Review Article

# A Quick Review of the Family Chironomidae (Order: Diptera) with Effect on the Environment

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## ABSTRACT

The chitinous head capsules of larval Chironomidae remind in sediments for a long time. The morphological trait of it shows the climatic changes, history of environment, and chironomids fauna perfect for paleoecological researches. To search about this project, we used a series of keywords as follows: Chironomidae, bioindicator, environment, water stream, water quality, anthropogenic disturbance, pollutant, fossil, industrial waste, aquatic habitats. Chironomidae was used once in single and again in combination with others. Google Scholar, Scopus, Springer, ScienceDirect, PubMed, ProQuest, JSTOR, EBSCO, BioOne, ResearchGate, Sage, Wiley Online Library, and SID were using database or search engines. Then, results were sorted into four sections; distribution and ecology, biotic indicators, food, and paleoecological studies. The identification key of chironomids and molecular technics should be expanded to clarify the taxa characteristics in detail. Anyway, the role of this family in all types of pollutants is ambiguous. More studies are needed to particularize the importance of Chironomidae based on genera and species levels.

**Keywords:** Chironomidae; Diptera; Indicator; Pollutants Environment

## Introduction

Organic pollutants, pathogens, nutrients and agriculture runoff, suspended solids and sediments, inorganic pollutants (salts and metals), and thermal pollution are considerable contaminators of water [1,2]. Toxic metals as toxic waste affect fish health. It damages growth and changes glycogen and triglycerides in the liver as well as the activities of metabolic enzymes of the catfish [3]. Some chemical elements have negative effects on the embryonic development, hatching, and viability of the mallard [4]. Also, these are harmful to human health in either short or long-term exposure. The kidney, pancreas, heart, bones, veins, arteries liver, and brain would be dysfunctional by intake of certain specific water pollutants through drinking water [5]. Bioindicator refers to all possible causing sensitivity to ecological and natural changes by anthropogenic disturbance affecting biodiversity and community of species in it [6-8]. Aquatic macroinvertebrates such as (*Baetis* sp., *Fallceon* sp., *Leptohyphes* sp., *Tricorythodes* sp., *Farrodes* sp., *Phyllogomphoides* sp., *Hydroptila* sp., *Mayatrichia* sp., *Neotrichia* sp., *Oxyethira* sp., *Nectopsyche* sp.1, *Nectopsyche* sp.2, *Oecetis* sp. are sensitive to water contamination as bioindicators [9]. Moreover, Chironomidae is used as a significant insect for bioassessment of water quality for a long time [10]. This study is aimed to determine Chironomidae as an important bioindicator in all types of water bodies and environments furthermore, the role of this macroinvertebrate in the food chain, transfer energy, and paleoecological investigations.

## Methods

To search about this project, we used a series of keywords as follows: Chironomidae, bioindicator, environment, water stream, water quality, anthropogenic disturbance, pollutant, fossil, industrial waste, aquatic habitats. Chironomidae was used once in single and again in combination with others. Google Scholar, Scopus, Springer, ScienceDirect, PubMed, ProQuest, JSTOR, EBSCO, BioOne, ResearchGate, Sage, Wiley Online Library, and SID were using database or search engines. Then, results were sorted into four sections; distribution and ecology, biotic indicators, food, and paleoecological studies. The obtained articles and scientific documents were often helpful. Only a few of them were dropped from our work because of low quality or overlap.

