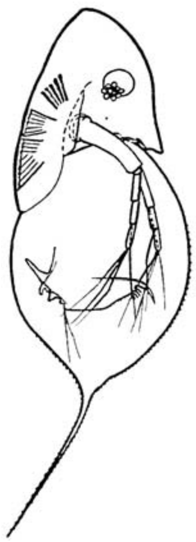
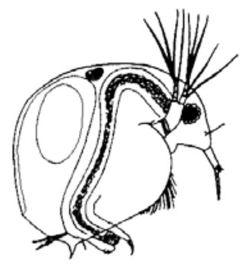
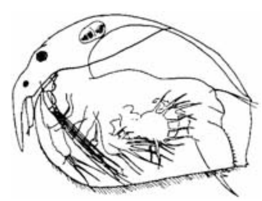
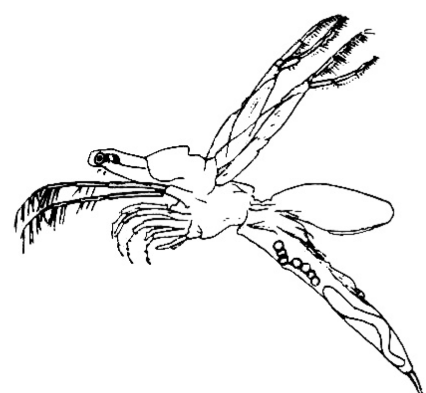
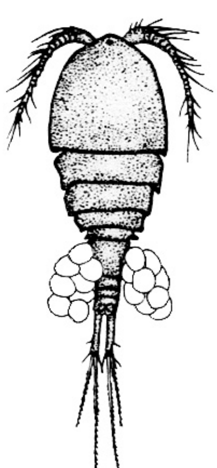
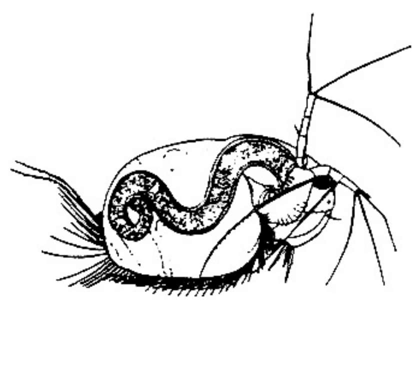
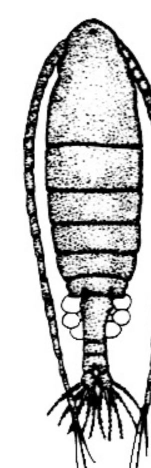


Practical Guide to Identifying Freshwater Crustacean Zooplankton



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Practical Guide to Identifying Freshwater Crustacean Zooplankton

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Cover page diagram credits

Diagrams of Copepoda derived from:
Smith, K. and C.H. Fernando. 1978. A guide to the freshwater calanoid and cyclopoid copepod Crustacea of Ontario. University of Waterloo, Department of Biology. Ser. No. 18.

Diagram of Bosminidae derived from:
Pennak, R.W. 1989. Freshwater invertebrates of the United States. Third edition. John Wiley and Sons, Inc., New York.

Diagram of Daphniidae derived from:
Balcer, M.D., N.L. Korda and S.I. Dodson. 1984. Zooplankton of the Great Lakes: A guide to the identification and ecology of the common crustacean species. The University of Wisconsin Press. Madison, Wisconsin.

Diagrams of Chydoridae, Holopediidae, Leptodoridae, Macrothricidae, Polyphemidae, and Sididae derived from:
Dodson, S.I. and D.G. Frey. 1991. Cladocera and other Branchiopoda. Pp. 723-786 in J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press. San Diego.

