

Mosquitoes of the Chaoboridae Family (Insecta: Diptera).

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The Culicomorpha are an infraorder of Nematocera, including mosquitoes, black flies, and several extant and extinct families of insects. There are phylogenetic patterns that are used to interpret bionomic features such as differences like blood-feeding by adult females, daytime or nighttime feeding by adult females, and occurrence of immature stages in aquatic habitats [1].

Nematocera is a suborder of dipterous insects, which includes mosquitoes. Characterized by long antennae, usually with more than six segments, as opposed to suborder Brachycera. They are holometabolic (complete development), and sexual reproduction. The eggs have varied formats and, when in a liquid medium, have a special structure for flotation. Larvae are generally worm-like and pupae may be motile or immobile [2].

The Chaoboridae are a family of nematocerous dipterans of the suborder Culicomorphs and the superfamily Culicoidea, like mosquitoes. They are related to Corethrellidae and Chironomidae, from which they are distinguished by the venation of the wings. They have about fifty species, divided into 6 genera, of which only one (*Chaoborus*) is cosmopolitan and common. The adults of some species are edible. This is the case with *Chaoborus edulis* Edwards, 1930 (*edulis*: edible), which is traditionally consumed in Malawi (Figure 1) [1-3].

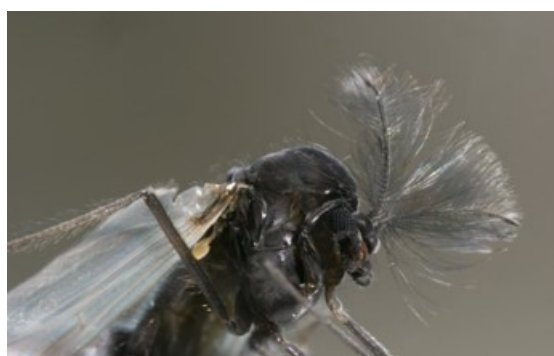


Figure 1. Specimen of Chaoboridae Family.

Source: https://commons.wikimedia.org/wiki/File:Chaoboridae_Richard_Bartz.jpg

Their antennae are 15-segmented and the females' antennae are somewhat bristly; the antennae of males, on the contrary, are very plumose. Also, in this respect, they resemble many of the Nematocera and, in particular, the Chironomidae. Species range in size from about 2 mm to 10 mm in length in their adult stages. The larvae are almost transparent, sometimes with a slightly yellow tint; its more opaque features are two airbags, one in the thorax and the other in the abdomen, in the second last segment. Adults are delicate flies that resemble Chironomidae (Figures 2-4) [1-3].

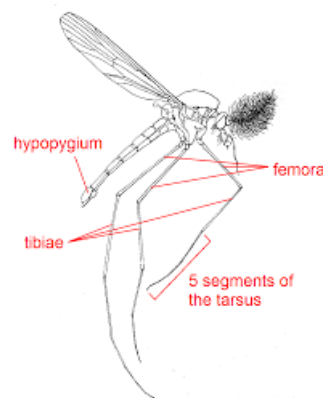


Figure 2. Morphology of the Chaoboridae Family. Source: <https://www.diptera-in-beeld.nl/Ref-Key%20Chaoboridae,%20key%20to%20British%20species.pdf>.

