A Revised Key to the Zooplankton of Lake Champlain

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ABSTRACT

This key was developed by undergraduate research students working on a project with NYDEC and the Lake Champlain Monitoring program to develop long-term data sets for Lake Champlain plankton. Funding for development of this key was provided by, the Lake Champlain Basin Program and the New York Department of Environmental Conservation (NYDEC). The key contains couplet keys for the major taxa in Cladocera and Copepoda and Rotifer plankton in Lake Champlain. Illustrations are by Erin Hayes-Pontius and Ian Ater. Many thanks to the employees of the Lake Champlain Research Institute for hours of excellent work in the field and in the lab; especially Casey Bingelli, Heather Bradley, Amanda Groves and Carrianne Pershyn.

Keywords: Lake Champlain; zooplankton; identification; key

INTRODUCTION

Lake Champlain is one of the largest freshwater bodies in the United States. The Lake Champlain drainage basin is bordered by the Adirondack Mountains of New York to the west and the Green Mountains of Vermont to the east. This unique ecosystem has a surface area of 1130 km², a length of 200 km and a mean depth of 19.4 m. The lake shoreline extends from Quebec in the north, 200 km south to Whitehall, New York, where it connects to the Hudson-Champlain canal.

Islands and man-made transport causeways divide the lake into several distinct parts: Main Lake, South Lake, and Northeast Arm including Missisquoi Bay, and Mallets Bay. Mallets Bay and Missisquoi Bay are nearly isolated from the Northeast Arm, Mallets Bay by a narrow, shallow channel located between North and South Hero Islands, and Missisquoi Bay by an elongated shallow region (Myer and Gruendling, 1979). The Northeast Arm is separated from the Main Lake by large islands that result in relative isolation (Shanley and Denner 1999). South Lake is south of Crown Point and is described as a river-like section that represents 40% of the lakes length, but less than 1% of its volume; while the Main Lake, which occupies the area from Rouses Point to Crown Point, represents 82% of the total volume (Myer and Gruendling 1979, Shanley and Denner 1999).

The Lake Champlain Monitoring Program has measured water quality variables and collected biological samples for plankton at 12-14 sites throughout Lake Champlain since the early 1990’s. Zooplankton sampling procedures were based on handbooks published by Vollenweider (1969) and Edmonson (1971).

All sampling, (water quality and biological) was conducted by the New York Department of Environmental Conservation (NYDEC) and the New York State Museum staff. Zooplankton samples were taken as vertical net tows; from just above the sediment to the surface, using a 30cm diameter, 153micron mesh net. Net retrieval rate was 1 meter per second. All samples were preserved using a formalin-rose Bengal solution.
Lab identification was made to the lowest possible taxon using standard taxonomic keys (Balcer et al. 1984, Stemberger 1979, Grothe and Grothe 1977, Pennak 1989, Thorp and Covich 1991, Smith and Fernando 1978) with verification as needed by regional experts. While keys to the zooplankton of the Great Lakes exist, no key has been developed specific to Lake Champlain zooplankton. All identifications were made using an inverted compound microscope with 200-800x oculars. Rotifers were allowed to settle in Sedgwick-rafter cells prior to identification.

The following is a dichotomous key developed by student researchers at the Lake Champlain Research Institute. It is representative of the zooplankton identified in the samples collected by NYDEC between 1992 and 2001, and historical records from (Shambaugh et al. 1999, Myer and Gruendling 1979, and Muenscher 1930).

![Figure 1. Map of Lake Champlain monitoring sites.](image)
Figure 2. General morphology of Cladocera
Figure 3. General morphology of Copepoda
Figure 4. A young Cladocera (left) and a young Chydoridae (right)

Figure 5. Examples of juvenile Daphnia.

Figure 6. Examples of juvenile bosminids

Figure 7. A nauplius (immature Copepoda)
PHYLUM ARTHROPODA
Subphylum Crustacea
Class Branchiopoda
Order Cladocera
Suborder Haplopora
   Family Leptodoridae—Leptodora
Suborder Ctenopoda
   Family Holopediidae—Holopedium
   Family Sididae—Sida, Diaphanosoma
Suborder Anomopoda
   Family Chydoridae—Chydorus, Alona, Alonella, Pleuroxus
   Camptocercus, Acroperus, Eury cercus
   Family Bosminidae—Bosmina
   Family Daphniidae—Ceriodaphnia, Daphnia