Acknowledgements

Since the first edition of this manual was published in 2002, several changes have occurred within the field of freshwater zooplankton taxonomy. Many thanks go to Robert Girard of the Dorset Environmental Science Centre for keeping me apprised of these changes and for graciously putting up with my never ending list of questions. I would like to thank Julie Leduc for updating the list of zooplankton found within the Sudbury Region, depicted in Table 1. A special thank you goes to Dee Geiling, my taxonomic mentor, for her patient guidance throughout my personal learning process. With her retirement later on this year the discipline of zooplankton taxonomy will certainly be lacking. Lastly, this Guide is dedicated to students of this field who find themselves overwhelmed by the task at hand. It is my hope that this paper will help to build a solid knowledge base and simplify the undertaking.

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Section 1. Introduction

This Guide is based upon personal observations of freshwater crustacean zooplankton (Cladocera and Copepoda) found in Sudbury Region lakes, located in Northeastern Ontario, Canada. The purpose was not to provide thorough details on all aspects of zooplankton taxonomy, nor to present identification keys since these already exist (refer to Section 4). Rather, the attempt was to clearly outline the basic essential elements that must be understood by novices to the field who require guidance for the identification of their samples.

The users of this Guide should be aware of the primary factors complicating taxonomic decisions. It has been well established for daphniids, among other groups, that identifications are exceedingly difficult due to the "extensive variation created by a combination of phenotypic plasticity (i.e. cyclomorphosis), the coexistence of morphologically similar species and interspecific hybridization" (Brooks, 1957). Cyclomorphosis refers to seasonal changes in morphology driven by environmental conditions, notably seen in the wide variation of *Daphnia* helmet shapes throughout the year (Schwartz et al., 1985).

Therefore, although the literature and keys present pictures of species, these only show "typical" or "average" specimens. The look of a species can vary widely from site to site, depending upon the above-noted factors. Furthermore, the preservative used to store samples will have varying impacts upon zooplankton specimens, sometimes causing features to twist and distort. Organisms may also have broken structures (ex. *Daphnia* tails) or other key features may become deformed. Diagrams in text books show "perfect" specimens that rarely exist in nature.

Genetic analysis is currently becoming more prevalent and "is an increasingly important component of taxonomic studies on zooplankton" (Hebert and Finston, 1997). Therefore, this is a field in constant flux so that one must keep up-to-date on new advancements. This Guide represents a summary of current general knowledge as it specifically relates to local freshwater crustacean zooplankton found within the Sudbury Region.

Section 2. Zooplankton classification

This general taxonomic scheme only makes mention of those genera found in Sudbury Region lakes, located in Northeastern Ontario, Canada, as of 2004 and is based upon the classification outlined by Smith (2001).

(Phylum, Subphylum, Superclass, or Class) Crustacea

A. Class (or Subclass) Branchiopoda:

1) Order Anomopoda
    - Family Bosminidae
        - Genus *Bosmina*
            - Subgenus *Bosmina*
        - Genus *Eubosmina*
            - Subgenus *Eubosmina*
            - Subgenus *Neobosmina*
    - Family Chydoridae
        - Genus *Acroperus*
        - Genus *Alona*
        - Genus *Alonella*
        - Genus *Camptocercus*
        - Genus *Chydorus*
        - Genus *Disparalona*
        - Genus *Eurycercus*
        - Genus *Leydigia*
        - Genus *Pseudochydorus*
        - Genus *Rhynchotalona*
    - Family Daphniidae
        - Genus *Ceriodaphnia*
        - Genus *Daphnia*
            - Subgenus *Daphnia*
            - Subgenus *Hyalodaphnia*
        - Genus *Simocephalus*
    - Family Macrothricidae
        - Genus *Acantholeberis*
        - Genus *Ilyocryptus*
        - Genus *Macrothrix*
        - Genus *Ophryoxus*

2) Order Ctenopoda
    - Family Holopediidae
        - Genus *Holopedium*
    - Family Sididae
        - Genus *Diaphanosoma*
        - Genus *Latona*
        - Genus *Sida*