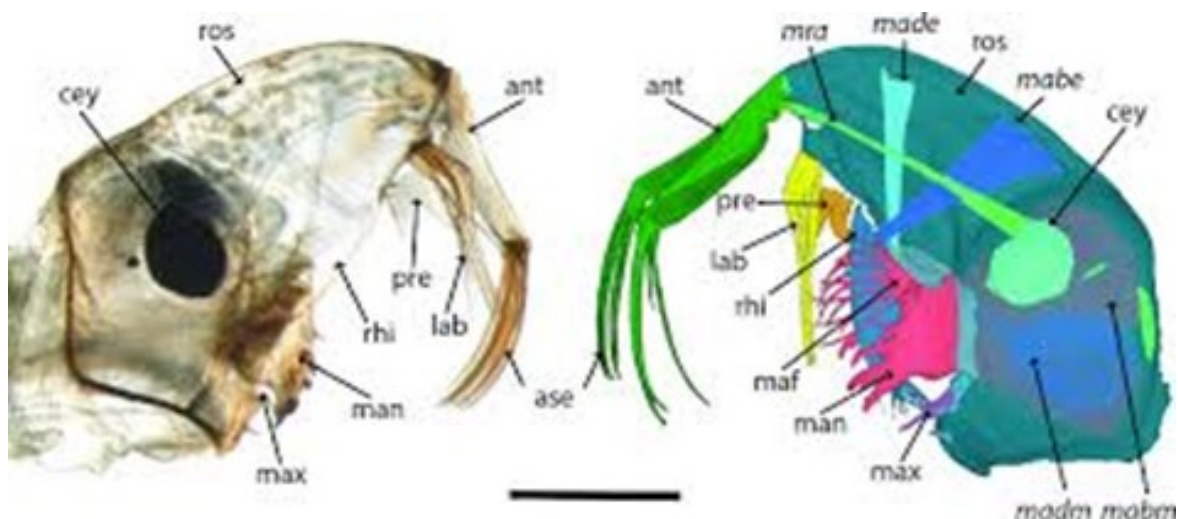


Figure 3. Overview of *Chaoborus obscuripes* (Wulp, 1859) larval head morphology. left: microscopic image, right: micro-CT-based reconstruction. ant = antenna basis; ase = antenna's setae; cey = compound eye; lab = labral setae; mabe = musculus abductor epipharyngis; mabm = musculus abductor mandibulae; made = musculus adductor epipharyngis; madm = musculus adductor mandibulae; maf = mandibular fan; man = mandible; max = maxilla; mra = musculus retractor antennae; pre = prelabral appendages; rhi = rhinopharynx; ros =

rostrum. Source: <https://doi.org/10.1371/journal.pone.0214013.g001>.

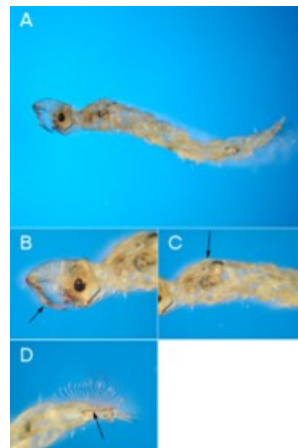


Figure 4. male adult *Chaoborus astictopus* Dyar & Shannon, 1924; **B** – *Chaoborus trivittatus* Saether, 1970 pupa; **C** – fourth instar larva *C. trivittatus*; **D** – wing of *Chaoborus americanus* Johannsen, 1903. Genus *Chaoborus*: Only one genus of Chaoboridae has been collected in North Dakota, the *Chaoborus*. These midges live in standing water, including in deeper areas of lakes and temporary pools. They sprawl during daylight hours but swim at night. *Chaoborus* are predators and sometimes eat mosquito larvae. Source: <https://www.waterbugkey.vcsu.edu/php/familydetail.php?idnum=&show=1510&fa=Chaoboridae&o=Diptera&ls=larvae>.

If they eat, the adults feed on nectar. The larvae are aquatic and unique in their feeding method: the antennae of ghost midges larvae are modified into grasping organs slightly similar to the raptor arms of a praying mantis, with which they capture their prey. They mainly feed on small insects such as mosquito larvae and crustaceans such as *Daphnia*. The antennae impale or crush prey and bring it into the larva's mouth, or stylet. As larvae nadam e às vezes formam grandes enxames em seus habitats lacustres (Figure 5) [4-6].