Subclass Copepoda
Order Calanoida
   Family Centropagidae—Limnocalanus
   Family Diaptomidae—Leptodiaptomus, Skistodiaptomus
   Family Pseudocalanidae—Senecella
   Family Temoridae—Epischura
Order Cyclopoida
   Family Cyclopidae—Acanthocyclus, Cyclops, Diacyclops, Eucy clops, Macrocyclops, Mesocyclops, Tropocyclops
Order Harpacticoida

PHYLUM ROTIFERA
Class Monogononta
Order Collothecacea
   Family Atrochidae—Cupelopagis
   Family Collothecididae—Collotheca
Order Flosculariacea
   Family Conochilidae—Conochilus, Conochiloides
   Family Filinidae—Filinia
Order Ploima
   Family Asplanchniidae—Asplanchna
   Family Brachionidae—Anuraeopsis, Brachionus, Kellicottia, Keratella, Notholca, Plationus, Platyias
   Family Euchlanidae—Euchlanis
   Family Gastropodidae—Ascomorpha, Gastropus
   Family Lecanidae—Monostyla, Lecane
   Family Synchaetidae—Ploesoma, Polyarthra, Synchaeta
   Family Trichocercidae—Trichocerca
### Cladocera

*Species rare in Lake Champlain*

1. Thorax, abdomen, and thoracic appendages covered by a shell-like carapace
   - Thorax, abdomen, and thoracic appendages not covered by carapace

2(1) Body long and slender (up to 18mm long); eye small relative to body, second antennae with approximately 50 swimming setae (Fig. 8)...
   - *Leptodora kindtii*

   Body comparatively small and rounded (< 2mm long); eye large relative to body (Fig. 10)...
   - *Polyphemus pediculus*

3(1) Humpbacked animals, often a gelatinous sheath covers the back, swimming appendages unbranched in females (Fig. 9)...
   - *Holopedium gibberum*

   Back not humped, no gelatinous sheath, swimming appendages branched in two...

4(3) Swimming appendages with more than 14 setae in a row on one side of the dorsal branch of the 2nd antennae...
   - SIDIDAE, 5

4. Swimming appendages with 14 or fewer setae on the dorsal branch of the 2nd antenna...
   - 6

5(4) Dorsal branch of the 2nd antennae with 2 segments, postabdominal spines absent, basal segment of 2nd antennae longer than head, ocellus absent (Fig. 11)...
   - *Diaphanosoma birgei*

   Dorsal branch of 2nd antennae with 3 segments, postabdominal spines present, basal segment of 2nd antennae shorter than head, ocellus present (Fig. 11)...
   - *Sida crystallina*
Figure 8. *Leptodora kindtii*
Figure 9. Holopedium gibberum
Figure 10. *Polyphemus pediculus*
Figure 11. Family Sididae: *Diaphanosoma birgei* (top) and *Sida crystallina* (bottom, in lateral view)
6(4) 1st antennae is a paired, tusk-like structure that is at least as long as head (Fig. 12) ......................................................... BOSMINIDAE, 7

1st antennae is covered by a beak-like structure, 2nd antennae is not covered; three segments on both branches (Fig. 13-18).............................. CHYDORIDAE

1st antennae is not a paired, tusk-like or beak-like structure (Fig. 20) .......................................................... DAPHNIIDAE, 9

7(6) Posterior mucro (shell spine) present (Fig. 12) .................................................. 8

No mucro present (former genus Eubosmina) (Fig. 12)............................... Bosmina coregoni

8(7) Sensory bristle located partway between eye and base of 1st antennae (common species) (Fig. 12). ............................................................ Bosmina longirostris

Sensory bristle located at base of 1st antennae, notches may be present on ventral margin of mucro (Fig. 12) ...................................................... Bosmina longispina

9(6) Rostrum (beak) present, posterior shell spine located at midline of carapace; helmet shapes vary (Fig. 20)........................................................... 10

Rostrum (beak) absent, head is small and compacted; ventral side is rounded (Fig. 19) .......................................................... 13

10(9) Pecten (comb) on ventral margin of postabdominal claw uniformly small (Fig.20); ocellus may or may not be present ........................................ 11

Middle pecten on ventral margin of postabdominal claw slightly larger than proximal and distal pecten (Fig. 20); ocellus absent................................. 12

11(10) Setae from the base of the 2nd segment of dorsal ramus extends to at least ½ the length of the longest setae on the end of the ventral ramus; helmet pointed with peak near midline of body; ocellus present but often inconspicuous (Fig. 20) .......................................................... Daphnia galeata mendotae

