Open Access Research Journal of
Life Sciences
Journals home page: https://oarjpublication/journals/oarjls/
ISSN: 2783-025X (Online)

(Review Article)

Chironomidae Family (Diptera: Chironomidae) in biogeochemical processes in lake sediments

Carlos Henrique Marchiori *

Instituto Federal Goiano, Biology, Parasitology, Goiânia, Goiás, Brazil.

Open Access Research Journal of Life Sciences, 2022, 03(01), 088–126

Publication history: Received on 01 February 2022; revised on 06 March 2022; accepted on 08 March 2022

Article DOI: https://doi.org/10.53022/oarjls.2022.3.1.0031

Abstract

Chironomidae ids are not known to be dangerous to humans, in particular because they do not bite and do not seek contact with our food like some flies. At the time of metamorphosis, the adult leaves its envelope on the surface of the water, without contact with it and usually without direct contact with polluted sediments. It does not transmit germs or parasites through the bite, but it may be a local vector of certain microbes or viruses to animals that eat it, or to humans via fomites, which has yet to be demonstrated. Purpose of this paper is to verify the impact of Chironomidae larvae on the decomposition of organic matter and on the exchange of nutrients. With emphasis on conceptual and taxonomic aspects was carried out in the years 1930 to 2021. Only complete articles published in scientific journals and expanded abstracts presented at national and international scientific events, Doctoral Thesis and Master's Dissertation were considered. Data were also obtained from platforms such as: Scielo Frontiers, Qeios, Pubmed, Biological Abstract, Publons, Dialnet, World, Wide Science, Springer, RefSeek, Microsoft Academic, Science.

Keywords: Nutrients; Organic matter; Larvae; Decomposition; Health

1. Introduction

The Chironomidae form a family of nematocerous dipterans, which is divided into eleven subfamilies, more than 5,000 described species, of which 700 are found in North America alone. Chironomids represent one of the most important families of Diptera (Figures 1, 2A and 2B) [1].

Figure 1 Specimens of Chironomidae Family; (Source: https://bugguide.net/node/view/43262)

* Corresponding author: Carlos Henrique Marchiori
Instituto Federal Goiano, Biology, Parasitology, Goiânia, Goiás, Brazil.

Figure 2A Chironomidae Family (Left: Male, Right: Female); (Source: https://www.nies.go.jp/yusurika/en/contents/intro.html)

Figure 2B From *Stenochironomus munteanpurin* sp. n., a new leaf-mining species from Brazil (Diptera: Chironomidae) (Source: https://www.nies.go.jp/yusurika/en/contents/intro.html)

1.1 Description

Feather chironoma, green in color and characteristic "feathered" antennae. Larva, called "blood worm". Chironomids are insects related to small Ceratopogonidae, Simuliidae, and Thaumaleidae. Very similar to mosquitoes, they are commonly confused with the latter. They are easily distinguished by:

- The greenish color of adults:
- A generally larger size (but there are species of small size);
- Absence of elongated mouthparts (the organ that bites the female) of mosquitoes (Culicidae); one of its English names is "non-biting mosquitoes", which means "non-biting mosquitoes";
- Antennae in the form of a thick or wide feather duster on the male;
- and, for those who are used to it, a buzzing different from that of the mosquito (Figures 3, 4, 5, 6, 7A, 7B, 8, 9 and 10) [1,2].

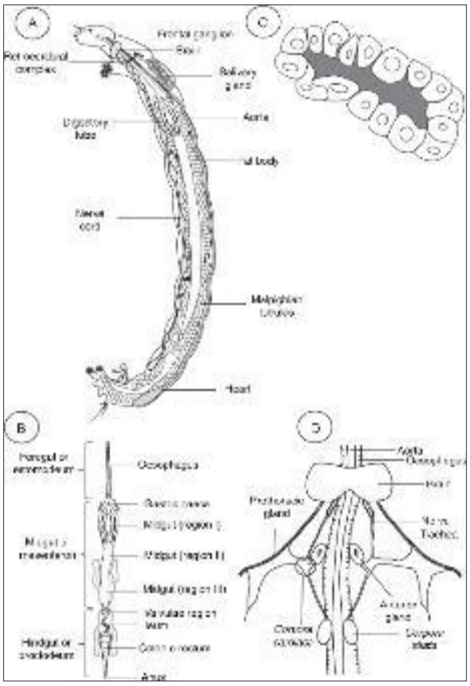


Figure 3 Schematic representations of organs and tissues of immature Chironomidae Family (A) Internal morphology of the larva; (B) morphology of the digestive tract; (C) aspect of the salivary gland; (D) disposition of the endocrine glands in the retrocerebral complex; (Source: https://www.scielo.br/j/rbent/a/gTDNVbrrd5DHdQgGxbB59mM/?lang=en)

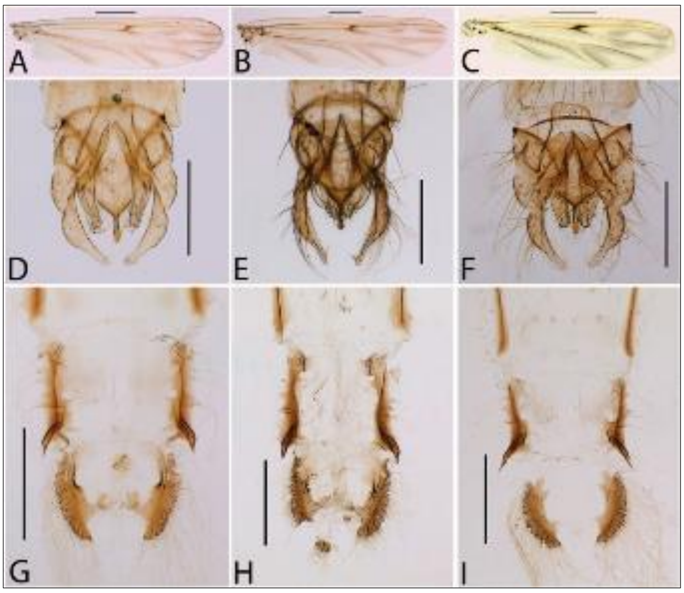


Figure 4 Adult male and pupae. *Chironomus striatipennis* Kieffer, 1910, Indian population. A Wing D Hypopygium, dorsal view G Anal spur, dorsal view. *Chironomus kiiensis* Tokunaga, 1936, Japanese population B Wing E Hypopygium, dorsal view H Anal spur, dorsal view. *Chironomus striatipennis*, Brazilian population C Wing F Hypopygium, dorsal view I Anal spur, dorsal view. Scale bar: 500 µm (A, B, C, G, H, I); 200 µm (D, E, F); (Source: https://zookeys.pensoft.net/article/5744/element/2/11/)

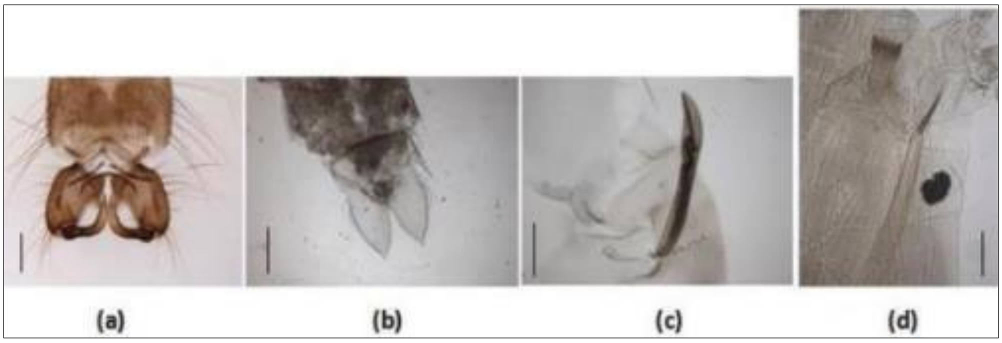


Figure 5 Tanypodinae subfamily (a): male hypopygium (b): anal lobe of the pupa (c): thoracic horn of *Xenopelopia falcigera* Kieffer, 1911; (d): cephalic capsule of the larva; (Source: **h**ttps://www.intechopen.com/chapters/74836**)**

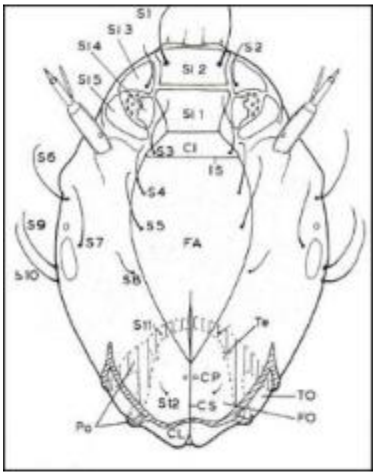


Figure 6 Cephalic capsule of a Chironomidae (dorsal view). Cl: clypeus, CL: coronal lobe, CP: coronal pores, CS: coronal suture, FA: frontal apotome, FO: occipital foramen, IS: clypeolabral suture, Po: postmentum, S 1–12: cephalic seta, Sl (Sl 1 –5): sclerites. Te: tentorium, TO: occipital triangulum; (Source: https://www.intechopen.com/chapters/74836)

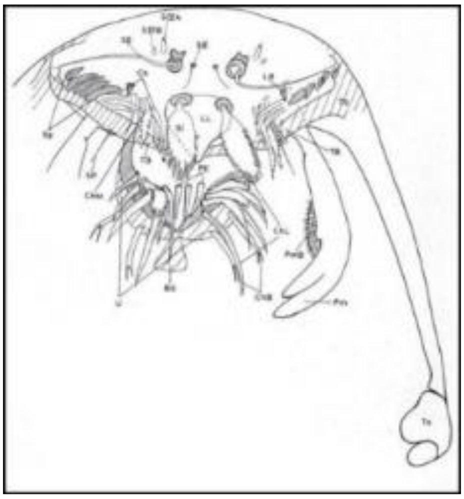


Figure 7A Structure of the labrum. BS: basal sclerite, Ch: chaeta, ChB: basal chaetulae, ChL: Chaetulae laterales, ChM: media chaetules, LL: lamella labrales, LR: labral rod, PE: pecten epipharyngis, Pm: premandibles; PmB: premandibular brush; SI, SII, SIII, SIVA, SIVB: labral setae, SP: seta premandibularis, TB: tormal bar, To: occipital triangulum, TS: triangular sclerite, U: ungula; (Source: https://www.intechopen.com/chapters/74836)

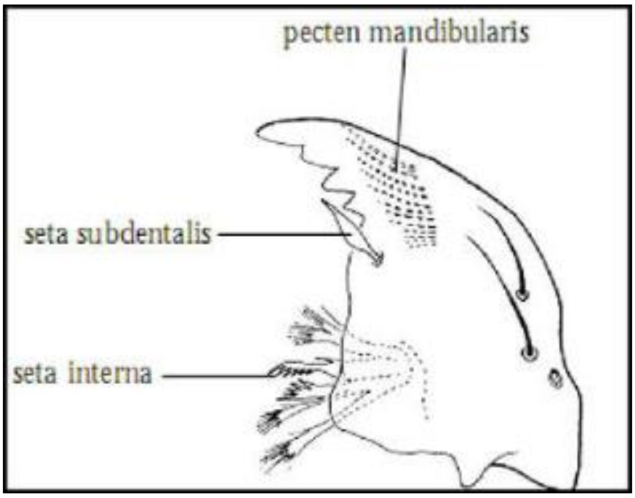


Figure 7B Structure of the mandible of Chironomidae; (Source: https://www.intechopen.com/chapters/74836)

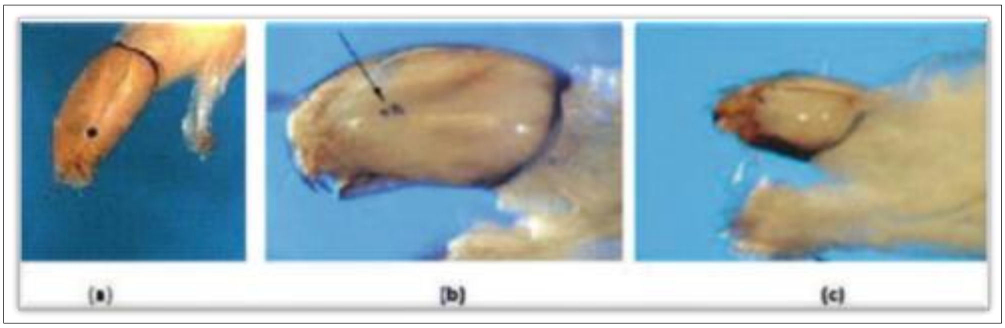


Figure 8 Position of eye spots in Chironomidae. (a): Tanypodinae, (b): Orthocladiinae and (c): Chironominae; (Source: https://www.intechopen.com/chapters/74836)

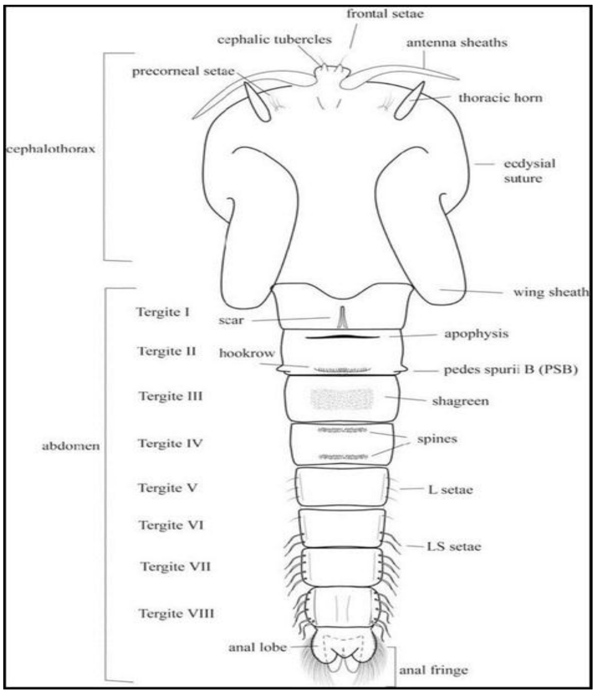


Figure 9 Morphology of Chironomidae pupa; (Source: Illustration by M.R. Rufer)

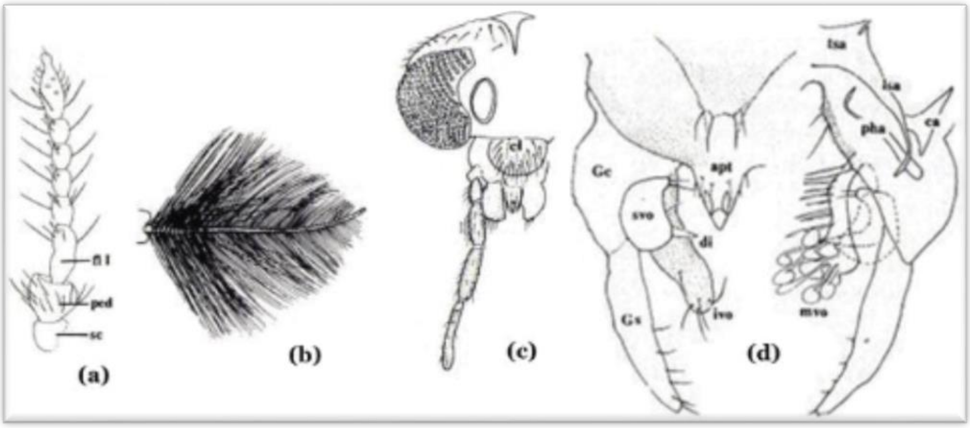


Figure 10 Morphology of the adult: (a): antenna of the female; (b) the male antenna; (c): the head; (d): male genitalia. Apt: anal point; ca: coxapodema; cl: clypeus; di: digitus; fl: flagellomere; Gc: gonocoxitis; Gs: gonostyle; ivo: inferior volsella; lsa: lateral sternapodema; mvo: median volsella; ped: pedicel; pha: phallapodema; sc: scape; svo: superior volsella; tsa: transverse sternapodema; (Source: Illustration by M.R. Rufer)

1.2 The egg and the larva

1.2.1 Main article: Chironoma larva

The chironoma egg is oval, yellowish and translucent. Eggs are laid in dense clusters in the belt of floating or emergent objects, or on the shore at the water's edge. The chironoma larva is often called the “blood worm” in France. It is a characteristic blood red color (hemoglobin), while the adult will be greenish. Hemoglobin, along with wave motions, allows the larvae to absorb enough oxygen, even in an oxygen-poor environment. Thin, short bristles are present in each segment. Note: the larva is a filter organism that forms a "protective tube" (Figure 11) [2,3].