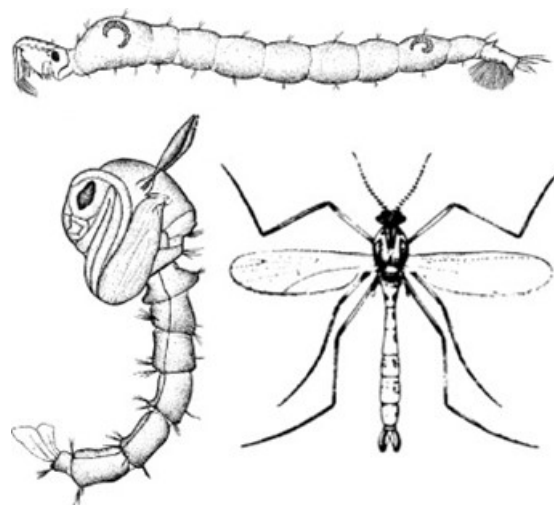


Figure 5. Fourth instar larva (top), pupa (left), and adult (right) of *Chaoborus punctipennis* (Say, 1823). Source: Adapted

from Johannsen OA (1934) Aquatic Diptera. Part I. Nemocera, exclusive of Chironomidae and Ceratopogonidae). Memoirs of the Cornell University Agricultural Experimental Station 164: 1–70.

The larvae are almost transparent, sometimes with a slightly yellow tinge; its opaquest features are two airbags, one in the thorax and one in the abdomen approximately in the penultimate segment. Adults are delicate flies that closely resemble (Figures 6) [7-9].



Figure 6. Both sets of paired gas sacks under 10x magnification.

Sources: <http://people.se.cmich.edu/mcnau1as/zooplankton%20web/chaoborus/chaoborus.htm>.

The larvae live in groups in lakes and ponds. They usually swim between two drinks of water, thanks to hydrostatic vesicles and abdominal swimming paddles. Transparent, sometimes called "crystal worms". They are predators. They feed on very small prey, such as daphnia and mosquito larvae, which they capture with their modified antennae. These antennae grab the prey and drive it to the mouth. Adults have short lives. They feed on nectar, or not at all [10-12].

Primary consumers

1. Insect larva.
2. *Macrobrachium* sp. (Palaemonidae).
3. *Melanoides tuberculata* (Muller, 1774) (Gastropoda: Thiaridae).
4. *Hippeutis thienemanni* Rensch, 1934. (Gastropoda: Planorbidae).

Three consumer.

5. Larva Discidae.
6. Larva Fam. Libellulidae.

Quaternary consumers.

7. *Trichogaster pectoralis* (Regan, 1910) (Belontiidae).

8. Fifth Consumers.

9. *Clarias batrachus* (Linnaeus, 1758) (Clariidae).