Setae from the base of dorsal ramus absent or, if present, does not extend past the end of the ramus; helmet rounded; ocellus absent (Fig. 20) .......... Daphnia longiremis

Zooplankton of Lake Champlain
12(10) Helmet curved so peak extends past dorsal margin of carapace; caudal spine at least \( \frac{1}{2} \) length of body (very common) (Fig. 20)........................................................................Daphnia retrocurva

Helmet rounded; rostrum very short; caudal spine less than \( \frac{1}{4} \) length of body (Fig. 20).........................................................................................................Daphnia parvula*

13(9) Postabdominal claw with large pecten; carapace with reticulated polygons..................................................................................................Ceriodaphnia reticulata

Postabdominal claw without pecten; polygons absent (Fig.19)..................................................................................................Ceriodaphnia lacustris

Figure 12. Family Bosminidae: Bosmina coregoni (top), Bosmina longirostris (bottom left), Bosmina longispina (bottom right).
Figure 13. *Chydorus* sp.

Figure 14. *Alonella*

Figure 15. *Alona* sp.

Figure 16. *Eurycercus* sp.

Figure 17. *Camptocercus* sp.

Figure 18. *Pleuroxus* sp.

Figure 19. *Ceriodaphnia* spp.
Figure 20. *Daphnia* spp., left to right: *D. longiremis*, *D. galeata mendotae*, *D. retrocurva*, *D. parvula*. (Inset images of postabdominal claw)
### Copepoda orders

1. Metasome and urosome not distinctly separate; first antennae shorter than cephalic segment; not normally seen in water column (Fig. 22) .......................................................... **Harpacticoida**

Urosome noticeably narrower than metosome; first antennae generally as long as or longer than cephalic segment ..........................2

2(1) First antennae reaching to or beyond caudal rami ..................................**Calanoida**, 3

First antennae not reaching past genital segment ..................................**Cyclopoida**, 11

### Calanoida

3(2) Caudal ramus with three broad terminal setae in addition to shorter inner and outer setae or spines (Fig. 21); Adult females have twisted urosomes with short thick spines on outer corner of the caudal rami. Adult males have smaller spines on the rami and enlarged lateral processes on the right side of urosome..........................................................**Epischura lacustris**

Caudal ramus with more than three broad terminal setae .........................4

4(3) Caudal ramus with four well-developed terminal setae in addition to slender inner and outer setae; body length large; 2.4 - 2.7mm (Fig. 22) ..........................................................**Senecella calanoides**

Caudal ramus with five well-developed terminal setae ..........................5

5(4) Caudal ramus more than three times as long as wide; large animals up to 3.0mm (Fig. 23) ..........................................................**Limnocalanus macrurus**

Caudal ramus length less than or equal to three times width; terminal setae of caudal ramus approximately equal in length ..................**DIAPTOMIDAE**, 6

6(5) Right 1st antenna geniculate; exopod on fifth leg enlarged; egg sacs never present .........................................................♂, 7

Right 1st antenna not geniculate; exopod on fifth leg not enlarged, egg sacs may be present .........................................................♀, 9

7(6) Lateral spine on exopod subterminal; lacking projection from base of 3rd to last segment of geniculate antenna (Fig. 26) ..........................**Skistodiaptomus oregonensis** ♂
Lateral spine on exopod not subterminal; with projection from base of 3\textsuperscript{rd} to last segment of geniculate antenna …………………….\textit{Leptodiaptomus}, 8

8(7) Lateral spine minute and located between midpoint and distal third of exopod; projection from base of 3\textsuperscript{rd} to last segment of geniculate antenna longer than penultimate segment; (Fig. 24) …………………………………………………………………………………\textit{Leptodiaptomus minutus} \textit{♂}

Lateral spine large and located at distal third of exopod; projection from base of 3\textsuperscript{rd} to last segment of geniculate antenna shorter than penultimate segment (Fig. 25) ………………………………………………………………\textit{Leptodiaptomus sicilis} \textit{♂}

9(6) Metasomal wings distinctly pointed at corners; three urosomal segments (Fig. 25) …………………………………………………………………………………\textit{Leptodiaptomus sicilis} \textit{♀}

Metasomal wings rounded at corners, two or three urosomal segments ……………………………………………………………………………………………...10

10(9) Metasomal segment with minute spines at corners; two urosomal segments (Fig. 24)………………………………………………………………………………\textit{Leptodiaptomus minutus} \textit{♀}

Metasomal segment without minute spines at corners; three urosomal segments (Fig. 26) ………………………………………………………………………...\textit{Skistodiaptomus oregonensis} \textit{♀}
Figure 21. *Epischura lacustris*

Figure 22. *Senecella calanoides*

Figure 23. *Limnocalanus macrurus*
Figure 24. Female (left) and male (right) *Leptodiaptomus minutus*. 
Figure 25. Female (left) and male (right) *Leptodiaptomus sicilis*.
Figure 26. Female (left) and male (right) *Skistodiaptomus oregonensis*.