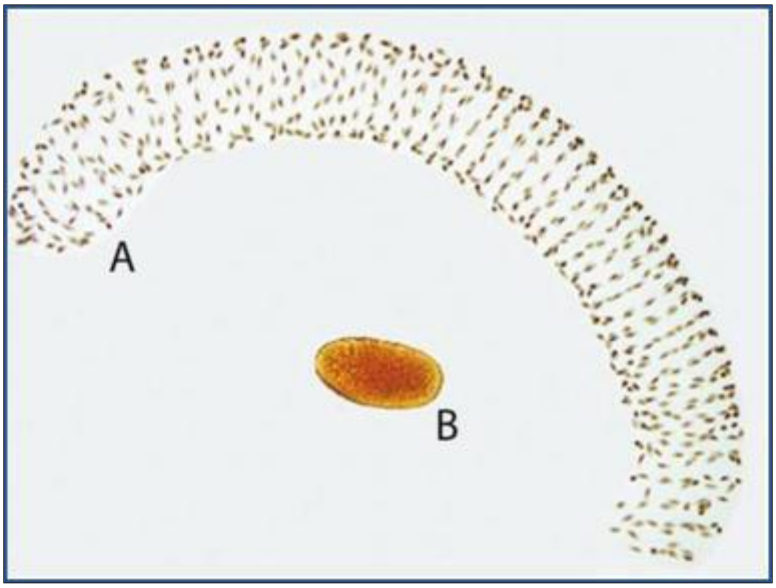


Figure 11 (A): Egg mass; (B): Egg; (Source: Illustration by M.R. Rufer)

It is called "blood worms" by English speakers, this word can also designate in English polychaete worms that live in marine sediments (*Glycera* sp.) (Figure 12) [2, 3].

Figure 12 Chironomid larvae; (Source: Illustration by M.R. Rufer)

1.3 Behavior

Many chironomidae have sophisticated antennae. The chironoma larva (filtering and suspensivorous) is well known by the vernacular name of "blood worm" Behavior.

At the time of emergence and reproduction, adults usually form on the banks of rivers and canals, and above trees or shrubs, and sometimes higher (for example, above a steeple roof) in the late afternoon, insect clouds characteristic swirls, which are unusually so dense that they can be mistaken from a distance for billowing smoke. A fall in the river made visible the spawning chironomids that normally run with the water. Preserved by the gelatinous strands and the humidity of the substrate, they will survive a few tens of hours (Location: Blendecques in France) (Figure 13).

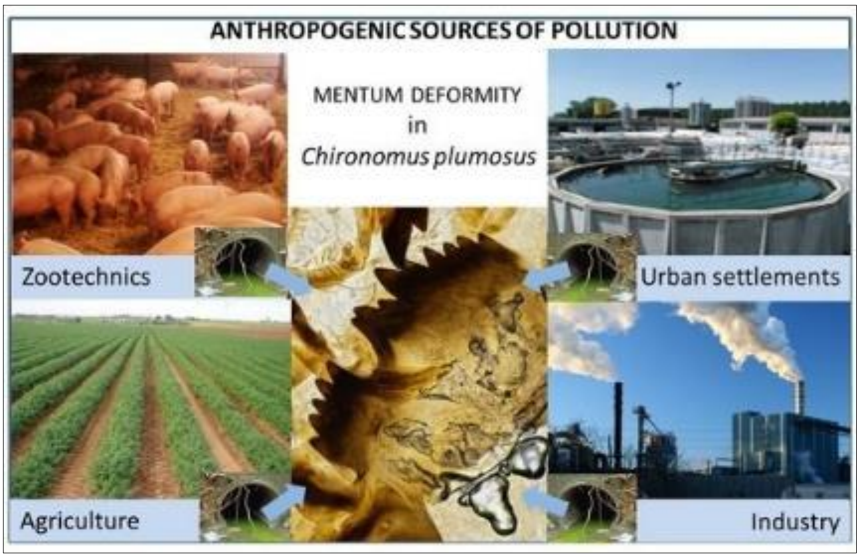


Figure 13 Use of larval morphological deformities in Chironomidae; (Source: https://www.intechopen.com/chapters/74836)

Each dot visible in this macro photograph is a chironoma egg. These eggs, placed on a gelatinous ribbon (about 1 cm long), firmly fixed to the substrate to resist the current, were placed in a single night (from September 1990) on a smooth submerged surface so that it was flush with the surface. water, in Blendecques (France), on the river Aa, at the time when it was the most polluted (Figure 14) [3,4,5].

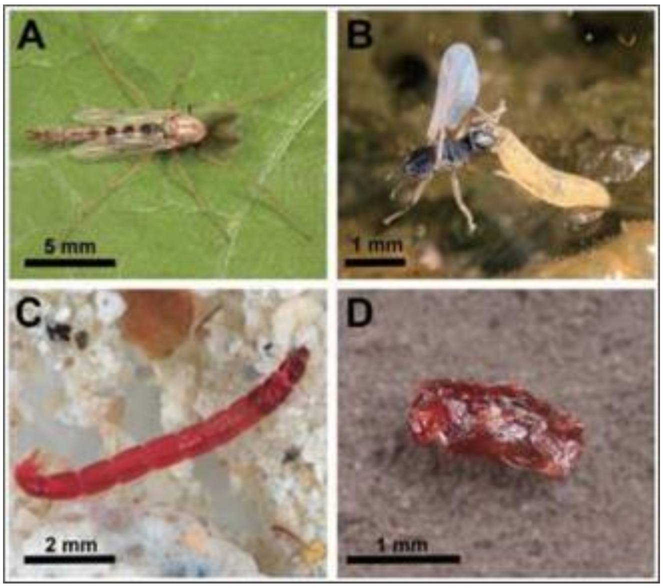


Figure 14 (A) Male adult of *Chironomus plumosus* (Linnaeus, 1758), the biggest of all Chironomids. Note the fluffy antennae, characteristic of males in most of the species in this family. (B) Mating of *Clunio tsushimensis* Tokunaga, 1933. on a seashore. This marine species shows a conspicuous sexual dimorphism with an apterous worm-like female. (C) *Polypedilum tamanigrum* Sasa, 1983 larva found in an acidic stream. Most Chironomid larvae are red, since their body fluid contains hemoglobins, and they are thus commonly called bloodworms. (D) Larva of the anhydrobiotic species *Polypedilum vanderplanki* Hinton, 1951 in the dry state (Source: https://www.researchgate.net/figure/Life-cycle-of-Chironomus-sancticaroli-1-eggs-2-larvae-eclosion-3-first-instar_fig1_333827598)

1.4 Environmental functions

Chironomus plumosus (Linnaeus, 1758) larvae colonize by the millions the surface of sediments highly polluted by certain organic matter. It is one of the few organisms other than bacteria to survive there. It usually coexists with a leech species (and tubifex replaces them in even more anoxic areas). By aerating the sludge, they contribute to the self-purification process and to the transparency of the water. Each tube constitutes a kind of small "biological reactor" where bacterial activity is more intense (Figure 15) [5,6,7].

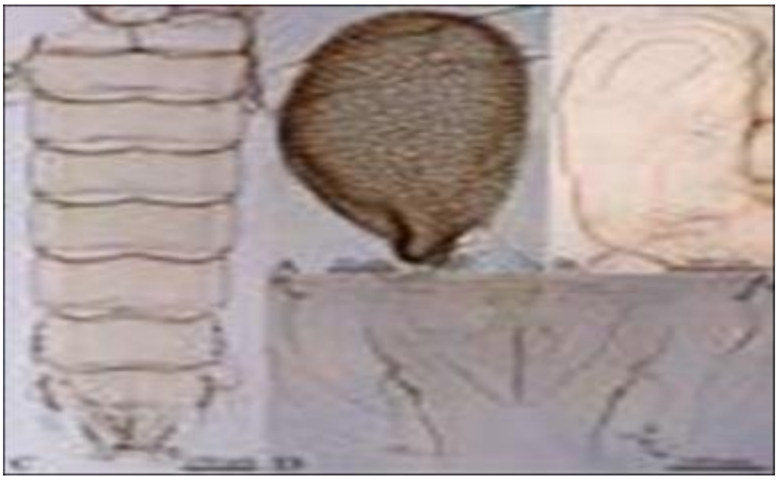


Figure 15 Chironomidae, pupa. (A) thoracic horn; (B) wing sheath; (C) abdomen; (D) anal lobe. This figure is in color in the electronic version; (Source: https://www.scielo.br/j/aa/a/cYtyKXLtrfbCR848WYF4bPP/?format=html&lang=en)

Accumulation of thousands of feathered exuviae of chironomids, in a row of water-level bricks, on the banks of the a in Blendecques at the time of 1985-1995. This river was particularly polluted. In an urban concrete basin, the larva cannot bury its pipe in silt or sediment. It feeds on the biofilm that covers the bottom (see light spot) and here it has made a protective tube made from its own droppings. A representative of the Chironomidae, Tanytarsus, presents an example of paedogenesis (Figure 16) [6,7].

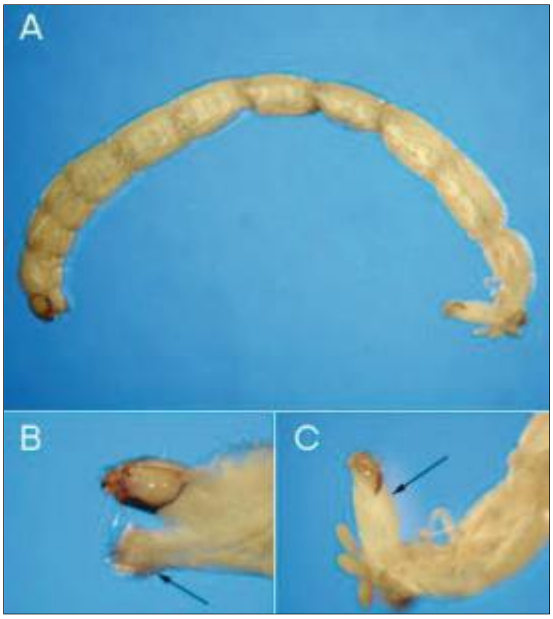


Figure 16 The body of the larva of Chironomidae. (A): complete larva; (B): anterior pseudopods; (C): anal region of a Chironominae. Arrows show the anterior and posterior pseudopods; (Source: https://d3i71xaburhd42.cloudfront.net/37ecbf44b7f40e2a6ecf015700f714535e93a42a/5-Figure18-1.png)

Larval-stage chironomids are found in almost all aquatic and semi-aquatic habitats, including tree cavities, bromeliads, decaying vegetation, soil, sewers, and man-made containers. They represent an important part of the macrozoobenthos (aquatic invertebrates) of most freshwater ecosystems. Chironomids lay associated eggs in yellowish or slightly orange gelatinous and translucent ribbons of several hundred eggs. These ribbons that swell rapidly in water get stuck on the edge or periphery of an object floating or emerging from the water (when the environment is very anoxic) (Figure 17) [7,8].

Figure 17 Genera of larvae of Australian Chironomidae (Diptera); (Source: https://d3i71xaburhd42.cloudfront.net/37ecbf44b7f40e2a6ecf015700f714535e93a42a/5-Figure18-1.png)

Some chironomid species readily colonize septic tanks (if they have access not protected by a mosquito-type filter). The larvae can then live there in the hundreds of thousands, or even millions, earlier and later in the season [8,9].

1.5 Life cycle

Its life cycle is holometabolous: egg, larva (4 instars), pupa and adult. The larval stage corresponds to about 95% of its entire life cycle, and it is at this stage that feeding occurs. Their females are not hematophagous, and live exclusively for reproduction. The life cycle varies according to gender, food availability, temperature and pH. Its life cycle can vary in length from one week to two years (Figure 18) [9,10].

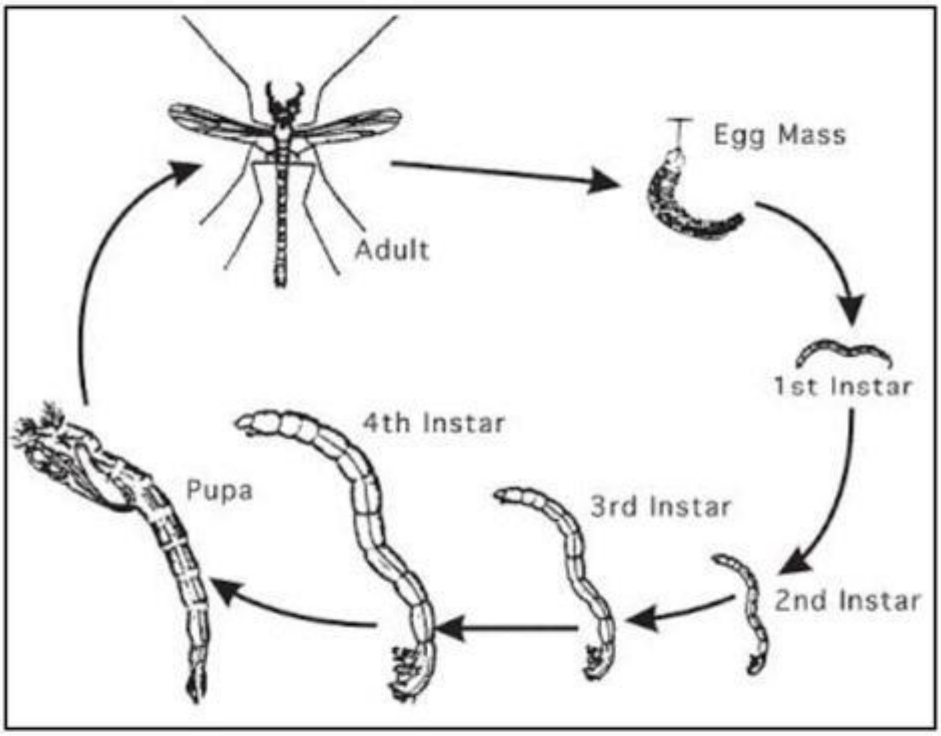


Figure 18 Chironomid life cycle; (Source: Illustration by M.R. Rufer)

That the Chironomidae family is subdivided into 11 subfamilies and only 5 of these have already been recorded for Brazil and only one has not been recorded for the Neotropical region [11,12].

1.6 Taxonomy

list of subfamilies: Aphroteniinae, Buchonomyiinae, Chilenomyiinae, Chironominae, Diamesinae, Orthocladiinae, Podonominae, Prodiamesinae, Tanypodinae, Telmatogetoninae, Usambaromyiinae and Aenneinae (Figures 19, 20, 21, 22, 23, 24, 25, 26 27A and 27B) † [12,13].

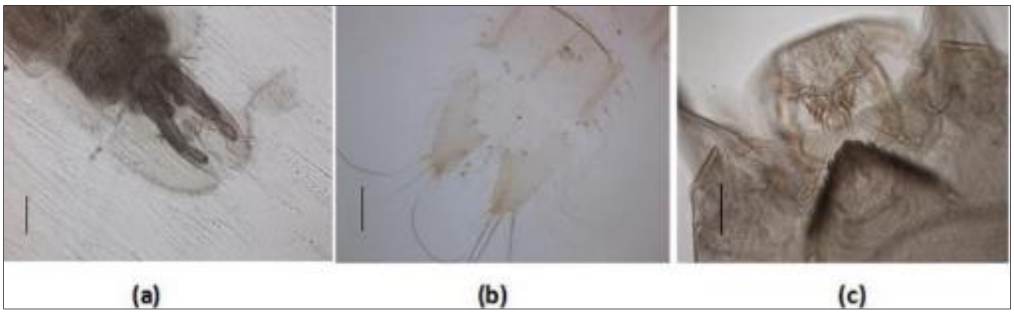


Figure 19 Orthocladiinae subfamily (a): anal lobe and hypopygium platypus; (b): anal lobe of Chironomidae; (c): cephalic capsule of the larva; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

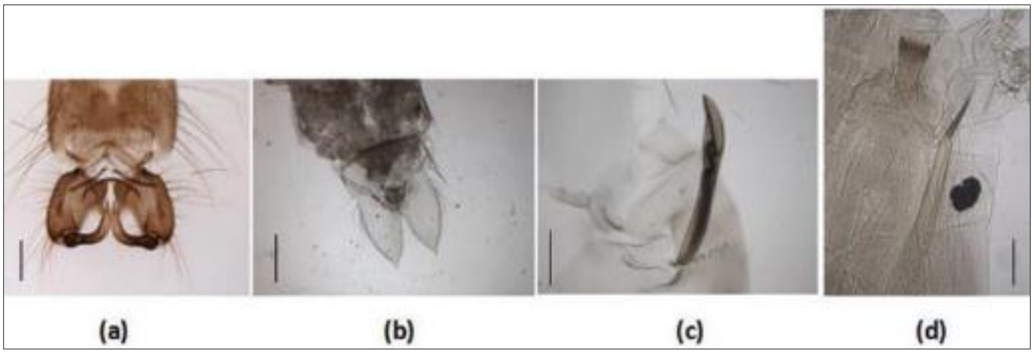


Figure 20 Tanypodinae subfamily (a): male hypopygium; (b): anal lobe of the pupa of *Psectrotanypus varius* (Fabricius, 1787); (c): thoracic horn; (d): cephalic capsule of the larva (scale bar: (200 µm); (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

