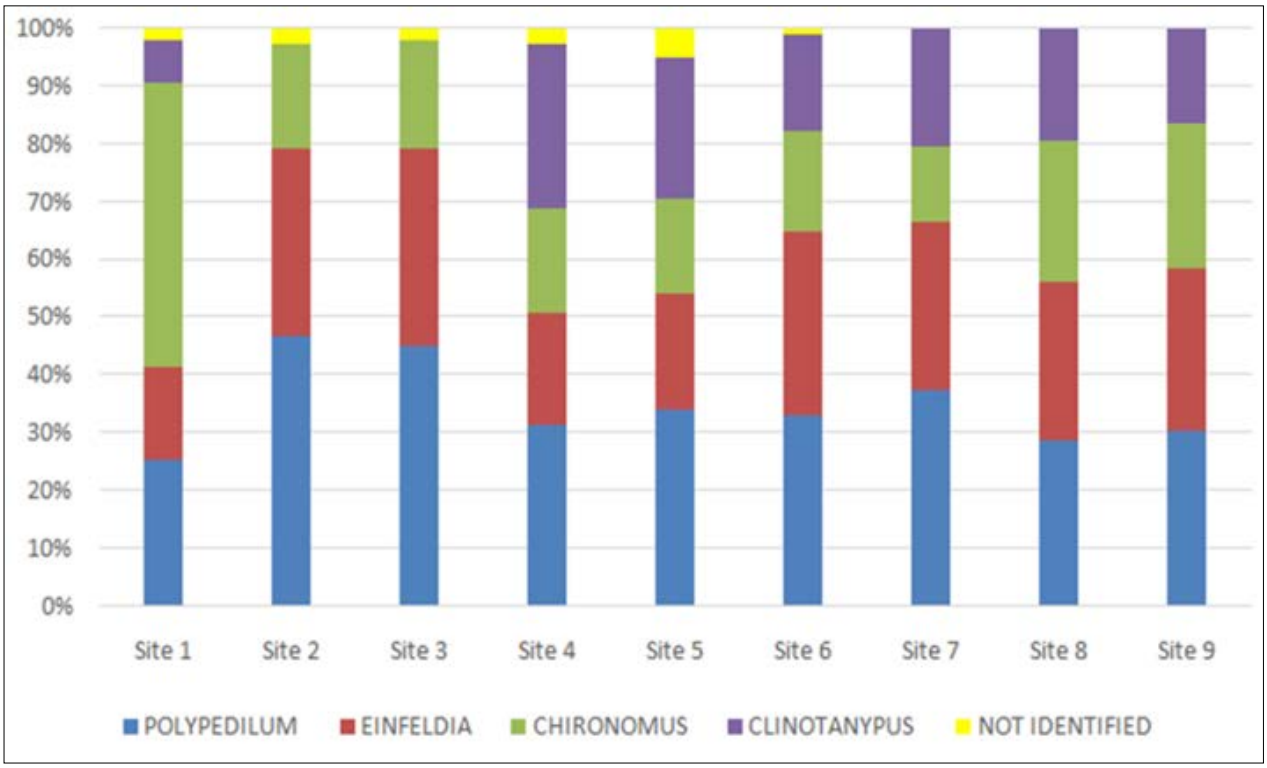


**Fig 2:** Bar graph showing relative abundance of chironomid genera (site wise).

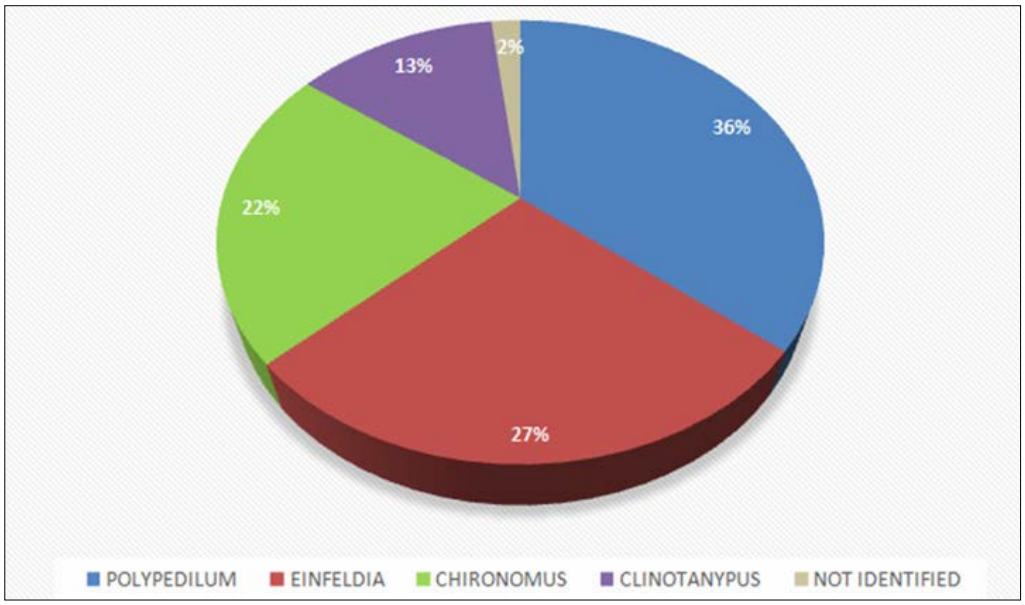


**Fig 3:** Pie graph showing relative abundance of chironomid genera (overall).

Chironomid benthic larvae constitute one of the most abundant organisms of invertebrate communities in freshwater ecosystems. Short life span, short generation time of approximately one month, small body size up to few centimeters and capacity of flight facilitate dispersal and ability to exploit available food resources. Chironomids are able to survive extreme climatic conditions such as oxygen poor water, saline rich water and freezing temperature due to presence of heat shock proteins and hemoglobin analogue which temporarily store oxygen. Larval chironomids are important aquatic food webs as sources of protein, lipids and minerals for aquatic macroinvertebrates, fishes, amphibians and aquatic birds (Armitage *et al*, 1995) [2]. Chironomids are sensitive to minor changes in water quality, so serve as bioindicators in freshwater biomonitoring assessments. Mouthparts deformities also indicate specific water contamination. Dominant subfamilies of Chironomidae at higher altitudes are Diamesinae, Orthocladiinae and Podonominae, while at lower altitudes are Chironominae and Tanypodinae (Acosta & Prat, 2010) [1]. Present studies generate knowledge of chironomid taxonomy in limo-terrestrial environments of Jaisamand Lake and provide fundamental information for using these animals for environmental monitoring in future. This study will also help to understand the taxonomic diversities of chironomids in Jaisamand Lake under response to various environmental pressures. A total of four genera (*viz. Chironomus, Clinotanypuus, Einfeldia* and *Polypedilum*) were identified with dominant genus *Polypedilum*. *Polypedilum* was found to be most dominant (36%) among four reported genera. *Einfeldia* (27%) was found second most dominant genus. *Chironomus* (22%) was at third place in dominance and least reported genus was *Clinotanypus* (13%) (Graph 2). The maximum diversity of chironomid genera was reported at site 8 and minimum at site 2. Maximum dominance of chironomids was reported site 2 and minimum at site 8. Maximum evenness index was reported at site 8 and minimum at site 1 (Table 3).