3) Order Haplopoda
    - Family Leptodoridae
        - Genus *Leptodora*

4) Order Onychopoda
Family Polyphemidae
Genus *Polyphemus*

B. Class (or Subclass) Copepoda:

1) Order Calanoida
Family Centropagidae
Genus *Limnocalanus*
Family Diaptomidae
Genus *Aglaodiaptomus*
Genus *Leptodiaptomus*
Genus *Skistodiaptomus*
Family Pseudocalanidae
Genus *Senecella*
Family Temoridae
Genus *Epischura*

2) Order Cyclopoida
Family Cyclopidae
Genus *Acanthocyclops*
Genus *Cyclops*
Genus *Diacyclops*
Genus *Eucyclops*
Genus *Macrocyclops*
Genus *Mesocyclops*
Genus *Orthocyclops*
Genus *Paracyclops*
Genus *Tropocyclops*

3) Order Harpacticoida (**Extremely rare, not dealt with in this Guide*)

Summary

Samples from Sudbury Region lakes may include representatives from 8 cladoceran families and 3 copepod orders. These are outlined in Table 1 and summarized here. This represents the number of genera and species found to date (2004).

Cladocera: *- Bosminidae (2 genera, 5 species)*
- Chydoridae (10 genera, 10+ species)
- Daphniidae (3 genera, 14 species)
- Holopediidae (1 genus, 1 species)
- Leptodoridae (1 genus, 1 species)
- Macrothricidae (4 genera, 4+ species)
- Polyphemidae (1 genus, 1 species)
- Sididae (3 genera, 3 species)

Copepoda: *- Calanoida (6 genera, 9 species)*
- Cyclopoida (9 genera, 13+ species)
** - Harpacticoida (this group is extremely rare in these samples - just ID to order)*

Table 1a. Cladoceran zooplankton genera/species found in 92 Sudbury Region lakes from 1990 to 2004 (by Martyn Futter – DESC, 2002; updated by Julie Leduc, 2004)

EMRB Species code	Family	Genus (Subgenus) / Species name	% of Sudbury sites found in
164	BOSMINIDAE	*Bosmina* sp.	17.4
189	BOSMINIDAE	*Bosmina (Bosmina) freyi*	72.8
190		*Bosmina (Bosmina) liederi*	42.4
132	BOSMINIDAE	*Eubosmina (Eubosmina) coregoni*	8.7
150		*Eubosmina (Eubosmina) longispina*	31.5
133	BOSMINIDAE	*Eubosmina (Neobosmina) tubicen*	22.8
102	CHYDORIDAE	*Acroperus harpae*	15.2
107	CHYDORIDAE	*Alona quadrangularis*	1.1
109		*Alona* sp.	22.8
157	CHYDORIDAE	*Alonella nana*	1.1
162		*Alonella* sp.	1.1
166	CHYDORIDAE	*Camptocercus* sp.	3.3
118	CHYDORIDAE	*Chydorus sphaericus*	57.6
167		*Chydorus* sp.	1.1
155	CHYDORIDAE	*Disparalona acutirostris*	2.2
134	CHYDORIDAE	*Eurycercus lamellatus*	1.1
170		*Eurycercus* sp.	1.1
705	CHYDORIDAE	*Leydigia leydigi*	1.1
153	CHYDORIDAE	*Pseudochydorus globosus*	2.2
348	CHYDORIDAE	*Rhynchotalona falcata*	1.1
111	DAPHNIIDAE	*Ceriodaphnia lacustris*	12.0
115		*Ceriodaphna* sp.	10.9
168	DAPHNIIDAE	*Daphnia* sp.	13.0
119	DAPHNIIDAE	*Daphnia (Daphnia) ambigua*	37.0
120		*Daphnia (Daphnia) catawba*	22.8
124		*Daphnia (Daphnia) pulicaria*	18.5
125		*Daphnia (Daphnia) parvula*	1.1
126		*Daphnia (Daphnia) pulex*	18.5
127		*Daphnia (Daphnia) retrocurva*	29.4
223		*Daphnia (Daphnia) minnehaha*	6.5
121	DAPHNIIDAE	*Daphnia (Hyalodaphnia) dubia*	8.7
122		*Daphnia (Hyalodaphnia) mendotae*	48.9
123		*Daphnia (Hyalodaphnia) longiremis*	8.7
159		*Daphnia (Hyalodaphnia) dentifera*	2.2
146	DAPHNIIDAE	*Simocephalus serrulatus*	1.1
147		*Simocephalus vetulus*	1.1
186		*Simocephalus* sp.	1.1
135	HOLOPEDIIDAE	*Holopedium glacialis*	79.4
138	LEPTODORIDAE	*Leptodora kindtii*	15.2
101	MACROTHRICIDAE	*Acantholeberis curvirostris*	6.5
136	MACROTHRICIDAE	*Ilyocryptus spinifer*	1.1
178	MACROTHRICIDAE	*Macrothrix* sp.	1.1
140	MACROTHRICIDAE	*Ophryoxus gracilis*	4.4
142	POLYPHEMIDAE	*Polyphemus pediculus*	30.4
152	SIDIDAE	*Diaphanosoma birgei*	85.9
137	SIDIDAE	*Latona setifera*	6.5
145	SIDIDAE	*Sida crystallina*	15.2