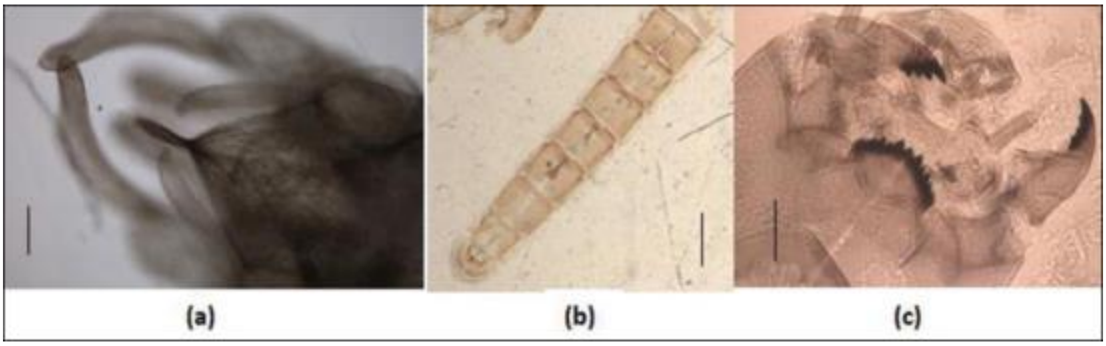


Figure 21 Subfamily of Chironominae (a): hypopygium of *Chironomus plumosus* (Linnaeus, 1758) (scale bar 200 µm); (b): pupal exuvia (scale bar 200 µm); (c): mentum and mandible (scale bar 100 µm); (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

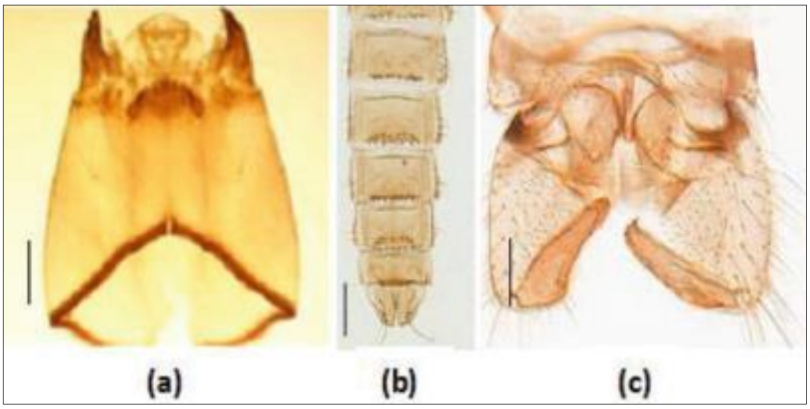


Figure 22 Diamesinae subfamily: (a): the cephalic capsule; (b): pupal exuvia; (c): male hypopygium; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

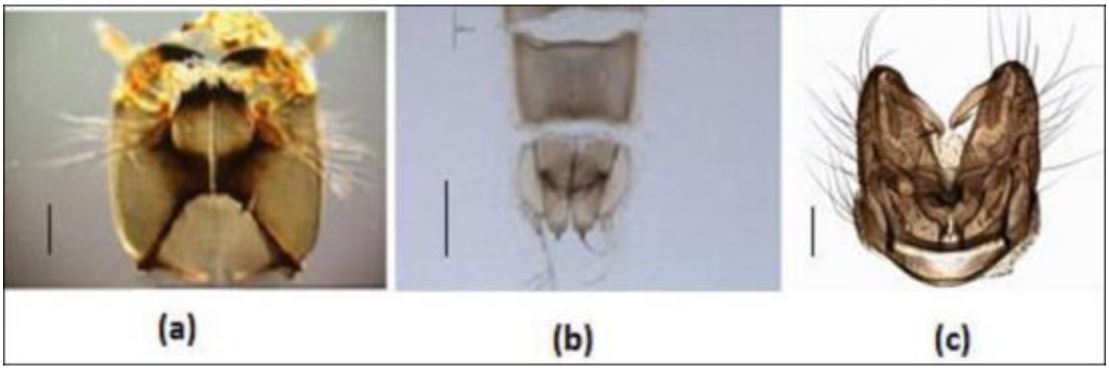


Figure 23 The Prodiamesinae subfamily. (a): cephalic capsule; (b): pupal exuvia; (c): male hypopygium (scale bar: 200 µm); (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

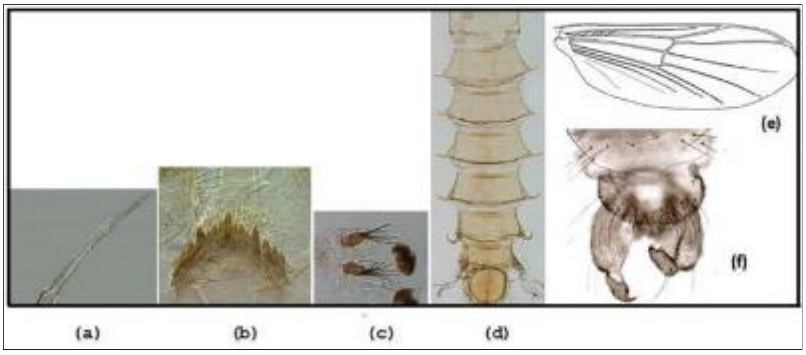


Figure 24 The Podonominae subfamily. (a): antenna of *Boreochlus* sp.; (b): mentum of *Boreochlus* sp.; (c): procerci; (d): pupal exuvia; (e): wing; (f): male hypopygium; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

Figure 25 The Podonominae subfamily. (a): antenna of *Boreochlus* sp.; (b): mentum of *Boreochlus* sp.; (c): procerci; (d): pupal exuvia; (e): wing; (f): male hypopygium; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

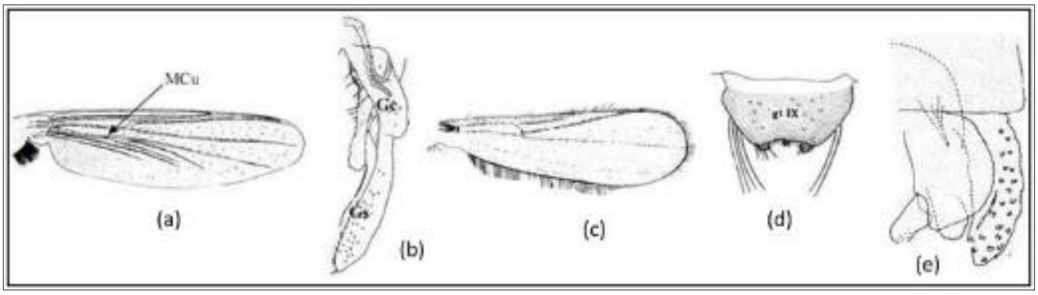


Figure 26 Subfamilies of Buchonomyiinae, Aphroteniinae and Chilenomyiinae. (a) and (b): wing and hypopygium of *Buchonomyiia*; (c) and (d): wing and hypopygium; (e): hypopygium of *Chilenomyia* sp. (Gc: gonococciitis; Gs: gonostyle; gt: gonotergite); (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

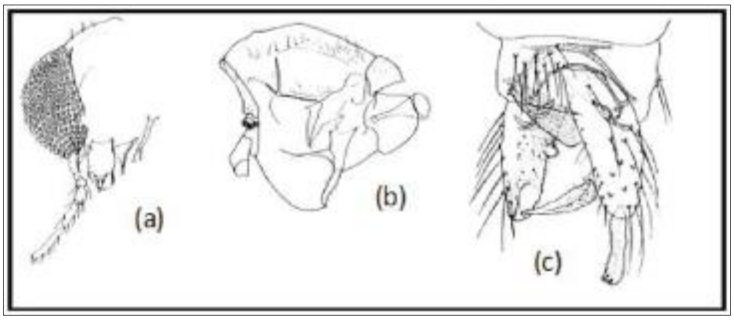


Figure 27A The subfamily of Usambaromyiinae: (a) the head; (b): thorax; (c): male hypopygium; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

Figure 27B A swarm of *Chironomus plumosus* (Linnaeus, 1758) over a tree top; (Source: Karima Z. Chironomidae: Biology, Ecology and Systematics. 1th. ed. Algiers: University of Guelma. 2020)

1.7 Uses

Some species have abnormally large chromosomes that are visible under a microscope, which makes them retained for various scientific or educational experiments [12,13].

Larvae of certain chironomid species known as "blood worms" are sought after by fishermen and specialist companies to bait or feed aquarium fish live food (at the risk of importing microbes and pollutants of the type. *Dioxins* or heavy metals, if applicable) (Figure 27C) [12,13].

Figure 27C Larvae of certain chironomid species known as "blood worms"; (Source: https://www.zoology.ubc.ca/~srivast/pitilla/s/Diptera.54.html)

1.8 Chironome and health

Chironomids are not known to be dangerous to humans, in particular because they do not bite and do not seek contact with our food like some flies. At the time of metamorphosis, the adult leaves its envelope on the surface of the water, without contact with it and usually without direct contact with polluted sediments. It does not transmit germs or parasites through the bite, but it may be a local vector of certain microbes or viruses to animals that eat it, or to humans via fomites, which has yet to be demonstrated. (Where it swarms, it can splatter windows, walls, and clothes that dries up tiny greenish droppings (Figure 27D) [13,14].

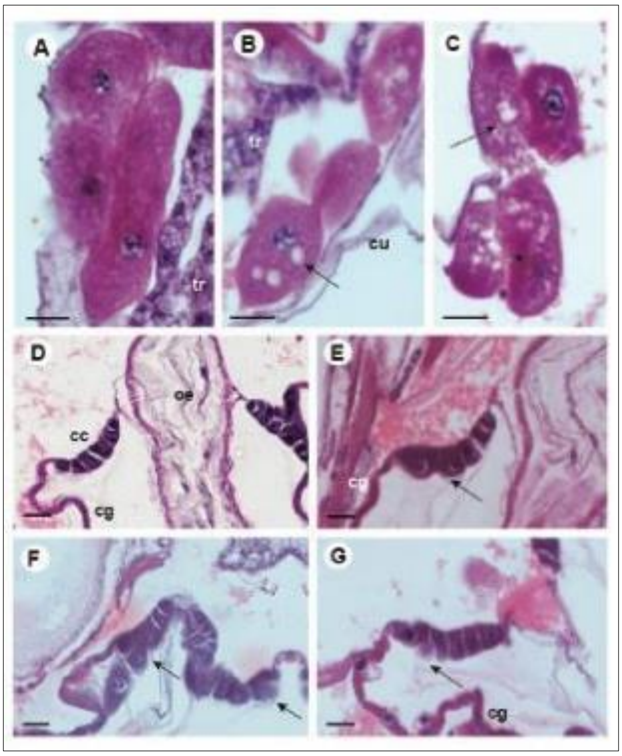


Figure 27D *Micrographs* of oenocytes and Cuenot cells of *Chironomus sancticaroli* Strixino-Strixino, 1981, larvae after PBDE exposure. A. Oenocytes of control (water). B. Oenocytes exposed to BDE-17 at 20 µg L^{-1}. C. Oenocytes exposed to BDE-47 at 2.0 µg L^{-1}. Arrows show cytoplasm vacuolization. D. Cuénot cells of control (water). E. Cuénot cells exposed to BDE 17 at 20 µg L^{-1}. F. Cuenot cells exposed to BDE 47 at 2.0 ug L^{-1}. G. Cuenot cells exposed to BDE 99 at 0.5 µg L^{-1}. Arrows show the brush border disruption and displacement in the apex cell. tr: trophocytes, cu: cutile, cc: Cuénot cells, oe: esophagus, cg: gastric caeca. Scale bar: 20 µm; (Source: https://www.scielo.br/j/rbent/a/RpWPYCSBzWVDfbrB5qG3dPj/?lang=en)

Chironomids are an important reservoir for *Vibrio cholerae* Koch, 1883*.* insect eggs can be colonized by *V. cholerae* (6 to 36 bacteria per egg). The bacterium can also adhere to the chitinous surface of adults allowing, during flight, the dispersion of *V. cholerae* by air in the environment, locally, but perhaps also at a distance under the effect of prevailing winds (Figure 27E) [13,14].

Figure 27E Bacterium *Vibrio Cholerae* Koch, 1883 which causes cholera; (Source: https://microbeonline.com/vibrio-cholerae-laboratory-diagnosis-confirmation/)

We have already mentioned allergies to chironomids in particularly sensitive people, but it remains to prove that the allergy is due to the insect and not to a molecule that it would have taken from a very polluted environment (Figure 27F) [13,14].

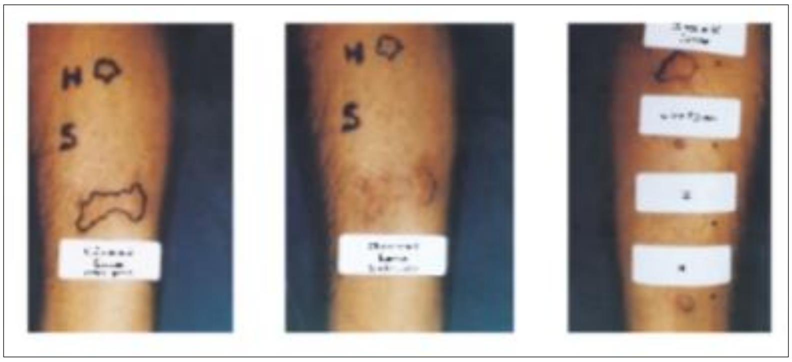


Figure 27F Prick test with extract of chironomid midge and aedes mosquito. Allergy to chironomid larvae (red migde larvae) in non-professional handlers of fish food; (Source: https://www.semanticscholar.org/paper/Allergy-to-chironomid-larvae-(red-migde-larvae)-in-Ballesteros Barrio/6f2585c561ab31f635d7e409e4497509533406ea/figure/1)

1.9 Bioindicator

Chironomids are important bioindicators of the health status of a water body (the presence, absence or amount of a variety of species present in it witnessing) (Figure 27G) [15,16].

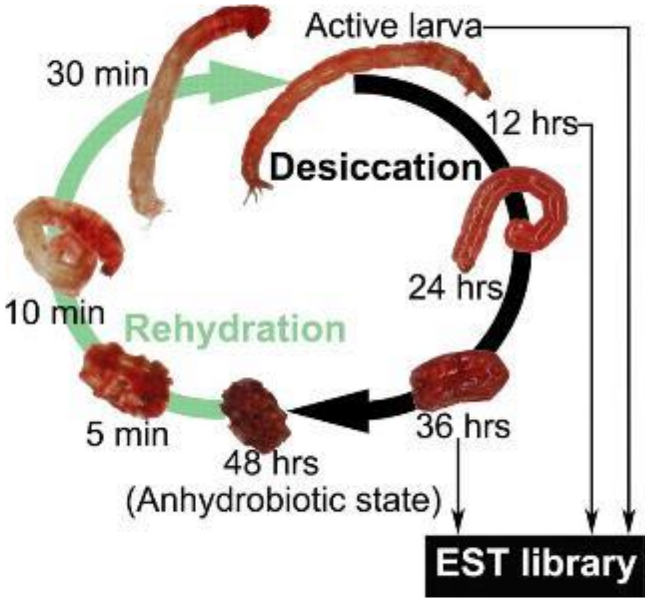


Figure 27G Dessication-rehydration cycle of the sleeping chironomid; (Diagram from Identification of Anhydrobiosis-related Genes from an Expressed Sequence Tag Database in the Cryptobiotic Midge *Polypedilum vanderplanki* Hinton, 1951 (Diptera; Chironomidae); (Source: https://www.jbc.org/article/S0021-9258(20)46928-5/fulltext)

These species often abound near small rivers heavily polluted by organic matter (or downstream of sewers or certain dysfunctional or undersized treatment plants, as well as downstream of insufficiently purified waste from paper mills, slaughterhouses, certain agri-food units. These outbreaks previously reserved for rich countries, are developing in poorer areas. You can find hundreds of eggs laid every night on every centimeter of the bank in the right season. The river bottom can literally be littered with larvae where the current slows down, under the stones or where sediments are fixed by their weight or by symbiotic associations of bacteria (usually filamentous bacteria) and aquatic fungi, sometimes with red algae (Figures 27H and 27I) [15,16].