**Table 3:** Diversity indices obtained for sampling sites.

| Diversity Indices | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 9 |
|---|---|---|---|---|---|---|---|---|---|
| Individuals | 155 | 246 | 237 | 150 | 155 | 202 | 107 | 134 | 139 |
| Shannon index (H) | 1.187 | 1.032 | 1.04 | 1.36 | 1.351 | 1.338 | 1.318 | 1.376 | 1.363 |
| Simpson index (D) | 0.6482 | 0.6238 | 0.6298 | 0.7367 | 0.7318 | 0.7264 | 0.7169 | 0.745 | 0.7392 |
| Dominance (1-D) | 0.3518 | 0.3762 | 0.3702 | 0.2633 | 0.2682 | 0.2736 | 0.2831 | 0.255 | 0.2608 |
| Evenness (E) | 0.8197 | 0.9357 | 0.9432 | 0.9736 | 0.9653 | 0.953 | 0.9341 | 0.9898 | 0.9771 |

## Conclusion

We propose a general pattern of biodiversity, distribution and abundance of chironomids along shoreline of Jaisamand Lake. This study will give idea about ecology of this area because environmental factors are strongly correlated with the composition of chironomid communities. This study will also provide basic data for comparison of chironomid community present in nearby and other areas, so we can use these organisms as potential bioindicators in this water body. Out of these four genera identified in this Lake, three genera (*viz Chironomus, Einfeldia and Polypedilum*) belong to subfamily Chironominae and one genus (*Clinotanypus*) belongs to subfamily Tanypodinae. Three genera (*viz. Chironomus, Einfeldia and Polypedilum*) were also reported in Fatehsagar, Pichola and Udaisagar Lakes of Udaipur region, which is about 50 km (straight distance) away from this site. Same three genera (*viz. Chironomus, Einfeldia and Polypedilum*) were also reported recently from Rajsamand Lake which is about 90 km (straight distance) from this site. Tanypodinae subfamily with genus *Clinotanypus* was reported for the first time in Rajasthan.

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