Table 1b. Copepod zooplankton genera/species found in 92 Sudbury Region lakes from 1990 to 2004 (by Martyn Futter – DESC, 2002; updated by Julie Leduc, 2004)

EMRB Species code	Family	Genus (Subgenus) / Species name	% of Sudbury sites found in
201	IMMATURE CALANOIDA	Calanoid copepodid	97.8
215		Calanoid nauplius	98.9
212	CENTROPAGIDAE	*Limnocalanus macrurus*	1.1
203	DIAPTOMIDAE	*Aglaodiaptomus leptopus*	7.6
202	DIAPTOMIDAE	*Leptodiaptomus ashlandi*	4.4
204		*Leptodiaptomus minutus*	88.0
208		*Leptodiaptomus sicilis*	4.4
209		*Leptodiaptomus siciloides*	2.2
205	DIAPTOMIDAE	*Skistodiaptomus oregonensis*	48.9
213	PSEUDOCALANIDAE	*Senecella calanoides*	1.1
214		*Senecella calanoides* copepodid	2.2
210	TEMORIDAE	*Epischura lacustris*	29.4
211		*Epischura lacustris* copepodid	22.8
227		*Epischura* sp.	2.2
301	IMMATURE CYCLOPOIDA	Cyclopoid copepodid	97.8
313		Cyclopoid nauplius	97.8
304	CYCLOPIDAE	*Acanthocyclops vernalis* complex	18.5
339		*Acanthocyclops robustus*	3.2
340		*Acanthocyclops venustoides*	1.1
346		*Acanthocyclops brevispinosus*	1.1
303	CYCLOPIDAE	*Cyclops scutifer*	22.8
321		*Cyclops* sp.	1.1
302	CYCLOPIDAE	*Diacyclops bicuspidatus thomasi*	58.7
322		*Diacyclops* sp.	1.1
306	CYCLOPIDAE	*Eucyclops agilis*	8.7
325		*Eucyclops* sp.	1.1
336		*Eucyclops prionophorus*	2.2
347		*Eucyclops elegans*	5.4
308	CYCLOPIDAE	*Macrocyclops albidus*	2.2
309	CYCLOPIDAE	*Mesocyclops edax*	65.2
310	CYCLOPIDAE	*Orthocyclops modestus*	28.3
330	CYCLOPIDAE	*Paracyclops* sp.	1.1
338	CYCLOPIDAE	*Tropocyclops extensus*	54.4
345		*Harpacticoid* sp.	3.3

This table is a summary of the Sudbury Region data held within the EMRB_ZOO database as of October 2004. The originator, the Environmental Monitoring & Reporting Branch (EMRB) of the Ontario Ministry of the Environment, compile the zooplankton data from government and academic sources. Note that you may come across genera and species not listed in this table.