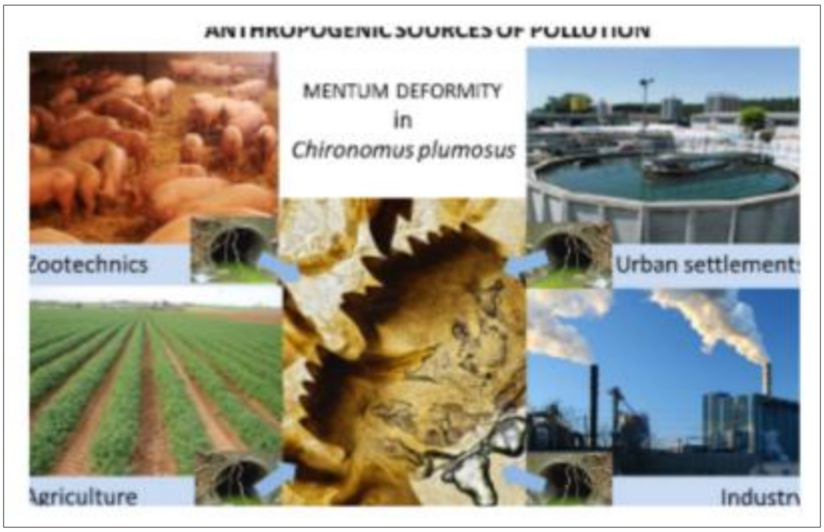


Figure 27H Use of larval morphological deformities in *Chironomus plumosus* (Linnaeus, 1758) (Chironomidae: Diptera) as an Indicator of Freshwater Environmental Contamination (Lake Trasimeno, Italy); (Source: https://www.google.com/search?q=Habitat+of+the+Chironomidae+Family&source=lnms&tbm=isch&sa=X&)

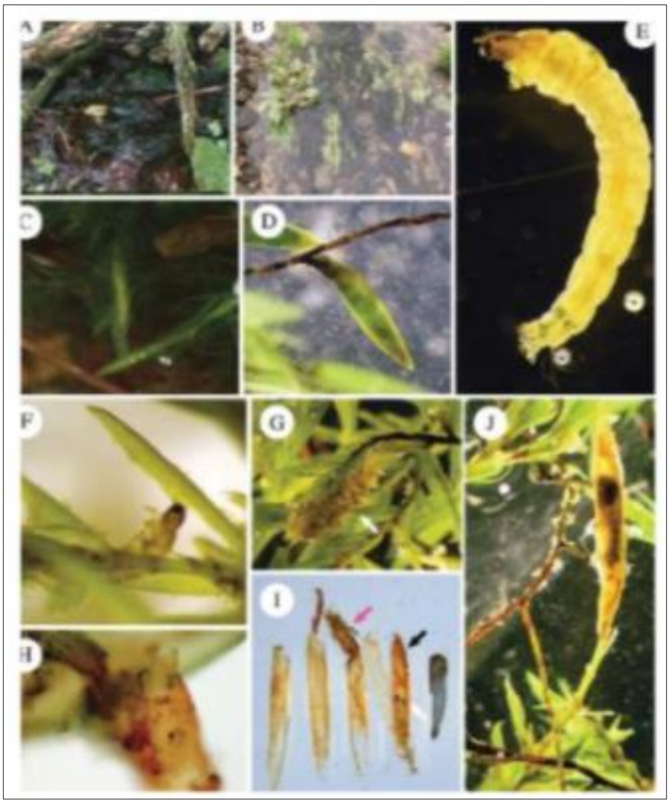


Figure 27I Biology of *Eukiefferiella endobryonia* sp. nov. A colony of *Fontinalis dalecarlica* Bruch & Schimper (Fontinalaceae) Mountain Lake B a colony of *Fontinalis novae-angliae* var. delamarei (Renauld & Cardot) (Fontinalaceae) occurring in a rapidly flowing stream at Sparks Lane C fourth-instar larva underwater D immature capsule of *F. dalecarlica* attached to the stem underwater E fourth-instar larva F fourth-instar larva feeding on a leaf margin of *F. dalecarlica* G a tube structure of the third-instar larva, which was mainly built from particles from the feces of mature larvae Hydrogenated amorphous-silicon, jelly-like silk mass spotted with detritus and diatoms, ripped off of the inner wall of the inner end of the pupal case I a dissected leaf-rolling case, consisting of five leaves and the resident pupa J pupa; (Source: https://zookeys.pensoft.net/article/47834/)

1.10 Diagnostic features

Chiromonus is one of our best known midges, with larvae commonly referred to as “blood worms” due to their vivid red colour (when live). Like other chironomids the general body form is worm-like, but with a distinct head, and with paired prolegs under the head and at the end of the abdomen. In *Chironomus* the eyes are split into two well-separated parts, one above the other, and tubular “blood gills” are visible near the end of the abdomen (Figures 28 and 29).

Figure 28 *Chironomus* ventral “blood gills”; (Source: Image: Stephen Moore)

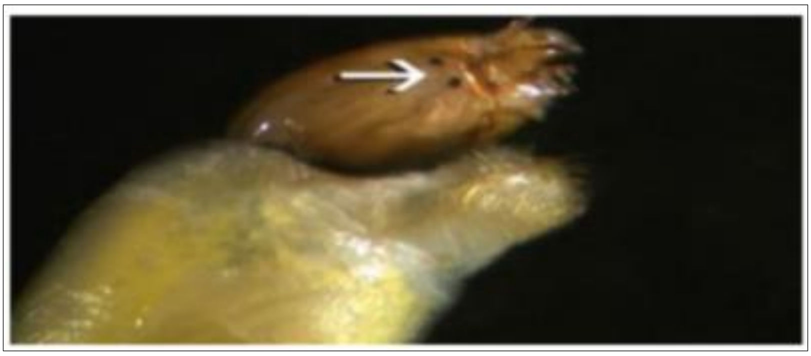


Figure 29 *Chironomus* Widely separated double eyes; (Source: Image: Stephen Moore)

When the water is purer, the larger chironomid species are replaced by smaller ones. Certain chironomids (generally large species) are bioindicators of very poor water quality if they are present in large numbers. In temperate zones, if the river deteriorates further, they disappear in favor of the tubifex, often accompanied by a species of leech that is very resistant to pollution [15,16,17].

1.11 Phylogeny

Chironomid midges (Diptera; Chironomidae) are found in various environments from the high Arctic to the Antarctic, including temperate and tropical regions. In many freshwater habitats, members of this family are among the most abundant invertebrates. In the present study, the genome sizes of 25 chironomid species were determined by flow cytometry and the resulting C-values ranged from 0.07 to 0.20 pg DNA (Figures 30, 31A, 31B and 32) [18].

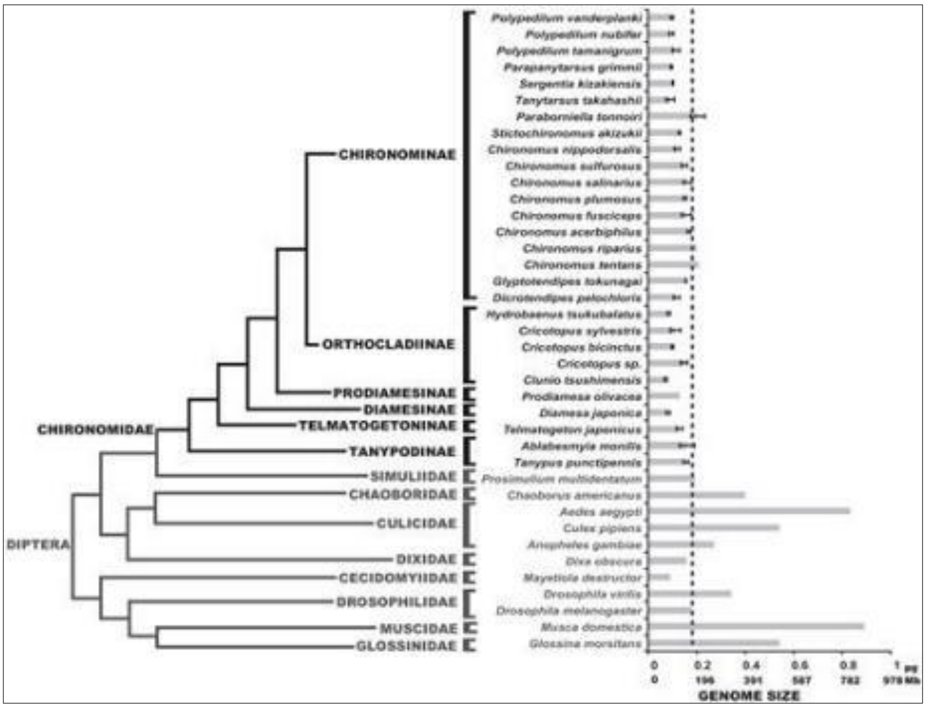
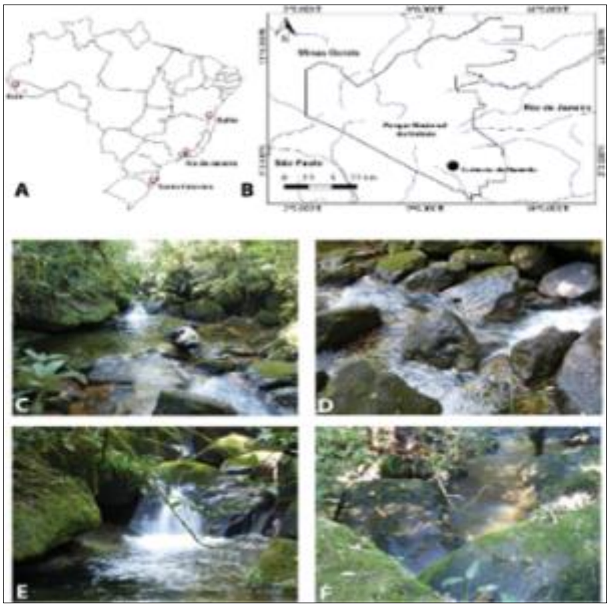


Figure 30 Phylogeny of Diptera showing estimated C-values. The Chironomid family is shown in black. The dash line shows the genome size of *Drosophila melanogaster* Meigen, 1830. The phylogenetic cladogram is a consensus from different Chironomid and Dipteran trees. Errors bars show standard deviation. Genome sizes without error bars were obtained from previous studies listed in the Animal Genome Size Database; (Source: Cornette R, Gusev O, Nakahara Y, Shimura S, Kikawada T, Okuda T. Chironomid Midges (Diptera, Chironomidae) Show Extremely Small Genome Sizes. Zoological Science. 2015; 32(3):248-254.)



A

B

Figure 31A *Stenochironomus munteanpurin* sp. n. were collected in the following Brazilian states: Rio de Janeiro, Santa Catarina, Bahia and Acre. Figure 31B Chironomidae sp. female on flower of *Euryops* sp. damage caused by beetles in family Meloidae; (Source: ttps://www.semanticscholar.org/paper/Stenochironomus-munteanpurin-sp.-n.%2C-a-new-species-Amora-Hamada/5daff6d672f12f640bccb61fbb6bd43315e50ee8#paper-header)

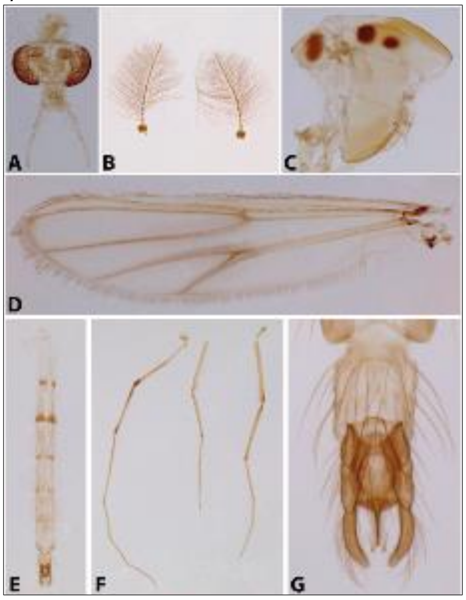


Figure 32 SI bifurcated, SII pinnate, SIII pinnate setae and, larval exuviae is compacted; pupa with shagreens being in all TI, less number of hooklets in TII, TVII without shagreens and presence of shagreen in conjunctive III/IV and IV/V. Adult male is very similar to the one of *Stenochironomus quadrinotatus* Borkent, 1984 but can be distinguished by a combination of the TIX with more than 25 setae medially and phallapodeme curved anteriorly; (Source: ttps://www.semanticscholar.org/paper/Stenochironomus-munteanpurin-sp.-n.%2C-a-new-species-Amora-Hamada/5daff6d672f12f640bccb61fbb6bd43315e50ee8#paper-header)

Stenochironomus quadrinotatus Borkent, 1984 is described and illustrated in all life stages, except eggs, from Brazil. The male is very similar to *S. quadrinotatus* due to same overall pattern of pigmentation. The new species can be distinguished from the other related species principally in immature stages: larva with labral lamella arranged in two groups with one or two conical-shaped teeth, spicules of pecten epipharyngis arranged in a row, unequal and irregularly distributed sizes [19].

Objective

Purpose of this paper is to verify the impact of Chironomidae larvae on the decomposition of organic matter and on the exchange of nutrients.

2. Methods

The method used to prepare this mini review was Marchiori 2021 methodology [20].

3. Studies conducted and selected

3.1 Study 1

The Chironomidae are one of the most widely distributed Diptera Nematocera families in the world, occurring in all zoogeographic regions, including the Antarctic region. The family, with more than 350 valid genera, comprises 11 subfamilies of which five (Chironominae, Orthocladiinae, Podonominae, Tanypodinae and Telmatogetoninae) occur in Brazil, all with representatives in the state of São Paulo. An updated inventory (June/2010) of Chironomidae species in the State of São Paulo is presented [21].

1-Wealth of Chironomidae in the State of São Paulo compared to other regions

The information on the website indicates a large difference between the records in the various regions of Brazil. In the northern region, including the states of Pará, Amazonas, Acre, Roraima and Maranhão, approximately 180 species are recorded. Next is São Paulo, with 150; the other states in the southeastern region with approximately 50 species recorded. The other regions had a much lower number of records (Northeast ≈ 20 spp., Midwest ≈30 spp., South ≈ 35) (Figure 33) [21].

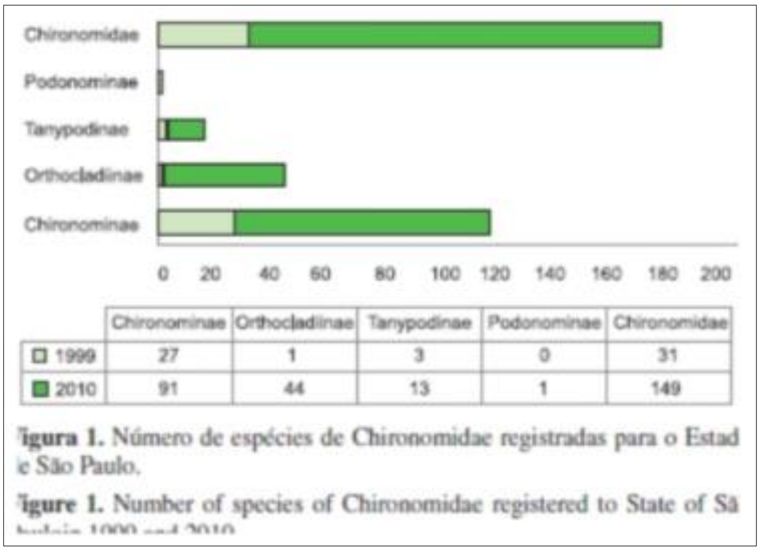


Figure 33 Number of species recorded for the State of São Paulo Pauloin 1990 and 2010; (Source: https://www.scielo.br/j/bn/a/9jgzr7GB6HXkG3QBy3hJLhh/?lang=pt#)

Regarding the geographic distribution of the species in the state of São Paulo, the available data do not yet allow us to discuss their ranges, since most of the faunal surveys were carried out during the Biota/Fapesp project and the collections were concentrated mainly in the eastern regions (Atlantic Forest) and central (cultivated areas) [21].

3.2 Study 2

The family Chironomidae (Diptera) is the most abundant in freshwater aquatic systems, with the ability to colonize different environments, which allows it to present different responses to environmental fluctuations ranging from sensitivity to impacts to tolerance to more [22].

The objective of this study was to analyze the ecological integrity of urban lakes using the attributes of Chironomidae (Diptera) in the city of Rio Branco (Acre, Brazil) [22].

To carry out the study, three lakes were selected, two of which were located within the Zoobotanical Park of the Federal University of Acre (UFAC): Piaba lake and Viveiro lake (Figures 34, 35 and 36) [22].

Figure 34 Zoobotanical Park of the Federal University of Acre; (Source: https://www.tripadvisor.com.br/LocationPhotoDirectLink-g1076245-d2406531-i222598370-Parque_Zoobotanico-Rio_Branco_State_of_Acre.html)

For example, several studies have pointed to larvae of the *Chironomus* genus as an indicator of impacts and alterations. The result of the physical-chemical analysis suggests a distinction between samples from three preserved and altered lakes [22].

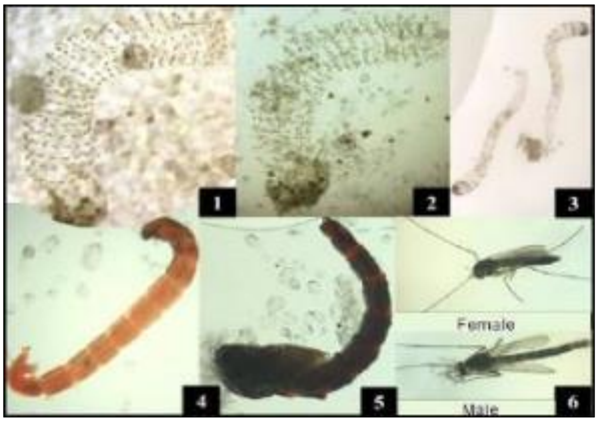


Figure 35 Life cycle of *Chironomus* (1) eggs (2) larvae eclosion (3) first instar larvae (4) larvae from fourth instar (5) pupa, and (6) adult female, adult male; (Source https://www.researchgate.net/figure/Life-cycle-of-Chironomus-sancticaroli-1-eggs-2-larvae-eclosion-3-)

The so-called preserved lakes (Piaba and Viveiro) had higher average concentrations of dissolved oxygen and pH, while higher average values of air temperature, water temperature, alkalinity, total hardness, ammonia and nitrite were observed in the altered lake [22].