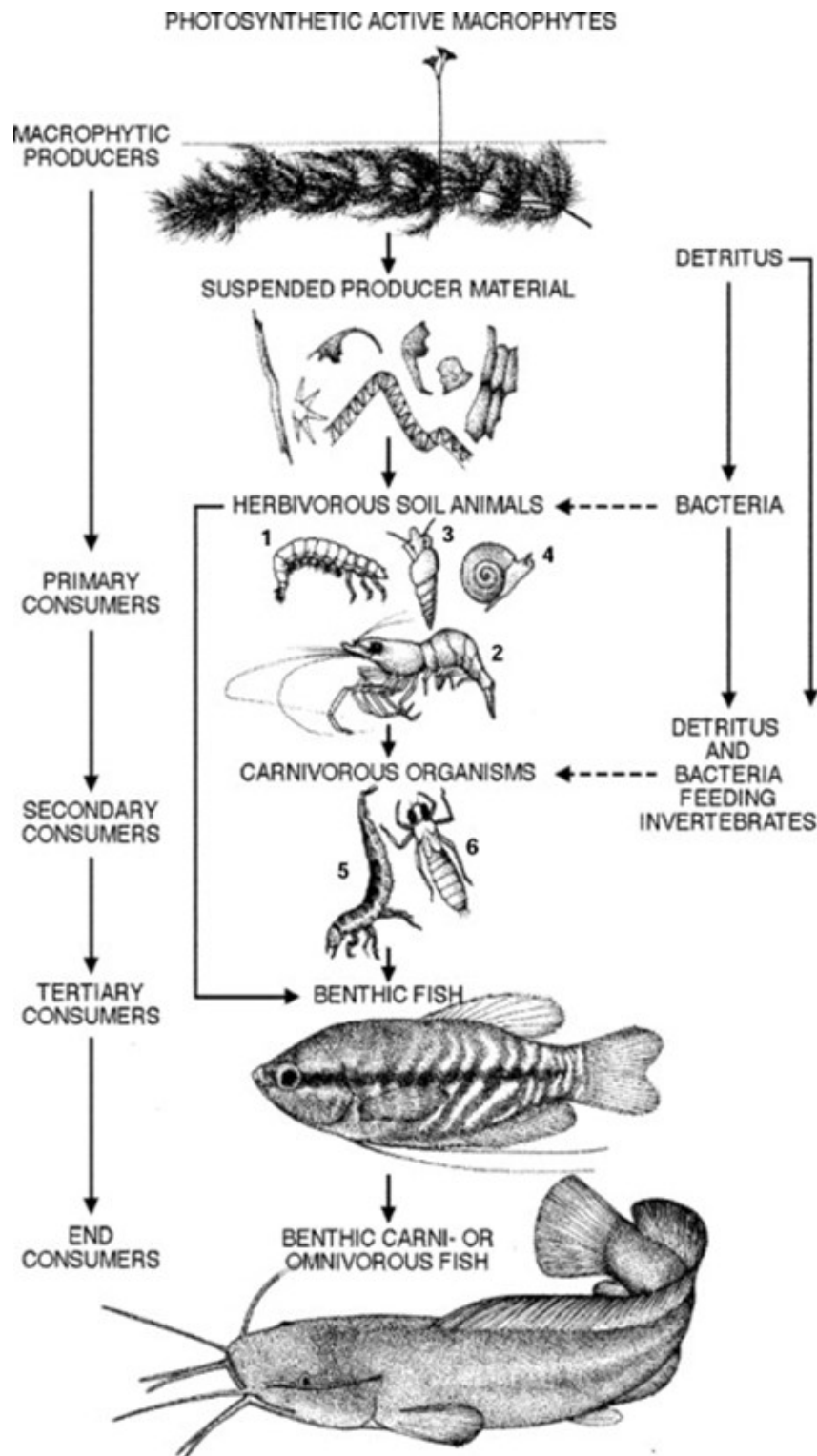
Zooplankton and their predators.

Among the zooplankton invertebrate predators, the most abundant and important are the mosquito larvae of the genera *Chaoborus* (Chaoboridae), at least in lakes and tropical reservoirs. These invertebrate predators usually select smaller zooplanktonic prey with less mobility such as rotifers and small cladocerans, favoring larger prey and/or with greater mobility such as copepods.

The Chaoboridae are also known to prey on larger zooplankton, favoring rotifers, and may have complex effects on both densities and composition, spatial distribution and structure size of zooplankton communities, up to even being responsible for population control or the extinction of their prey in some lakes.

Prey preferences can vary between instars and there is a relationship between the diameter of the larvae's mouth and the width, height 10, or maximum diameter of ingested organisms. Furthermore, the reproduction of Chaoboridae in the tropics occurs continuously, contributing to it being important in the pelagic trophic network of tropical lake ecosystems. However, predator invertebrates such as the Chaoboridae can also be preyed upon by zooplankton omnivorous fish, which favors small zooplankton organisms.

In this way, fish in larval and juvenile stages (fryers) and planktivorous adults, as well as how invertebrates such as Chaoboridae have configured as important predators on groups of zooplankton in lake ecosystems, especially rotifers, cladocerans, and copepods. The variation in the volume of water in these ecosystems, mainly due to the variation in the water balance, composes one of the extremely important abiotic factors for the predator-prey [dynamics of these organisms (Figure 7) [16-18].