## Results

### Distribution and Ecology

The family Chironomidae (order: Diptera) is a predominant insect in freshwater environments. Little studies have been carried about the lifecycle and ecology of this group. All chironomids have more than 5000 species worldwide but the exact number is unclear yet. A few chironomids have terrestrial habitats [11]. This family is categorized into 11 subfamilies and 22 tribes. Subfamilies include Telmatogetoninae, Usambaromyiinae, Aphroteniinae, Chilenomyiinae, Podonominae, Tanypodinae, Buchonomyiinae, Diamesinae, Prodiamesinae, Orthocladiinae, and Chironominae [12]. *Belgica antarctica*, *Eretmoptera murphyi* (subfamily Orthocladiinae), and *Parochlus steinenii* (subfamily Podonominae) are the only chironomid species identified from Antarctica areas [13]. The subfamily Chilenomyiinae is restricted in Chile, Buchonomyiinae with two species identified from Europe and Asia, The Aphroteniinae, including four genera, are recognized only from South America, South Africa, and Australia. Subfamilies including the Orthocladiinae, Tanypodinae, and Chironominae, are established more in lake sediments [14]. Genus *Dicrotendipes* Kieffer from China, comprise 8 species as: *Dicrotendipes flexus, Dicrotendipes fusconotatus, Dicrotendipes nervosus, Dicrotendipes nudus sp. n., Dicrotendipes pelochloris, Dicrotendipes saetanumerosus sp. n., Dicrotendipes septemmaculatus Dicrotendipes tamaviridis* [15]. This family has four larval instars with around one 1year of longevity but pupal and adult stages lasted about a few days or weeks depending on species and climate. Males swarm about 1 hr before sunrise and scatter about 1 hr after sunset for mating with females [16]. The larvae stage of *Paratendipes albimanus* and *Rheotanytarsus curtistylus* are remained in the second and third instar in winter [17]. Chironomidae were abundant in the organic content of sediments or beds of lakes/rivers [18]. For example, the presence of macrophytes (Potamogeton pectinatus, Ruppia maritima) or benthic algae (*Rhizoclonium hieroglyphicurn*) is a great component to grow *Cricotopus ornatus* (Meigen) (Diptera: Chironomidae) [19] Also, it has been found in gravel sediments. Overall, this is limited to the surface layers of soft sediments but some species habitat more deeply and depth of sediment may be confining to population density in some instances. Some species ingest wood because of having symbiotic microorganisms in their gut [20]. Notably, chironomids larvae use physiological or behavioral strategies to survive in habitats that repeatedly change in the situation, such as rain pools, phytotelmata, freshly filled ponds or soil layers, urban river, hot spring, and coastal lagoons [21-23].

### Biotic indicators

Chironomid Midges adapted to sites with different degrees of water quality of streams in the Scioto River basin, Ohio. *Stictocbironomus*—hard, alkaline unpolluted water; 2) *Pentaneura, Cricotopus,* and *Tanytarsus*—sewage enriched water; 3) *Procladius* and *Dicrotendipes*—high agricultural runoff; 4) *Ablabesmyia* and *Tribelos* —general organic pollution, soft acid water [24]. Moreover, *Chironomus riparius* is considered as an indicator of organic pollution and monitoring sediment toxicity [20,25]. Chironomidae larvae exist in lentic and lotic environments with different taxonomic levels [26-30]. This aquatic macroinvertebrate was found at polluted spots of Barbado Stream in Brazil that pollutants like domestic sewage, plastic materials, root, and slime sorted [31]. Remarkably, riparian vegetation affects Chironomidae assemblage and has a significant role in the composition of aquatic fauna in the neotropical streams [32, 33]. Neonicotinoid insecticides affect Chironomidae life in all stages. It means Chironomidae represent very high densities of high-affinity nicotinic acetylcholine receptors [34]. Also, the major factors influencing Chironomid distribution are temperature associated with $O_2$, $Cl^-$, $Al^{3+}$, $Mg^{2+}$, $Na^+$ ions in lakes of central Yakutia, Russia [35]. The chironomid species (i.e. *Anatopynia plumipes, Procladius* sp., *Psectrotanypus rarius, Cricotopus sylvestris, Psectrocladius edwardsi, Chironomus tentans, C. polaris, Chironomus* sp. I and II, *Einfeld ia dissidens, E. pagana,* and *Glyptotendipes paripés* have shown tolerance to low oxygen pressures and temperature in a frozen lake of northern Sweden [36]. Moreover, larval and pupal of *Pseudodiamesa arctica* were observed in temperature between $0^0$-$4^0$c of Nettilling lake in Baffin Island, Canada but $15^0$c is a desirable temperature in small water bodies for larval growth [37]. PH is one of another environment parameters. Chironomids species are diverse in PH range from 6.4 to 8.3 in small prairie ponds in central Saskatchewan, Canada [38]. *Chironomus salinarius* KIEFFER can tolerate a range of salinity levels [39]. It's more likely that *Baeotendipes noctivagus* (Kieffer, 1911) is the most inflexible species to salinity in the world [40]. The same result demonstrated that especial subfamily or tribe of chironomids inhabited in different sampling sites of Swartkops River, south of Africa by water quality. Dissolved oxygen, electrical conductivity, orthophosphate–phosphorus, total inorganic nitrogen, and turbidity were the pivotal variables consisting of chironomid communities [41]. The hydrocarbon phenanthrene as a chemical substance is harmful to benthic organisms in sediment through acute/chronic exposure. *Chironomus sancticaroli* larvae have frequently shown susceptibility to it in studies [42]. Additionally, biodegradation of amorphous carbon was identified in the digestive tract of Chironomidae species [43] Deformities in larvae reported often resulting from responding of Chironomidae to anthropogenic and environmental disturbances [44] The rate of deformity may be a practicable parameter for biomonitoring [45]. This event has been seen in *Ablabesmyia* sp. and *Procladius* sp. larvae in acid mine drainage [46]. Mouthpart deformities of *the Chironomini* tribe in response to sediments containing metals such as Pb, Zn, Cu, As, and Cd are recorded from a river in the USA [47].