The t test, however, confirmed this difference only for the total hardness variable with a significant difference (t-value=4.926; p-value=0.008). Among the lakes studied, significant differences in community attributes were recorded. Dominance was higher in the altered lake while diversity, richness estimated and evenness were higher in preserved lakes [22].

The t test confirmed that the variation in abundance (t-value=8.836; p=0.003) and diversity (t=4.249; p-value=0.000) among the lakes is significant, indicating that community attributes reduce in altered lakes. A total of 938 Chironomidae larvae were collected, distributed in the subfamilies Tanypodinae (87) and Chironominae (851). At larvae were distributed in 10 genera of which *Chironomus* was the most abundant with 531 organisms and *Pelomus* and *Tanytarsus* were the least abundant with only 12 organisms each (Figure 37) [22].

Figure 36 Genus *Chironomus; (*Source: https://en.wikipedia.org/wiki/Chironomus_anthracinus)

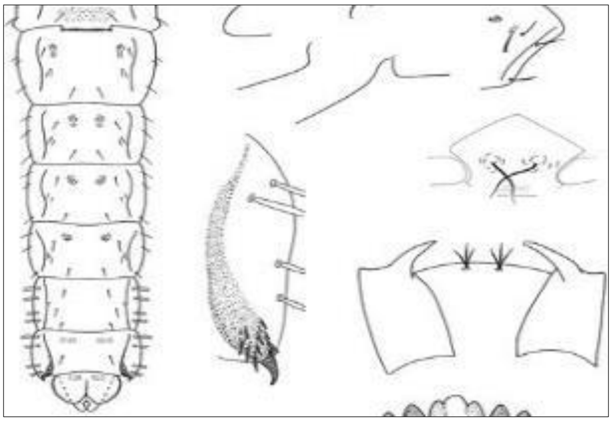


Figure 37 *Tanytarsus fittkaui* sp. n. pupa (28-32) e larva (33-34). 28) apótomo frontal; 29) corno torácico; 30) tórax; 31) tergitos I-IX; 32) pente posterolateral do segmento VIII; 33) clípeo com cerda clípeal S3 e tubérculos antenais; 34) mento e placa ventromental; (Source: https://www.researchgate.net/figure/34-Tanytarsus-fittkaui-sp-n-pupa-28-32-and-larva-33-34-28-frontal-apotome-29_fig2_42372857)

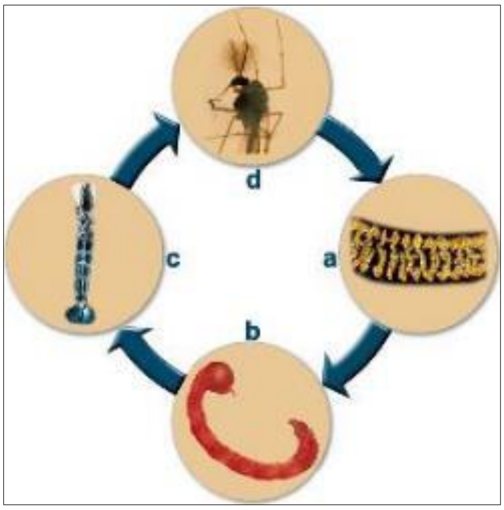


Figure 38 Four metamorphosis developmental stages of *Chironomus* sp. an egg mass. Each egg mass contains hundreds of eggs surrounded by gelatin matrix. b The larva (red colored because its hemolymph contains hemoglobin). c Pupal exuvium. d An adult male; (Source: https://www.researchgate.net/figure/Four-metamorphosis-developmental-stages-of-Chironomus-sp-a-An-egg-mass-Each-egg-mass_fig1_268880807)

The lakes preserved by the high vegetation cover ciliar presented the genera *Ablabesmyia, Chironomus, Endotribelus, Fissimentum, Paralauterborniella, Pelomus* and the species *Tanypodinae* sp., *Tanytarsus fittkaui* sp. nov. with predominance of the genus *Fissimentum* which recorded 185 larvae, being the most abundant in preserved areas and exclusive in preserved areas. Altered lakes showed *Asheum, Chironomus*, *Goeldichironomus* and the species *Tanypodinae* sp., with the genus *Chironomus* being the most abundant with 518 larvae (Figure 38) [22].

Among the lakes studied, significant differences in community attributes were recorded. Dominance was higher in the altered lake while diversity, richness estimation and evenness were higher in preserved lakes. The t test confirmed that the variation in abundance (t-value= 8.836; p-value= 0.003) and diversity (t-value= 4.249; p-value= 0.000) between lakes is significant, indicating that community attributes reduce in altered lakes [22].

3.3 Study 3

Among the various aquatic organisms used in the assessment of the quality of aquatic ecosystems, there is the family Chironomidae (Diptera). The family is represented by insects that complete their first stages of development in the aquatic environment. Their larvae are an important link between different trophic levels in the aquatic environment (Figure 39).

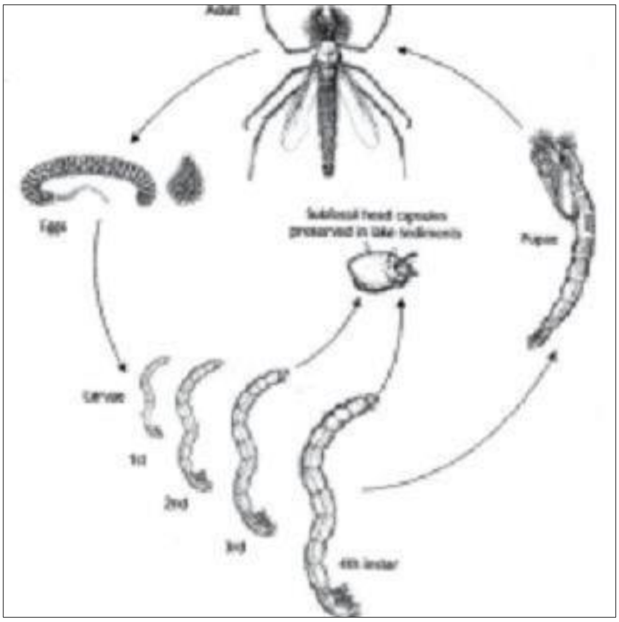


Figure 39 Life cycle of *Chironomus* larvae; (Source: https://www.researchgate.net/figure/Life-cycle-of-Chironomus-larvae_fig2_310)

Figure 40 Açude Grande, Cajazeiras – Paraíba; (Source: https://www.flickr.com/photos/egbertoaraujo/16004145697)

They are used in the evaluation environmental quality because they have useful characteristics in biomonitoring, such as: exploration of a wide range of trophic conditions, high capacity for physiological adaptation, tolerance to high temperatures, low pH and dissolved oxygen, high pollution and salinity. Some genera are considered indicators of environmental conditions.

The objective of this work was to register the genera of Chironomidae (Diptera) that occur in Açude Grande, Cajazeiras - PB. The initial survey of the fauna of Chironomidae makes it possible to know the biodiversity that still exists in the reservoir, also allowing to build a database for the assessment of the environmental quality of the ecosystem (Figures 40 and41).

During the study counted 189 larvae of Chironomidae (Diptera). the genres identified were: *Chironomus* (170 specimens), *Polypedililum* (9 specimens), *Aedokritus* (2 specimens), *Cladopelma* (2 specimens), *Dicrotendipes* (2 specimens), *Larsia* (2 specimens) and *Tanytarsus* (2 specimens). In the first collection, there was little abundance of genera, but greater richness (5), being represented by the genera *Polypedililum, Aedokritus*, *Cladopelma, Larsia* and *Tanytarsus*.

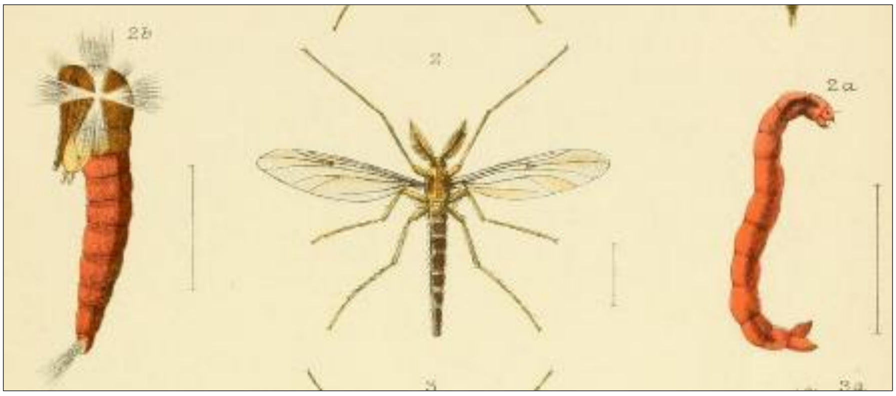


Figure 41 Pupa (left), adult (center), larva (right); (Source: https://en.wikipedia.org/wiki/Chironomus_zealandicus)

In the second collection, there was lower richness (2), represented by *Chironomus* and *Dicrotendipes*, with *Chironomus* dominance. The genus *Chironomus* corresponded to almost 100% of the organisms identified in the second sampling [23,24,25,26].

3.4 Study 4

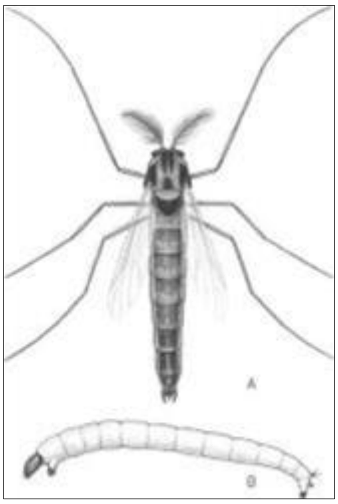


Figure 42 Chironomidae. (A) Adult male (*Chironomus* sp.); (B) larva (*Pseudodiamesa* sp.); (Source: From McCafferty, 1981.Copyright © 1981)

The Chironomidae family is also important in public health studies. Adult individuals of *Chironomus kiiensis* Tokunaga, 1936 may contain potentially inhalant allergens, which in contact with the human skin or mucosa, increase the levels of immunoglobulin E (IgE), causing allergies. Evidenced the bacterium *Vibrio cholerae* 1883 por Robert Koch (the causative agent of cholera) associated with the protein matrix of the postures of *Chironomus* and recorded adult individuals of Chironomidae as possible carriers of the bacterium *V. cholerae* (Figure 42) [27].

Another importance attributed to the group concerns paleolimnology, that is, the science that studies and interprets past limnological conditions, the changes and their possible causes. Chironomidae cephalic capsules give rise to subfossils and fossils in several layers of sediment. The Chironomidae family is also of agro-economic interest, being considered a pest when associated with rice plantations (Figure 43) [27].

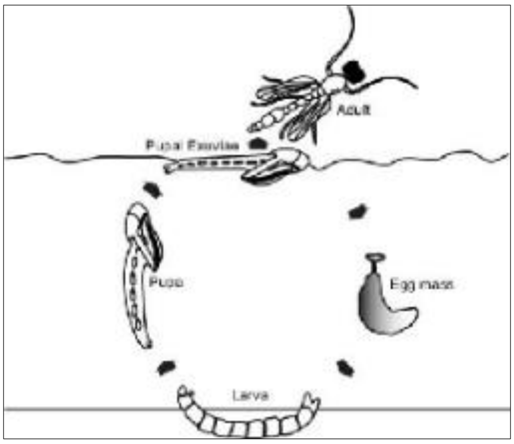


Figure 43 There are four life stages, egg, larva, pupa, and adult, in the chironomid life cycle. Female adults lay eggs on the surface of the water. Eggs sink to the bottom and typically hatch in several days to one week. After leaving the egg mass, larvae burrow into the mud or construct small tubes in which they live, feed, and develop. Larvae transform into pupae while still in their tubes. After pupation, pupae actively swim to the surface of the water and adults emerge from the pupal exuviae; (Source: https://www.researchgate.net/figure/Chironomid-life-cycle-There-are-four-life-stages-egg-larva-pupa-and-adult-in-the_fig1_280386987)

The genus *Chironomus* is widely distributed and can be found in lotic and lentic environments, usually in organically enriched waters. The genus comprises more than 100 known species. Oviposition is the beginning of the group's life cycle, the eggs are arranged inside a gelatinous matrix, which is placed on the surface of the water, usually found attached to some substrate (Figure 44) [27].

Figure 44 Examples of an area of SFPE accumulation and field collection techniques in a stream. (A) An example of where SFPE would accumulate upstream of a log. The white, foamy material is a combination of organic matter, such as macrophytes and algae, and can contain hundreds to thousands of pupal exuviae. (B) An example of how a collector would use a sieve and larval tray to collect SFPE from the riparian banks of the stream; (Source: https://www.researchgate.net/figure/Examples-of-an-area-of-SFPE-accumulation-and-field-collection-techniques-in-a-stream-A_fig2_280386987)

The ovigerous masses of Chironomidae are constituted by a protective gelatinous matrix of the eggs that, in contact with water, hydrates, giving the spawning a morphological aspect that can be characteristic for certain groups. The larvae, after hatching from the eggs (egg hatching (approximately 48 hours), had an average length of 792±128μm. The first instar of the *Chironomus* genus has a planktonic habit, a period in which the larvae remain between the substrate particles, feeding on bacteria. According to the author, the larvae begin to build tubes from the second instar (egg hatching (approximately 48 hours) (Figure 45) [27].

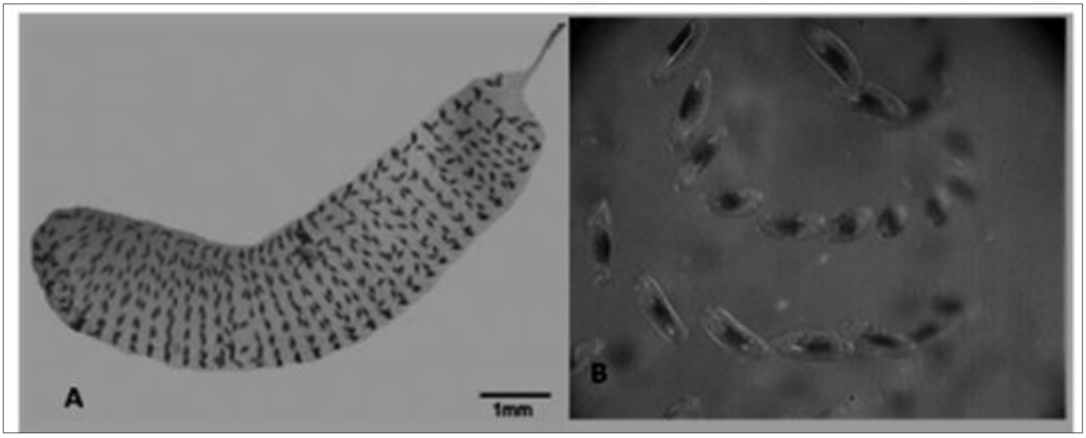


Figure 45 A: Egg masses of *Chironomus calligraphus* Goeldi, 1905. B: Detail of eggs loops; (Source: https://www.researchgate.net/figure/Examples-of-an-area-of-SFPE-accumulation-and-field-collection-techniques-in-a-stream-A_fig2_280386987)

The genus *Chironomus* is widely distributed and can be found in lotic and lentic environments, usually in organically enriched waters. The genus *Chironomus* is widely distributed and can be found in lotic and lentic environments, usually in organically enriched waters. The genus comprises more than 100 known species [27].

Oviposition is the beginning of the group's life cycle, the eggs are arranged inside a gelatinous matrix, which is placed on the surface of the water, usually found attached to some substrate The ovigerous masses of Chironomidae are constituted. by a protective gelatinous matrix of the eggs that, in contact with water, hydrates, giving the spawning a morphological aspect that can be characteristic for certain groups (Figure 46) [27].

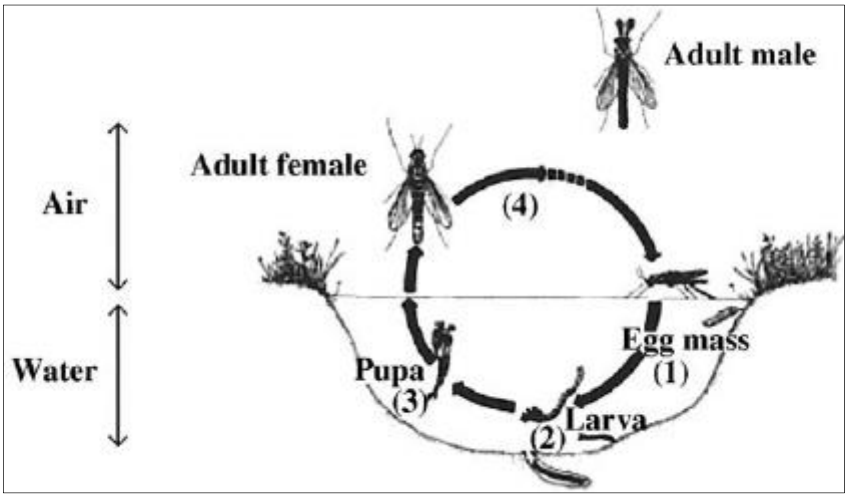


Figure 46 The life cycle of *Chironomus*; (Source: https://www.researchgate.net/figure/The-life-cycle-graph-of-Chironomus-riparius_fig1_230739357)

The larvae, after hatching from the eggs (egg hatching (approximately 48 hours), had an average length of 792±128µm. The first instar of the *Chironomus* genus has a planktonic habit, a period in which the larvae remain between the substrate particles, feeding on bacteria. According to the author, the larvae begin to build tubes from the second instar (egg hatching (approximately 48 hours) [27].