Figure 27. *Ergasilus* spp.
Cyclopoida
* Species rare in Lake Champlain

11(2) First antennae half the length of cephalic segment with setae that extend to the end of metosome; 2 caudal seta both long, one nearly as thick as caudal ramus; noticeable claws between antennae (Fig. 27)…………………Ergasilus spp.*

Not as above ……………………………………………………………………………………12

12(11) Inner caudal seta long, at least twice the length of ramus ………………………………13

Inner caudal seta short, less than twice length of ramus ………………………………………14

13(12) Inner caudal seta less than ½ length of longest caudal seta (Fig. 28)………………Macrocyclops spp.

Inner caudal seta longer than ½ length of longest caudal seta; inner margins of caudal rami of mature individuals hairy (Fig. 28)………………Mesocyclops edax

14(13) Small animals (0.5-0.8mm); extended first antennae reach genital segment (Fig. 28) …………………………………………………………………………Tropocyclops prasinus mexicanus.

Animals larger than 0.7mm; first antennae do not reach genital segment………………15

15(14) Outer caudal seta modified into a spine thicker than inner caudal seta; row of fine spinules along outer caudal ramus (Fig. 29) ……………Eucyclops serrulatus*

Outer caudal seta not thicker than inner seta …………………………………………………16

16(15) Inner margin of caudal rami with fine hairs, caudal rami 4 times as long as broad (Fig. 29) ……………………………………………………………….Cyclops scutifer*

Inner margin of caudal rami without hairs, caudal rami elongated, 5-7 times as long as wide…………………………………………………………….17

17(16) Lateral seta located on the posterior ¼ of caudal ramus (Fig. 29)…………………Acanthocyclops robustus

Lateral seta located near the middle of caudal ramus (very common) (Fig. 29)…………………………………………………………………………………Diacyclops thomasi
Figure 28. *Macrocyclops albidus, Macrocylops ater, Mesocylops edax, Tropocyclops prasinus mexicanus* (left to right).

Figure 29. *Eucyclops serrulatus, Cyclops scutifer, Acanthocylops robustus, Diacyclops thomasi* (left to right).
Literature Cited


A Key to Rotifer Genera of Lake Champlain

Trimmed down, slightly simplified, and occasionally re-worded by Erin Hayes-Pontius from the rotifer key by Richard Stemberger.


1  Paired ovaries (you probably don’t have this. go on to 2) .................................27
    Single ovary .................................................................2

2(1)  Body wall thickened (lorica stiffened), may be somewhat flexible
      or with vesiculate(bubbly) texture .........................................................3
      Body wall thin and flexible (lorica weakly developed) ..............................4

3(2)  Foot or foot opening present (foot may be retracted within lorica) ..................6
      Foot absent .................................................................16

4(2)  Foot present without defined foot opening (foot may be retracted against body) .........................................................21
      Foot absent .................................................................5

5(4)  Featherlike, armlike, or bristlelike appendages (not setae)
      arising from body wall .........................................................25
      Without body wall appendages (except for setae); body
      spheroid or oblong ..........................................................26
6(3) Body not bilaterally symmetrical but twisted and fusiform; coronal sheath present with spines or folds; toes spikelike and usually unequal in length ........................................... *Trichocerca*
9(8) Dorsal surface of lorica (body wall) with distinctive ridge pattern 
or with vesiculate texture; foot terminates in two toes 
and arises from the ventromedian surface; short broad 
anteromedian process may be present .................................................Ploesoma

Dorsal surface smooth .................................................................15

10(7) With two short toes; foot long; anterior margin with spines .........................11

With one or two long toes; foot short or long; anterior margin 
with two spines or with two small anterolateral spinelike 
processes ........................................................................................12
11(10) Foot annulated; anterior margin with two, four, or six spines; posterior spines may be present or absent ........................................... *Brachionus*

Foot segmented; anterior margin with ten spines; posterior with four spines ............................................................................ *Plationus*