### Food

*Chironomus plumosus* larvae are the source of natural substances more beneficial for farm fish diet. for instance, crude protein content was 7.6% and 55.7% in fresh larvae and dry weight respectively. Amino acids such as Arginine, Histidine, Isoleucine, Leucine, Valine, Lysine, Phenylalanine, Methionine, Threonine, and Tryptophan have been isolated from larvae of that species [48, 49]. Other food values of chironomid larvae are carbohydrate 23, chitin 4, ash 9%, and caloric content (4.6 to 6.1 kcal $g^{-1}$) [50]. Dragonfly larvae mostly feed at least 30% of their body weight on midges [51]. Similarly, Chironomidae larvae are solely diet for kind of leech (*Erpobdella octoculata*) so that leech survives in where Chironomidae grow and increase in running water [52]. Sometimes predators like nine-spine stickleback, *Pungitius pungitius,* and the damselfly, *Enallagma clausum* threaten the *Cricotopus ornatus* population when are in the fourth instar and pupal phases [19]. Chironomids are the main in the early dietary regime of young flightless dabbling ducks after hatching as well [36]. Furthermore, this family particularly Corynoneura participateS in the trophic cycle and decomposition of plant detritus in subtropical streams. Chemical elements of the detritus assemblage influence the structure of the chironomids community during a long time of exposure [53]. Moreover, chironomids with small body sizes have been detected in an environment with high levels of disturbance. It might be anthropic and climatic factors that caused this morphological trait [54]. There is a symbiotic relationship between Chironomidae larvae and benthic animals as follows; *Demeijerea rufipes*, Chironominae, a parasite of sponges and bryozoan, *Eukiefferiella ancyla*, subfamily Orthocladiinae, as commensal of the snail *Ancylus fluviatilis*, and *Symbiocladius rhithrogenae*, Orthocladiinae, a true and obligate parasite of Heptageniidae/Ephemeroptera larvae, feeding on the mayfly's hemolymph [55].

## Paleoecological studies

Climate affects chironomid fauna composition and their morphological structures [56]. Surficial sediments sampling upon altitudinal range can be useful. It means we can trace chemistry among lakes according to lake depth. On the other hand, Chironomid fauna presents the past condition of the environment in different depth. *Heterotrissocladius* was predominant in the deep lakes rather than shallow ponds. In contrast, *Cladopelma* was limited to shallow lakes as warmer habitats in summer [57]. Analysis of deposit has approved that more chironomid taxa were discovered at low elevations in the southern Canadian Cordillera lakes [58]. In a study using the larval head capsules fossils from surface sediment samples of 50 lakes, 7771 chironomids were identified, following 13 species, 10 species groups, four subgenera, 41 genera, four genus groups, five types, and three with unknown taxonomic affiliation. Taxon richness was described with physical, chemical, and biological variables such as water temperature, lake depth, pH, conductivity, alkalinity, calcium, magnesium, sodium, potassium, and total organic carbon, latitude, longitude altitude [59].

## Conclusion

Chironomids are a favorable candidate to use as bioassessment approaches in toxicity tests and paleolimnology. Detailed life-history information of some species is available from laboratory studies. In contrast, they might be disqualified as biochemical and physiological indicators of environmental stress resulting from taxonomic problems with larvae and small size [60]. Anyway, the role of this family in all types of pollutants is ambiguous. More studies are needed to particularize the importance of Chironomidae based on genera and species levels.

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