The life cycle of *Chironomus calligraphus* Goeldi, 1905 presented four instars with differentiated average duration time: the first instar presented an average duration of 3±2 days; the second instar had a mean duration of 4±1 day; the third instar also had a mean duration of 4±3 days and the fourth instar had a duration of mean of 8±2 days. After the fourth larval instar, the organism enters the pupal stage, which it has a dark coloration and a well-differentiated cephalothorax, soon emerging as a terrestrial adult than 100 known species (Figure 47) [27].

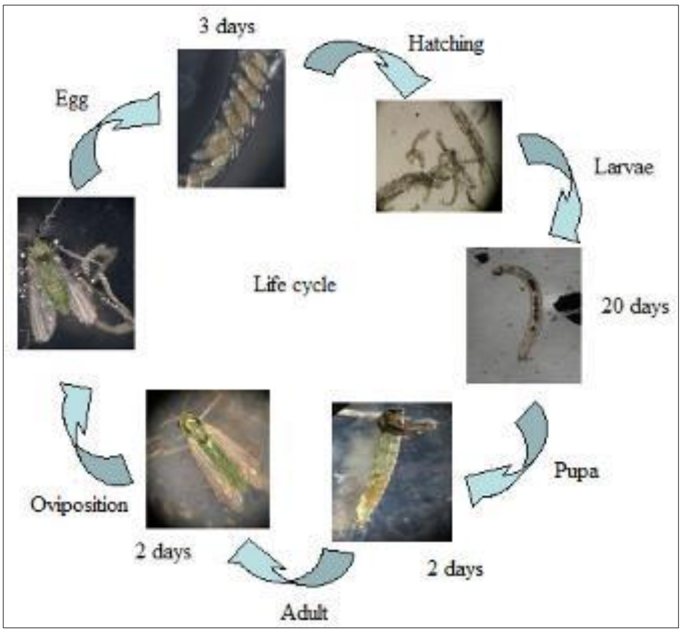


Figure 47 The life cycle of *Chironomus calligraphus* Goeldi, 1905; (Source: https://www.scielo.br/j/bjb/a/jQ3BZggGrc8LfnKqvCLJfPD/?lang=en)

Oviposition is the beginning of the group's life cycle, the eggs are arranged inside a gelatinous matrix, which is placed on the surface of the water, usually found attached to some substrate The ovigerous masses of Chironomidae are constituted by a protective gelatinous matrix of the eggs that, in contact with water, hydrates, giving the spawning a morphological aspect that can be characteristic for certain groups (Figure 48) [27].

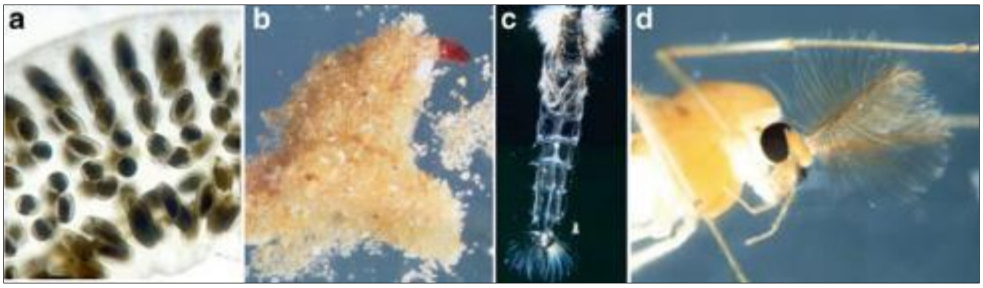


Figure 48 Developmental stages of *Chironomus* sp. (a) Egg dough. The eggs are arranged in a row, folded into loops to form a spiral, and embedded in a thick gelatinous cylinder. (Original magnification Â 40). (b) Larva dwelling in a sand tube. The head of the midge is seen outside the tube. (c) Pupal exuvium. (d) male adult; (Source: https://www.researchgate.net/figure/Developmental-stages-of-Chironomus-sp-a-Egg-mass-The-eggs-are-arranged-in-a-row_fig1_290283276)

3.5 Study 5

Chironomids are members of the order Diptera (true flies) and are close relatives to mosquitos. They complete a full life cycle (metamorphasis), and can be seen in and around stillwaters in larval, pupa and adult forms. Accounting for more than 40% of trout's diet, they are without question the most important stillwater trout food source (Figures 49, 50, 51, 52, 53, 54, 55 and 56) [28].

3.5.1 Study 5

The impact of Chironomidae larvae on organic matter decomposition and nutrient exchange

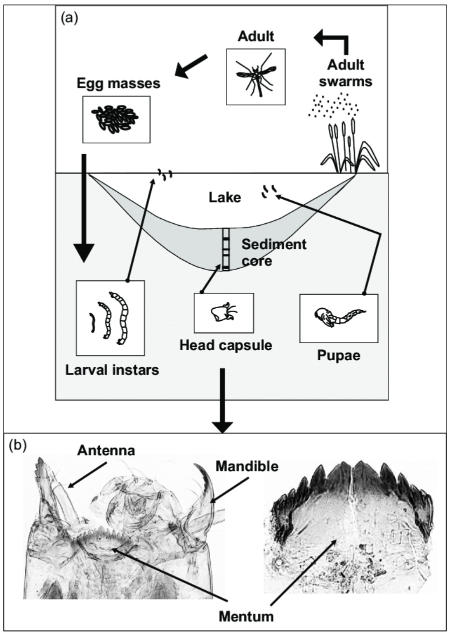


Figure 49 (a) Chironomidae life cycle (b) Fossil chironomid head capsules from Laguna Stibnite, Chile, showing taxonomical useful features; (Source: Massaferro and Brooks 2002)

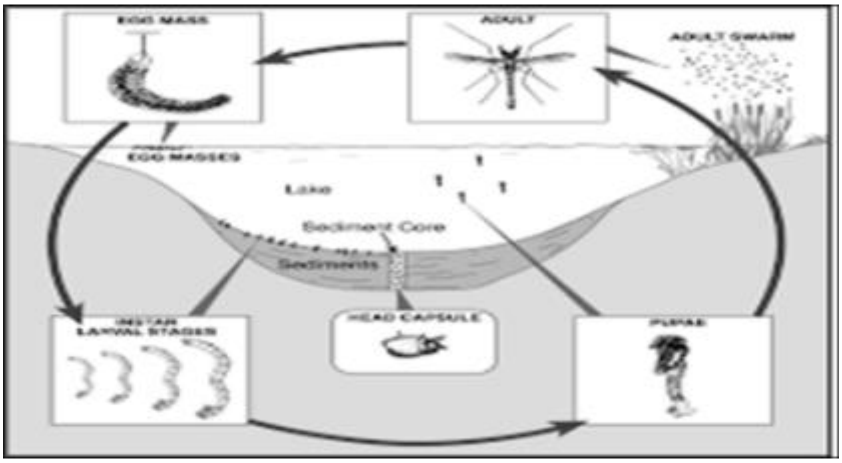


Figure 50 The use and application of freshwater midges (Chironomidae: Insecta: Diptera) in geographical research. Chironomids are cosmopolitan in distribution and frequently the most abundant insects found in freshwater ecosystems. The capacity of the family to tolerate large gradients of pH, salinity, depth, oxygen concentration, temperature and productivity enables members of the Chironomidae to occupy virtually every available niche present in freshwater environments;
(Source: https://journals.sagepub.com/doi/abs/10.1191/0309133303pp388ra?journalCode=ppga)

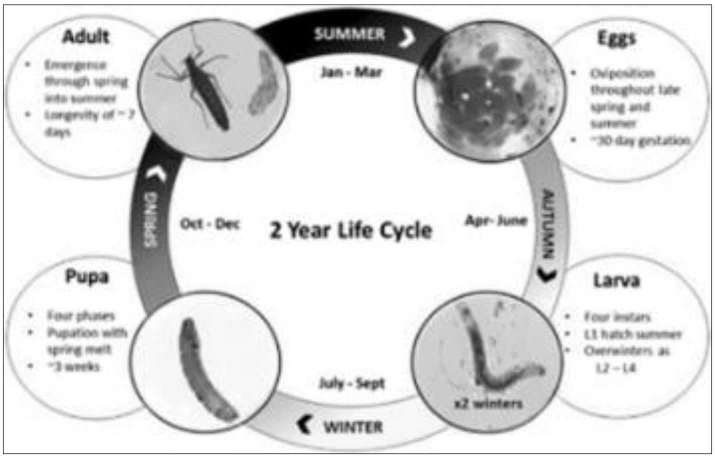


Figure 51 This study provides the first comprehensive documentation of the life cycle of *Eretmoptera murphyi* Schäffer, 1914, a flightless chironomid midge that is currently expanding its distribution following anthropogenic introduction to Signy Island; (Source: https://journals.sagepub.com/doi/abs/10.1191/0309133303pp388ra?journalCode=ppga)

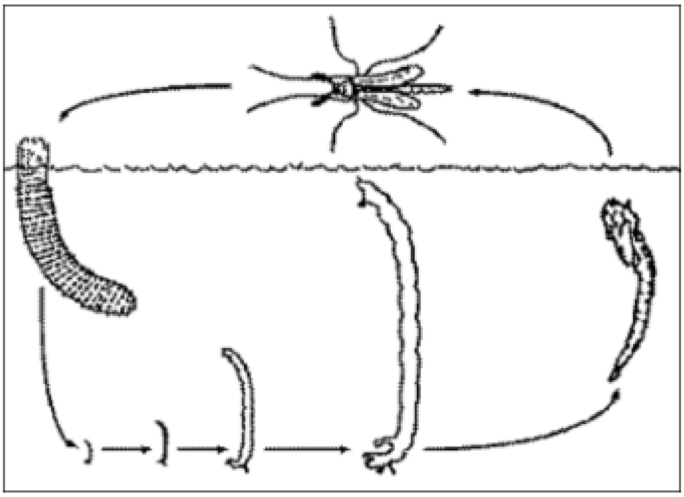


Figure 52 Life cycle of Chironomidae displaying the egg stage, the four larval instars, the pupal stage and the terrestrial imago; (Source: adopted from Timmermans)

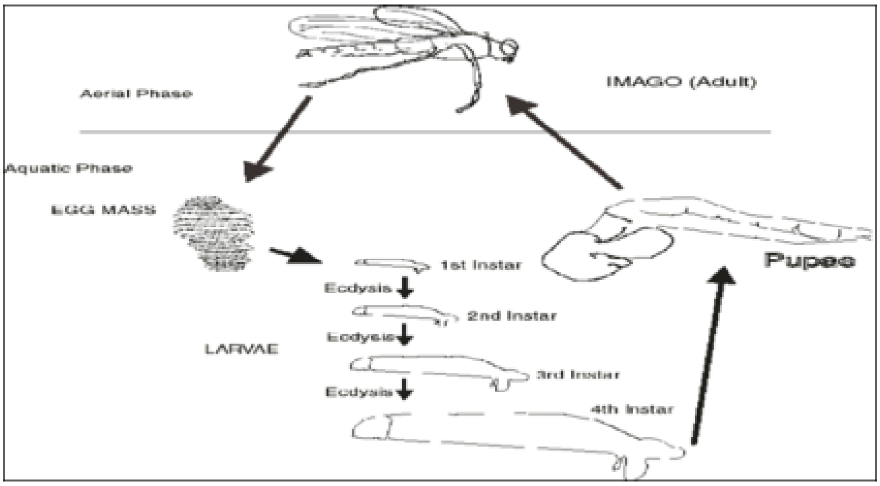


Figure 53 Life cycle of a typical Chironomid; (Source: https://www.researchgate.net/figure/Life-cycle-of-a-typical-Chironomid_fig1_327601594)

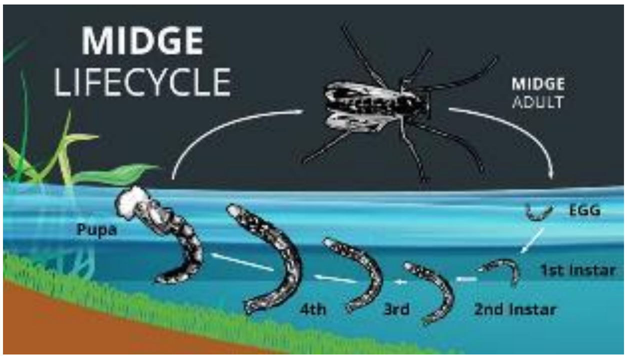


Figure 54 Life cycle of the Chironomiae family: Drifthook Is a Midge a Nymph. A Fly Fishing Perspective (Source: https://drifthook.com/blogs/discover/is-a-midge-a-nymph-a-fly-fishing-perspective)

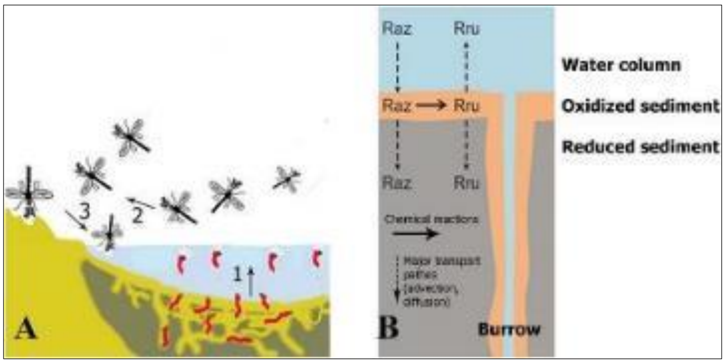


Figure 55 (A) At different stages of their life cycle, bioturban chironomid species, such as the widespread *Chironomus plumosus* L., 1758, are involved in the cycling of several chemical elements in aquatic and terrestrial ecosystems: 1. Chironomid larvae are increasing the fluxes of oxygen, ammonia, phosphorus through the sediment-water interface, by forced ventilation of sediments, nutrient excretion, promotion of inorganic reactions and bacterial activity. 2. Flying adults transfer organic matter and various elements from aquatic to terrestrial ecosystems. 3. Parts of dead adults are often thrown back into the water, providing an additional route for the flow of organic matter into aquatic ecosystems (B); (Source: https://www.nature.com/articles/srep27329)

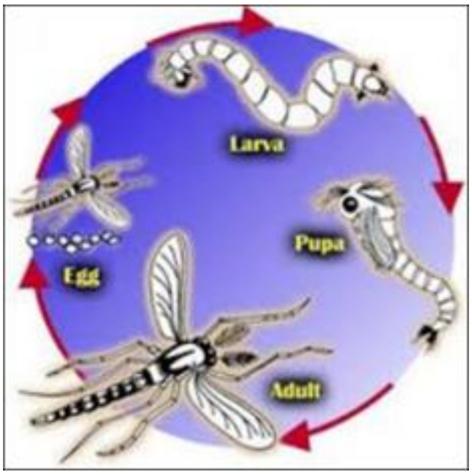


Figure 56 Life cycle of midges Chironomidae. These flies alternate between a long aquatic larval stage and a short flying adult stage. The aquatic larval stages are used in toxicity testing. Endpoints include growth, survival, emergence, and reproduction;
(Source:https://www.waterboards.ca.gov/water_issues/programs/swamp/newsletter/winter2016/test_species.pdf)

SWAMP Toxicity Test Species Highlight Midge larvae - *Chironomus dilutes* Shobanov et al. 1999 Midges are members of the family Chironomidae, the "non-biting" flies [29].

- Their larval stages are among the most numerous invertebrates present in Aquatic ecosystems around the world.
- They function as important primary consumers, eating benthic algae and Breaking down debris in benthic habitats.
- They are a key food source for fish.
- The 10-day larval growth and survival test with *C. dilutus* was added to the Stream Pollution Trends monitoring program (SPoT) in 2015.
- Though tolerant of organically enriched environments and low dissolved Oxygen, larval chironomids are sensitive to human-induced contaminants.
- Acute and chronic toxicity test protocols have been developed with *C. dilutes* Larvae for water and sediment monitoring.
- They have been shown to be particularly sensitive to several pesticides in Current use.
- Chironomids are the most sensitive species to newer classes of pesticides Such as imidacloprid (a neonicotinoid), and fipronil and its degradates.
- Use of both of these classes of pesticides is increasing in California.