References

- [1] Roskov Y. Species 2000 & ITIS Catalog of Life. 28th ed. Leiden: Naturalis. 2018.
- [2] Kagalou I, Economids G, Leonardo I, Papaloukas C. Assessment of a Mediterranean shallow lentic ecosystem (Lake Pamvotis, Greece) using benthic community diversity: Response to environmental parameters. *Limnologia*. 2006; 36(4): 269-278.

- [3] Arnett RH. American Insects: A Handbook of the Insects of America North of Mexico. 1st ed. Boca Raton: CRC Press. 2000.
- [4] Costa C, Ide S, Simonka CE. Immature insects: metamorphosis and identification. 1th. ed. Ribeirão Preto: Holos Editora. 2006.
- [5] Borror DJ, Triplehorn CA, Johnson JF. An introduction to the study of insects. 7th ed. Philadelphia: Saunders College Publishing. 2005.
- [6] Triplehorn CA, Johnson NF, Donald JB. Borror and DeLong's introduction to the study of insects. 7th ed. Belmont: Thompson Brooks/Cole. 2005.
- [7] Andersen T, Hagenlund LK, Håland, Kvitte GM, Skartveit J. New records of lower Diptera ("Nematocera") from Finnmark. Norwegian Journal of Entomology. 2013; 60: 182–189.
- [8] Minto WJ, Arcifa MS, Peticarrari A. Experiments on the influence of *Chaoborus braziliensis* Theobald, 1901 (Diptera: Chaoboridae) on the diel vertical migration of microcrustaceans from Lake Monte Alegre, Brazil. Brazilian Journal of Biology. 2010; 70(1): 25-35.
- [9] Pape T, Blagoderov V, Mostovski MB. Order Diptera Linnaeus, 1758. Animal biodiversity: An outline of higher-level classification. Zootaxa. 2011; 3148: 222–229.
- [10] Maes JM. Catalog of the Diptera of Nicaragua. Chaoboridae (Nematocera). Nicaraguan Journal of Entomology. 1990; 14: 17-1.
- [11] Costa CSR, Rocha RM. Invertebrates. Ribeirao Preto: Holos. 2002.
- [12] Grimaldi D, Engel MS. Evolution of the insect. 1st ed. Cambridge: Cambridge University Press. 2005.
- [13] Snodgrass RE. Principles of insect morphology. 1st ed. New York: McGraw Hill Book. 1993.
- [14] Autio O, Salmela J. The semi-aquatic fly fauna (Diptera) of wetlands of the Åland Islands. Memoranda Societatis pro Fauna et Flora Fennica. 2010; 86: 43–53.
- [15] Andersen T, Kvitte GM. Phantom midges (Diptera, Chaoboridae) from Finnmark, northern Norway. Norwegian Journal of Entomology. 2012; 59: 155–157.
- [16] Novais-Vicente MM, et al. A new species of the genus *Chaoborus* Lichtenstein (Diptera: Chaoboridae) from the State of São Paulo, Brazil. Studia Dipterologica. 2015; 2(2): 201–207.
- [17] Froese R. Species 2000 additional common names for the catalog of life. In: Roskov Y, Abucay L, Orrell T, Nicolson D, Flann DC, Bailly N, Kirk P, Bourgoin T, DeWalt RE, Decock W, Wever A, eds. Species 2000 & ITIS catalog of life annual checklist species 2000. 1st ed. Leiden: Naturalis; 2016. p. 1-15.

[18] Kagalou I, Economids G, Leonardo I, Papaloukas C. Assessment of a Mediterranean shallow lentic ecosystem (Lake Pamvotis, Greece) using benthic community diversity: Response to environmental parameters. *Limnologia*. 2000; 36(4): 269-278.