Every attempt was made to ensure the accuracy of the data presented in these tables. However, note that some of the species included probably do not occur within the Sudbury Region due to misidentifications of some of the rarer species. The reader should be aware of this situation and always confirm identifications using keys and/or other resources.

Section 3. Recent taxonomic changes

One of the most confusing aspects of this work involves the variable taxonomy that must be dealt with. Recent changes are summarized in Table 2, compiled by Robert Girard of the Dorset Environmental Science Centre (DESC). It is essential to be aware of changes that have occurred over the years since identification keys and literature pertaining to these species may refer to old and/or new nomenclature. Only a few of the more notable cases pertaining to species ***found within Ontario, Canada*** will be mentioned in the text of this Guide. Refer to Table 2 for a more extensive list of taxonomic changes.

- the locally found members of the subgenus *Sinobosmina* (family Bosminidae), namely *Bosmina (Sinobosmina) freyi* and *Bosmina (Sinobosmina) liederi,* were referred to in the past collectively as *Bosmina longirostris*. A paper by De Melo and Hebert (1994) proved that this latter species does not exist within Canada and is only found in the extreme South-Western United States. Many researchers continue to identify these organisms as *Bosmina longirostris*, despite the genetic findings.

- in a 2002 paper by Taylor et al., it was proposed that the designation of *Bosmina (Sinobosmina)* (family Bosminidae) was incorrect and that the 2 locally found members of this group should actually be placed in the subgenus *Bosmina*, thereby changing their designations to: *Bosmina (Bosmina) freyi* and *Bosmina (Bosmina) liederi*.

- in the family Holopediidae, all specimens found in this Region used to be termed *Holopedium gibberum*. Based upon the findings of Rowe (2000), the only species in this family present within the Sudbury Region is *Holopedium glacialis*. Again, many researchers continue to use the older terminology.

- *Diaphanosoma birgei* (family Sididae) was incorrectly referred to in the past as *Diaphanosoma leuchtenbergianum* and *Diaphanosoma brachyurum* (Kořínek, 1981)

- *Alonella acutirostris* (family Chydoridae) is now referred to as *Disparalona acutirostris* (Fryer, 1971)

- *Daphnia schodleri* (family Daphniidae) is now referred to as *Daphnia pulicaria* (Brandlova et al., 1972)

- *Daphnia rosea* (family Daphniidae) is now referred to as *Daphnia dentifera* (Taylor et al., 1996)

- *Daphnia galeata mendotae* (family Daphniidae) is now referred to as *Daphnia mendotae* (Taylor and Hebert, 1993)

- *Eucyclops neomacruroides* and *Eucyclops speratus* (order Cyclopoida) are now called *Eucyclops elegans* (Hudson et al., 1998)

- *Eucyclops serrulatus* (order Cyclopoida) is now called *Eucyclops agilis* (Torke, 1976)

- several species comprise what is termed the *Acanthocyclops vernalis* complex (order Cyclopoida). According to Hudson et al. (1998), the only members found in Ontario that can be positively differentiated are *Acanthocyclops brevispinosus* and *Acanthocyclops robustus.*

- *Tropocyclops prasinus mexicanus* (order Cyclopoida) is now called *Tropocyclops extensus* (Dussart and Fernando, 1990)

- several local species of calanoids used to be classified under Genus *Diaptomus*, further divided into several subgenera. According to Dussart and Defaye (1995), these subgenera are now elevated to full Genus status (*Aglaodiaptomus*, *Leptodiaptomus*, and *Skistodiaptomus* are locally found).