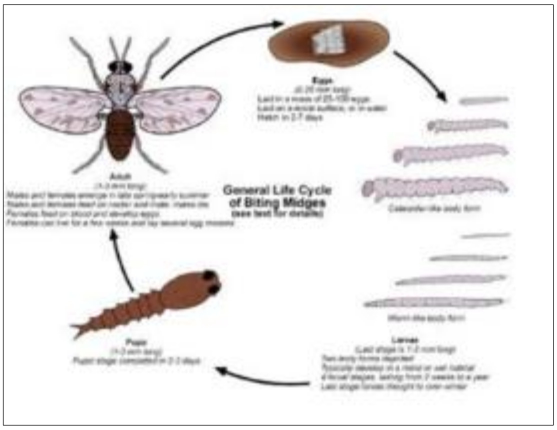


Figure 57 Biting midge life cycle; (Source: Illustration by: Scott Charlesworth, Purdue University, based in in part on Pechuman LL, Teskey HJ, 1981, IN: Manual of Nearctic Diptera, Volume 1)

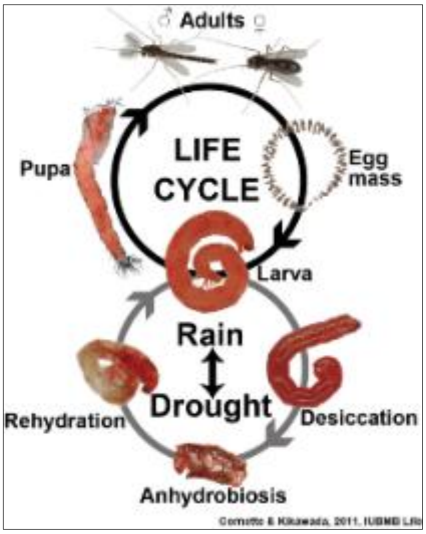


Figure 58 The flow chart shows the different cycles the midge takes through cycles of long drought in Africa. The reintroduction of water into the environment triggers the switch between cycles where seemingly mummified larvae can come back to life; (Source: https://www.oist.jp/news-center/photos/midge-life-cycle)

Biting midges undergo a type of development known as “complete metamorphosis.” This means the last larval stage molts into a non-feeding pupal stage that eventually transforms into a winged adult. Relatively few species have been studied, and the account below is based largely on pest species that have been reared in captivity (Figures 57, 58, 59 and 60) [30,31].

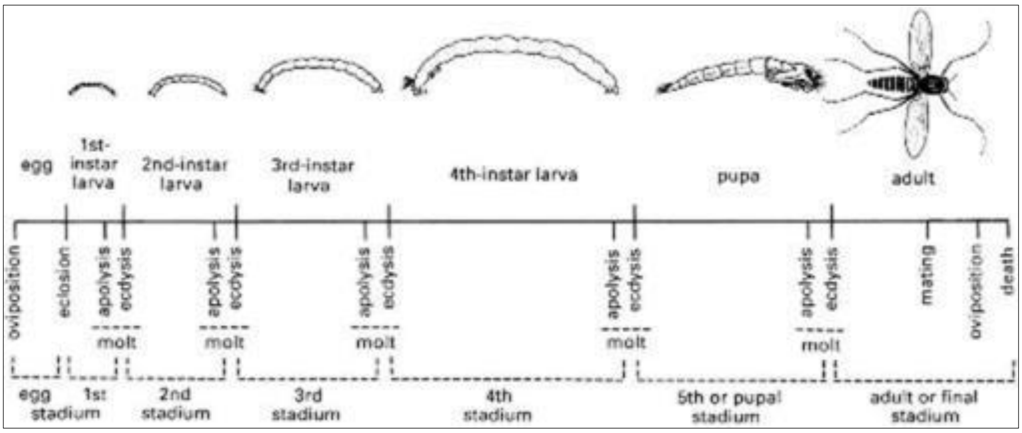


Figure 59 Schematic drawing of the life cycle of a non-biting midge (Diptera: Chironomidae, *Chironomus*) showing the various events and stages of insect development. In some pterygote taxa the total number of preadult growth stages or instars may vary within a species depending on environmental conditions, such as developmental temperature, diet, and larval density. In many other species, the total number of instars (although not necessarily final adult size) is genetically determined and constant regardless of environmental conditions; (Source: http://www.entomologa.ru/outline/95.htm)

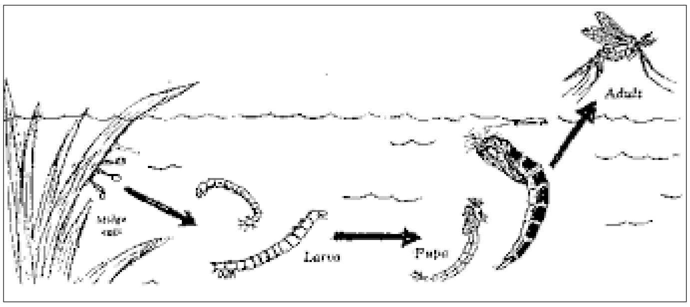


Figure 60 Diet: Fine detritus, microorganisms, plant parts, decaying wood, insect parts, algae. Food for: Fish, especially trout, predaceous water insects. Habitat: Bottom dweller in the mud, stones or plants, most widely adapted to any freshwater environment. Movement: Can float in water or scurry along bottom, some swim in still water. Breathing: Though skin or by obtaining surface air through a breathing tube. Some types have gills. Water Quality Indicator: Group III– can tolerate polluted waters; (Source: https://sitesmedia.s3.amazonaws.com/creekconnections/files/2013/12/midge.pdf)

Knowing the life cycle of the insects you use while fly fishing is not only enjoyable but it can help you make a choice on fly, location and depth to fish. Here is a great graphic outlining the life cycle of Chironomid (midge) (Figures 61, 62 and 63) [30,31].

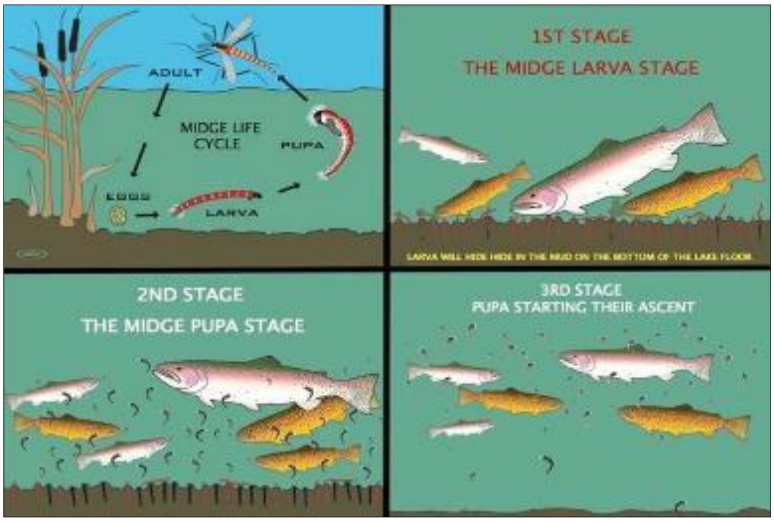


Figure 61 Music generously provided by: Frog and Toad; (Source: frogandtoadmusic.com)

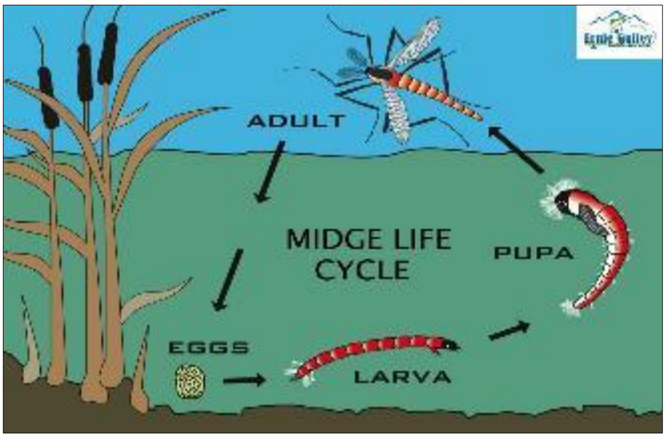


Figure 62 The fish (Spring) are now looking to start putting the bags of feed and fattening up as much as they can. Mosquitoes, which in most calm waters make up about 85% of a spring trout diet, are the main food source until other food items start appearing later in the season; (Source: Ernie Gulley Fly Fishing in Blog on 05 April 2016 Hits: 2736)

Figure 63 Chironomid/ midge pupae from a throat pump; (Source: Brian Chan)

Chironomid life cycle (typical life cycle of one year). After hatching, the larvae live buried in the mud/water interface at the bottom of a lake at depths ranging from a few meters to more than 25 meters. The larvae feed on decaying plants and other organic matter (Figure 64) [30,31].

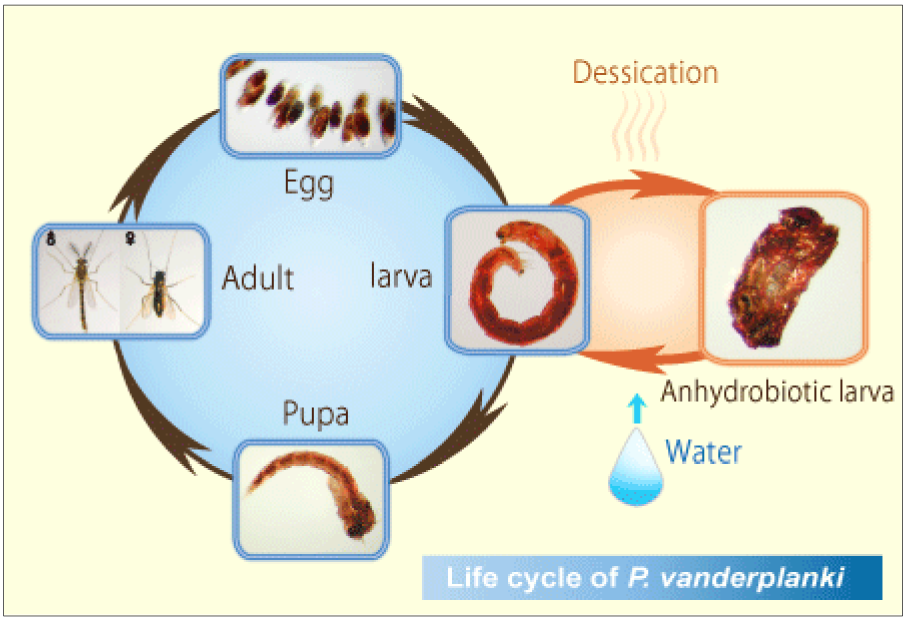


Figure 64 *Polypedilum vanderplanki* Hinton, 1951, chironomid adornado. It is one of the few metazoans that can resist almost complete desiccation (anhydrobiosis) to survive adverse environmental conditions; (Source*: Polypedilum anderplanki* Hinton, 1951, Chironomidae. It occurs in the semi-arid regions of the African continent. Their larvae are found in small tubular nests in the mud at the bottom of temporary puddles that often dry up during the life of P. vanderplanki larvae. Under these conditions, the larvae's body dehydrates to a water content of up to 3% by weight. In the dehydrated state, the larvae become impervious to many extreme environmental conditions and can survive temperatures from very high levels to 7000 gray gamma ray staining and exposure to vacuum) (Figure 65) [32,33].

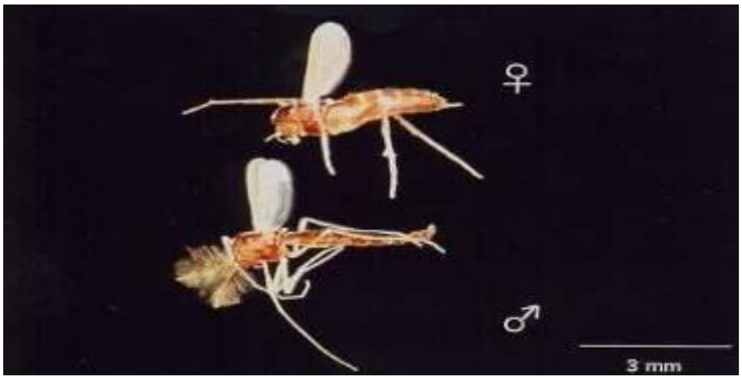


Figure 65 *Polypedilum vanderplanki* Hinton, 1951: Female and Male; (Source: https://alchetron.com/Polypedilum-vanderplanki)

3.6 Cryptobiosis

Human body contains about 80% of water, and which water plays important roles in the metabolism (chemical reactions that occur into the body and the cell in order to maintain life) or as a structural element constituting the body. That is why a water loss corresponding to only 10-12% of the body weight is critical for the maintenance of life. However, the sleeping chironomid can survive to a loss of about 97% of its body water. Of course, in such a dehydrated state, the normal metabolism is stopped (Figure 66) [34,35].

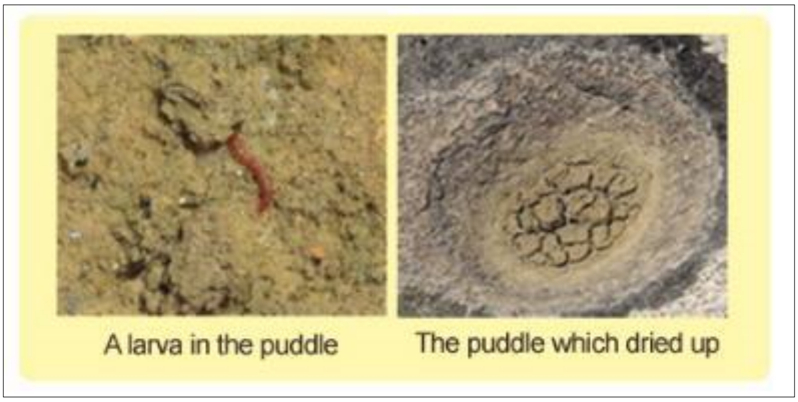


Figure 66 Then how can the sleeping chironomid survive? The sleeping chironomid builds up mud with its saliva, making a pipe shape called tubular nest, and stands inside this nest. When water evaporates, the larva desiccates little by little, protected in the tubular nest and its body water content finally drops to as low as 3% of body weigth. In this state, the sleeping chironomid waits until next rainfall; (Source: https://www.naro.affrc.go.jp/archive/nias/anhydrobiosis/Sleeping%20Chironimid/e-about-yusurika.html)

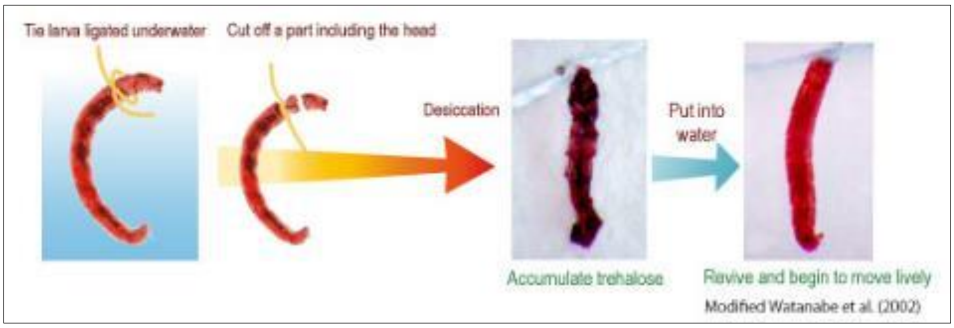


Figure 67 Cryptobiosis and to the revival of desiccated larvae; (Source: https://www.naro.affrc.go.jp/archive/nias/anhydrobiosis/Sleeping%20Chironimid/e-about-yusurika.html)

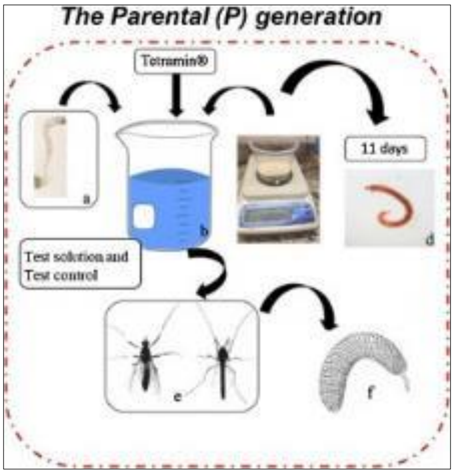


Figure 68 *Chironomus sancticaroli* Strixino-Strixino, 1981, generation test procedure with P generation: a) I instar larvae of *C. sancticaroli*, b) glass vessel with 340 mL of test solution or deionized water, c) 60 g formulated sediment, d) IV instar larvae, e) adults emerged (female or male) and f) egg; (Source: Bernegossi AC, Cardoso NPC, Mayara C, Lima FMR, Corbi SJJ. Chironomus sancticaroli generation test: A new methodology with a Brazilian endemic insect. Methods. 2019; 6(10): 92-97)

This experiment demonstrates that the brain is not directly involved in the physiological mechanism leading to the induction of cryptobiosis and to the revival of desiccated larvae. We are now discovering that the process of cryptobiosis depends on a mechanism, which is completely different from what is known in classical dormancy systems (Figure 67) [36,37,38,39].

The hydrocarbon phenanthrene is an organic compound commonly found in the environment. In aquatic ecosystems, it is highly toxic to organisms, although little is known about its effects on sediment-dwelling organisms. Phenanthrene had toxic effects on this chironomid, indicating risks for natural populations (Figures 68, 69A, 69B and 70).