Foot segmented; anterior margin with two spines; posterior with two spines ................................................................. *Platyias*
12(8, 10) Lorica (body wall) divided laterally or medially by membranes or cleft .................................................................13

Lorica not divided (one piece); first foot segment without spines; posterior margin of lorica not obliquely truncated in lateral view; anterior margin not serrated; foot clearly divided into three segments and terminates in two pointed toes; opening at anterior margin narrow, semicircular or v-shaped; lorica rigid ............................................Lepadella

13(12) Dorsal plate of lorica arched or domed; foot short with two long flattened toes; toes never with claws or spurs .........................Euchlanis

Body compressed dorsoventrally; foot jointed, indistinct and very short; one or two long flattened toes often terminating in claws or spurs ........................................................................14
14(13) Foot with single toe .................................................................Monostyla

Foot with two toes .................................................................Lecane
15(9) Body outline round or ovate; body laterally compressed; foot arises from ventral surface and terminates in one or two small toes (foot may be retracted); dorsal antennae small but prominent ................................................................. *Gastropus*

Body outline spindle-shaped; Two toes of equal length, not spinelike; toes minute, often not visible due to retraction of foot in preserved specimens; living specimens have conical body shape; bristlelike setae may be visible; fully contracted specimens appear as small balls .......................... *Synchaeta*

16(3) Anterior margin of lorica with spines ............................................................. 17

Anterior margin of lorica without spines ............................................................. 19
17(16) Anterior spines long; asymmetrical anterior spines and a single posterior spine highly elongated and pointed; loria surface smooth .................................................................**Kellicottia**

Anterior spines short .................................................................18
18(17) Arched dorsal plate of lorica with distinct polygonal facets; ventral plate flattened; one or two posterior spines usually present ...........................................................................................................Keratella

Keratella quadrata  Keratella cochlearis

Dorsal plate with fine longitudinal or wavy striations (plate juncture not well defined); anterior margin of dorsal plate with six spines, ventral plate with six folds; body oblong or rounded; a single truncated or pointed posterior extension or lorica may be present .................................................................Notholca
19(16) Lorica divided into dorsal and ventral plates by membrane ……………………..20

Lorica not divided into distinct plates; Anterior margin of lorica
with small pleatlike folds; two longitudinal furrows in thin
lorica; body ovate ……………………………………………………………Ascomorpha
20(19) Body dorsoventrally flattened; dorsal plate slightly larger than ventral plates; body ovate; four dark circular bodies usually visible in stomach; lorica surface smooth ……………………Ascomorpha

Dorsal plate arched, ventral plate flattened; anterior margin of dorsal plate notched; anterior margin of ventral plate slightly concave; body size small; large egg may be present, carries against ventral plate ……………………………………………Anuraeopsis
21(4) Foot long, without toes (foot may be retracted against body in preserved specimens); foot may be smooth or wrinkled, slender or corpulent; individuals may occur in a colony ..................22

Foot terminates with two or more toes (toes spinelike in some species); individuals never in colony ........................................24

22 (21) Lateral antennae present ..........................................................Conochiloides

Lateral antennae absent .................................................................23
23(22) A single fused or two separate antennae located in a conically-domed apical field; corona disc-like with ventral notch; may occur in colonies

\[ \text{Conochilus} \]

Coronal lobes short or absent; lobes may be contracted and only hairlike setae visible; foot long, slender and contractile

\[ \text{Collotheca} \]
24(21) Toes spinelike and usually of unequal length; body asymmetrical; pleatelike folds in epidermis at anterior margin; spinelike processes at anterior margin of coronal sheath often present

..............................................................Trichocerca

Two toes of equal length, not spinelike; toes minute, often not visible due to retraction of foot in preserved specimens; living specimens have conical body shape; bristlelike setae on apical field may be visible; fully contracted specimens appear as small balls ..............................................................Synchaeta
25(5) One posterior and two long anterior filament-like appendages .......................................................... Filinia

Four sets of feather-like fins protruding from anterior end .............................. Polyarthra

P. dolichoptera   P. euryptera   P. major

P. remata   P. vulgaris
26(5) Body large, transparent, balloon-like and oblate; no intestine

Asplanchna

Body small .................................................................26
27(26) Body pear-shaped; four dark spherical bodies usually visible in stomach

Ascomorpha

Body spheroid or ellipsoid; setae may project from anterior margin of body:
Contracted Synchaeta, Collotheca, Conochilus, or other illoricate rotifer

27(1) Class Digononta: You probably do not have this. Go back to start and go to step 2 instead and see where it takes you.