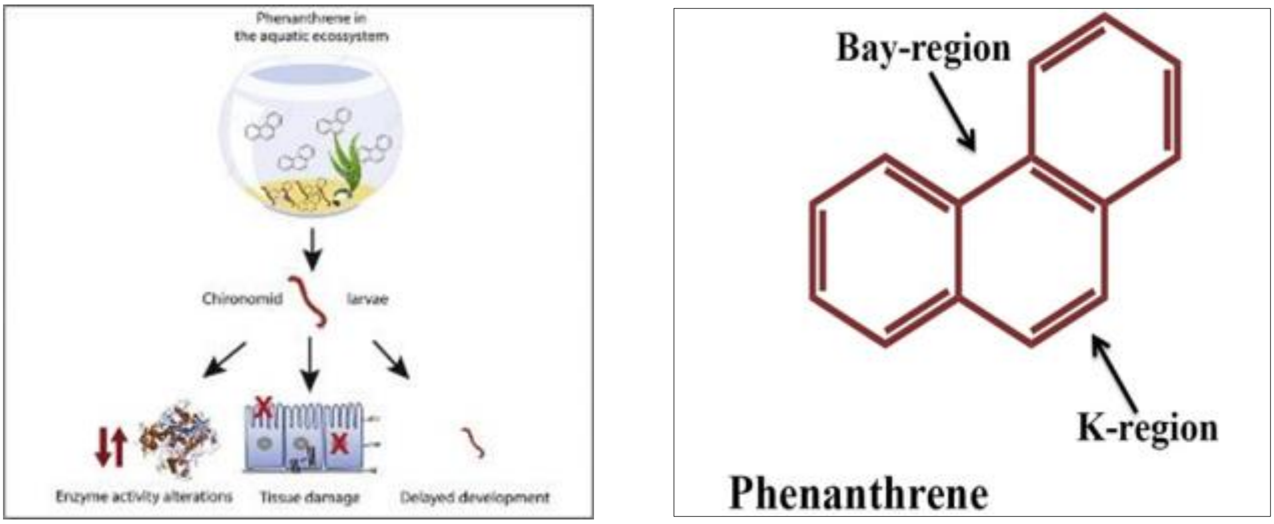


Figure 69 A Effects of phenanthrene on different levels of biological organization in larvae of the sediment-dwelling invertebrate. 69B Structure of phenanthrene, the simplest PAH containing bay and K region; (Source: Richardi VS, Vicentini M, Morais GS, Rebechi D, Silva TA, Fávaro LF, Navarro-Silva MA. Effects of phenanthrene on different levels of biological organization in larvae of the sediment-dwelling invertebrate *Chironomus sancticaroli* (Diptera: Chironomidae), Environmental Pollution. 2018; 242(A): 277-287)

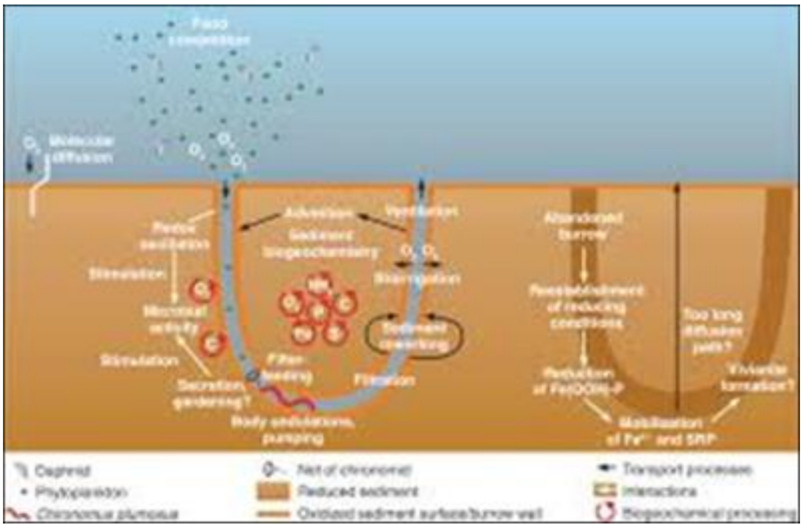


Figure 70 Tube-dwelling invertebrates: tiny ecosystem engineers have large effects in lake ecosystems. 2020; 6/166; (Source: Hölker F, Michael J, Vanni JAN, Kuiper J, Christof C, Hans-Peter MG, Stief P, Adrian R, Lorke A, Dellwig O, Brand A, Hupfer M, Wolf M, Mooij GN, Lewandowski J. Tube-dwelling invertebrates: tiny ecosystem engineers have large effects in lake ecosystems. 2020; 6: 166)

3.7 Study 7

Larvae and pupae. The larvae aquatic; phytophagous, or saprophagous; eucephalic. The pupae without a puparium (the last larval skin remaining attached to the posterior segments). Comments. Delicate, gnat-like flies, often with the head overhung by the humped thorax; wings narrow, usually held apart at rest. The males frequently dancing in swarms, especially near water. Classification. Suborder Nematocera; Division Culicomorpha; Superfamily Chironomoidea. British representation. 588 species in Britain. Generates about 140; with a few genera - *Chironomus, Cricotopus, Limnophyes, Metriocnemus, Paratanytarsus, Tanytarsus* represented by many species, but most by few (Figures 71A, 71B and 71C) [43].

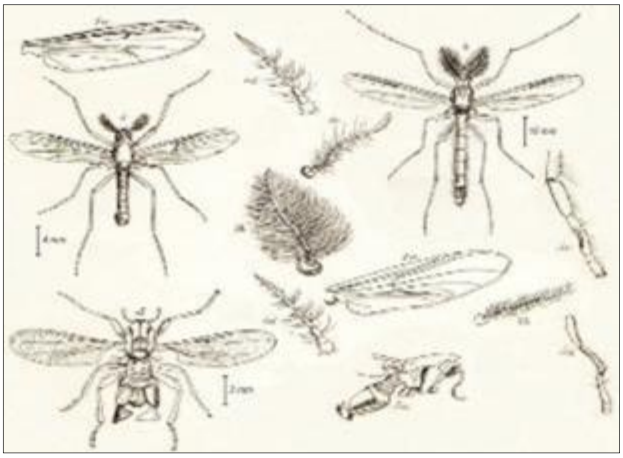


Figure 71A *Ablabesmyia, Chironomus, Clunio, Diamesa, Harnischia, Potthastia* (Walker). 1, *Potthastia gaedii* Meigen, 1838. 1a and 1c, details of wing and female antenna, respectively, of *Chironomus plumosus* (Linnaeus, 1758). 1b, antenna of male *Harnischia curtilamellata* Malloch, 1915. 1c, antenna of male *Diamesa tonsa* (Walker 1856). 2a and 2b, wing and female antenna of *Ablabesmyia monilis* (Linnaeus, 1758). 4, *C. plumosus*, male. 5, *Clunio marinus* Haliday, 1855, male, with side view (5a), details of an antenna (5b), and a hind tarsus (5c); (Source: Watson L, Dallwitz MJ. 2003 onwards. Insects of Britain and Ireland: the families of Diptera. Version: 27th. 2019)

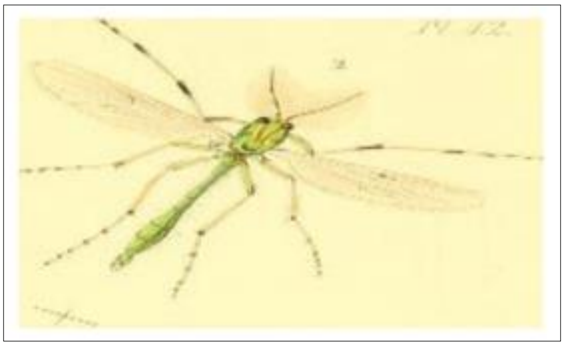


Figure 71B *Macropelopia nebulosa* (dissections: B. Ent. 501). Figure 71C cf. male of *Chironomus viridulus*, Stephens 1846; (Source: Watson L, Dallwitz MJ. 2003 onwards. Insects of Britain and Ireland: the families of Diptera. Version: 27th. 2019)

4. Conclusion

Chironomids are not known to be dangerous to humans, in particular because they do not bite and do not seek contact with our food like some flies. At the time of metamorphosis, the adult leaves its envelope on the surface of the water, without contact with it and usually without direct contact with polluted sediments. It does not transmit germs or parasites through the bite, but it may be a local vector of certain microbes or viruses to animals that eat it, or to humans via fomites, which has yet to be demonstrated.

References

[1] Anjos AF, Takeda AM, Pinha GD. Spatial and temporal distribution of Chironomidae larvae in different environments of the complex - Baia River, State of Mato Grosso do Sul, Brazil. Acta Scientiarum Biological Sciences. 2011; 33: 417-426.

[2] Panis L. On the relationship between vertical patches and adaptations to oxygen stress in coastal Chironomidae (Diptera). Hydrobiology. 1996; 3(318): 61-67.

[3] Walshe BM. Feeding mechanisms of Chironomus larvae. Nature. 1947; 160: 147.

[4] Kajan R, Frenzel P. The effect of chironomid larvae on methane production, oxidation and fluxes in a flooded rice soil. FEMS Microbiology. 1999; 28: 121-129.

[5] McLachlan AJ. Some effects of the tube shape on the feeding of Chironomus plumosus L. Journal of Animal Ecology. 1997; 46(3): 139-146.

[6] Tatrai I. Rates of ammonia release from sediments by chironomid larvae. Freshwater Biology. 1986; 16: 61–66.

[7] Granéli W. The influence of *Chironomus plumosus* larvae on oxygen uptake from sediments. Archive Hydrobiology. 1979; 87: 385-403.

[8] Vensson SJ. Influence of *Chironomus plumosus* larvae on ammonium flux and denitrification (measured by acetylene blocking and isotope pairing technique) in eutrophic lake sediments. Hydrobiology. 1997; 346: 157-168.

[9] Fukuhara H, Sakamoto M. Enhancement of inorganic nitrogen and phosphate release from lake sediment by tubificid worms and chironomid larvae. Oikos. 1987; 48: 312–320.

[10] Gallep GW, Kitchell JF, Barte SM. Phosphorus release from lake sediments affected by chironomids. Verhandlungen des Internationalen Verein Limnologie. 1987; 20: 458-465.

[11] Bund VWJ, Goedkoop W, Johnsonn RK. Effects of deposit feeder activity on bacterial production and abundance in deep lake sediment. Journal of the North American Benthological Society. 1994; 13: 532-539.

[12] Pierre A, Gauzere BA. Cholera news. Center Rene Labusquiere, Institute of Tropical Medicine. 1th ed. Bordeaux: University of Bordeaux. 2020.

[13] Gandouin E, Ponel P, Franquet E, Vliet-Lanoë VB, Andrieu-Ponel V, Keen DH, Brocandel BJM. Chironomid responses to younger drays and Holocene environmental changes in a northern French floodplain. The Holocene. 2007; 17(3): 331-34.

[14] Armitage PD, Cranston PS, Pinder LCV. The Chironomidae. biology and ecology of non-biting midges. 1th. ed. London: Chapman & Hall. 1995

[15] Bund VWJ, Johnson GRK. Effects of depositfeeder activity on bacterial production and abundance in deep lake sediment. Journal of the North American Benthological Society. 1994; 13: 532-539.

[16] Hansen K, Mouridsenn S, Kristensen E. The impact of *Chironomus plumosus* larvae on organic matter decomposition and nutrient exchange (N, P) in a eutrophic shallow lake sediment after a phytoplankton sedimentation. Hydrobiology. 1998; 364: 65–74.

[17] Ashe P, Murray DA, Reiss F. The zoogeographical distribution of Chironomidae (Insecta: Diptera). Annales de Limnologie. 1987; 23, 27–60.

[18] Reis EA, Filho AS, Silva VM. Chironomidae (Diptera) from the State of Tocantins, Brazil. EntomoBrasilis. 2012; 5 (1): 65-69

[19] Cornette R, Gusev O, Nakahara Y, Shimura S, Kikawada T, Okuda T. Chironomid midges (Diptera, Chironomidae) show extremely small genome sizes. Zoological Science. 1015; 32(3): 248-254.

[20] Marchiori CH. Biology and feeding behavior of adult ceratopogonid (Diptera: Ceratopogonidae). International Journal of Frontiers in Science and Technology Research. 2021; 1(2): 007–024.

[21] Trivinho-Strixino S. Chironomidae (Insecta, Diptera, Nematocera) from São Paulo State, Southeast Brazil. Neotropical Biota. 2011; 11(1): 675-684.

[22] Butakka CM, Ragonha MFH, Takeda AM. Chironomidae larvae (Diptera) of Neotropical floodplain: overlap niche in different habitats. Brazilian Journal of Biology. 2014; 74(2):363-370.

[23] Ferrington JLC. Global diversity of non-biting midges (Chironomidae; Insecta-Diptera) in freshwater. Hydrobiologia. 2008; 595: 447-455.

[24] Anjos AF, Takeda AM. Estrutura da comunidade das larvas de Chironomidae (Insecta: Diptera), em diferentes substratos artificiais e fases hídricas, no trecho superior do rio Paraná, Estado do Paraná, Brasil. Acta Scientiarum, Biological Sciences. 2010; 32:131-140.

[25] Butakka CMM, Ragonha FH, Takeda AM. Chironomidae larvae (Diptera) of Neotropical floodplain: overlap niche in different habitats. Brazilian Journal of Biology. 2014; 74(2):363-370.

[26] Molozzi J, et al. Development and test of a statistical model for the ecological. Assessment of tropical reservoirs based on benthic macroinvertebrates. Ecological Indicators. 2012: 23: 155-165.

[27] Higuti J, Takeda AM, Paggi AC. Spatial distribution of Chironomidae (Insecta, Diptera) from Rio Baia (MS-Brazil). Unimar Magazine. 1993; 15: 65-81.

[28] Ali A, Morris CD. Management of non-biting aquatic midges. IFAS, University of Florida Medical Entomology Laboratory Technical Bulletin. 1992; 4: 1-16.

[29] Elmer GW, Fusco RA, Noblet RCR, Wyatt RD. Field Evaluation of bactimos PT against chironomid midge (Diptera: Chironomidae) larvae in resistant ponds. Journal of the American Mosquito Control Association. 2011; 27(2): 173-176.

[30] Fusari LM, Roque FO, Hamada N. Sponge-dwelling Chironomids in the upper Paraná River (Brazil): Little known but potentially threatened species. Neotropical Entomology. 2008; 37(5):522-527.

[31] Rosin GC, Takeda AM. Chironomidae (Diptera) larvae from the upper Paraná River floodplain: distribution and composition in different environments and hydrological periods., Acta Scientiarum Biological Sciences.2007; 29:57-63.

[32] Clegg CS. Cryptobiosis; a peculiar state of biological organization. Comparative Biochemistry and Physiology. 2001; 128(4): 613–624.

[33] Calahan D, Maitreya D, Chris D, Koshland KE. Genetic analysis of description tolerance in Sachharomyces cerevisiae. Genetics. 2011; 189(2): 507–519.

[34] Shen-Miller J, Mudgett MB, Schopf WJ, Steven C, Berger D. Exceptional seed longevity and robust growth: Ancient sacred lotus from China. American Journal of Botany. 1995; 82(11): 1367–1380.

[35] Cihan E, Penkov S, Fahmy K, Kurzc BV. How worms survive desiccation: Trehalose pro water. Worm. 2012; 1(1): 61–65.

[36] Tunnacliffe A, Lapinski J, McGee B. The putative LEA protein, but not trehalose, is present in anhydrobiotic bdelloid rotifers. Hydrobiology. 2005; 546(1): 315–321.

[37] Karim K, Teymuras V. Trehalose renders the dauer larva of *Caenorhabditis elegans* resistant to extreme desiccation. Current Biology. 2011; 21(15): 1331–1336.

[38] Cristina G, Michiyo A. Larvae of Chironomidae (Diptera) from the upper Paraná River floodplain: Paraná: distribution and composition in different environments and hydrological periods. Acta Scientiarum Biological Sciences. 2007; 29(1): 57-63.

[39] Lima DVM, Souza LB, Capistrano PCC, Plese LPM, Vieira LJS. Use of Chironomidae (Diptera) larvae in the ecological technique analysis of urban lakes in western Amazon. Amazon Biota. Macapá. 2019; 9(3): 41-45.

[40] Bernegossi AC, Cardoso NPC, Mayara C, Lima FMR, Corbi SJJ. *Chironomus sancticaroli* generation test: A new methodology with a Brazilian endemic insect. Methods. 2019; 6(10): 92-97.

[41] Richardi VS, Vicentini M, Morais GS, Rebechi D, Silva TA, Fávaro LF, Navarro-Silva MA. Effects of phenanthrene on different levels of biological organization in larvae of the sediment-dwelling invertebrate *Chironomus sancticaroli* (Diptera: Chironomidae), Environmental Pollution. 2018; 242(A): 277-287.

[42] Rosin GC, Mangarotti DPO, Takeda AM. Chironomidae (Diptera) community structure in two subsystems with different states of conservation in a floodplain of southern Brazil. Acta Limnologica Brasiliensia. 2010; 22: 276-286.

[43] Spies M, Reiss F. Catalog and bibliography of Neotropical and Mexican Chironomidae (Insecta, Diptera). Spixiana. 1996; 22: 61-119.