Table 2. Taxa listed in the EMRB zooplankton database sorted by genus, updating taxonomic distinction (by Robert Girard - DESC)
(***Note that changes are highlighted in bold italics and that shaded species are those found within the Sudbury Region)***

EMRB SPECIES CODE	FAMILY	GENUS (SUBGENUS) / SPECIES NAME	ORIGIN_AUTHOR / CITATION
164	BOSMINIDAE	BOSMINA SP.	O.F. MÜLLER, 1785
188	BOSMINIDAE	BOSMINA ***(BOSMINA)*** LONGIROSTRIS	O.F. MÜLLER, 1785 ***EMEND. DE MELO & HEBERT, 1994***
189		BOSMINA ***(BOSMINA)*** FREYI	***DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
190		BOSMINA ***(BOSMINA)*** LIEDERI	***DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
653	BOSMINIDAE	***EUBOSMINA SP.***	SELIGO, 1900 ***EMEND. TAYLOR ET AL., 2002***
132	BOSMINIDAE	***EUBOSMINA (EUBOSMINA)*** COREGONI	BAIRD, 1857 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
150		***EUBOSMINA (EUBOSMINA)*** LONGISPINA	LEYDIG, 1860 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
156		***EUBOSMINA (EUBOSMINA)*** SP.	SELIGO, 1900 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
194		***EUBOSMINA (EUBOSMINA)*** MARITIMA	P.E. MÜLLER, 1868 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
193	BOSMINIDAE	***EUBOSMINA (LUNOBOSMINA) ORIENS***	***DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
654		***EUBOSMINA (LUNOBOSMINA) SP.***	***TAYLOR ET AL., 2002***
133	BOSMINIDAE	***EUBOSMINA (NEOBOSMINA)*** TUBICEN	BREHM, 1953 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
191		***EUBOSMINA (NEOBOSMINA)*** HUARONENSIS	DELACHAUX, 1918 ***EMEND. PAGGI, 1979 EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
192		***EUBOSMINA (NEOBOSMINA)*** HAGMANNI	STINGELIN, 1904 ***EMEND. DE MELO & HEBERT, 1994 EMEND. TAYLOR ET AL., 2002***
195		***EUBOSMINA (NEOBOSMINA) SP.***	LIEDER, 1957 ***EMEND. TAYLOR ET AL., 2002***
102	CHYDORIDAE	ACROPERUS HARPAE	BAIRD, 1843
161		ACROPERUS SP.	BAIRD, 1843
103	CHYDORIDAE	ALONA AFFINIS	LEYDIG, 1860
104		ALONA COSTATA	SARS, 1862
105		ALONA GUTTATA	SARS, 1862
106		ALONA INTERMEDIA	SARS, 1862
107		ALONA QUADRANGULARIS	O.F. MÜLLER, 1785
108		ALONA RECTANGULA	SARS, 1861
109		ALONA SP.	BAIRD, 1850
157	CHYDORIDAE	ALONELLA NANA	BAIRD, 1850
162		ALONELLA SP.	SARS, 1862
163	CHYDORIDAE	ANCHISTROPUS SP.	SARS, 1862
166	CHYDORIDAE	CAMPTOCERCUS SP.	BAIRD, 1843
706		CAMPTOCERCUS RECTIROSTRIS	SCHOEDLER, 1862
116	CHYDORIDAE	CHYDORUS BICORNUTUS	DOOLITTLE, 1909
117		CHYDORUS PIGER	SARS, 1862
118		CHYDORUS SPHAERICUS	O.F. MÜLLER, 1785
167		CHYDORUS SP.	LEACH, 1816
141	CHYDORIDAE	***DISPARALONA*** HAMATA	BIRGE, 1879 ***EMEND. in Smirnov, 1996***
155		***DISPARALONA*** ACUTIROSTRIS	BIRGE, 1878 ***EMEND. Fryer, 1971 in Smirnov, 1996***
171		***DISPARALONA SP.***	***FRYER, 1968***
134	CHYDORIDAE	EURYCERCUS LAMELLATUS	O.F. MÜLLER, 1785
170		EURYCERCUS SP.	O.F. MÜLLER, 1785
172	CHYDORIDAE	GRAPTOLEBERIS SP.	SARS, 1863
196		***GRAPTOLEBERIS TESTUDINARIA***	***FISCHER, 1848***
175	CHYDORIDAE	KURZIA SP.	DYBOWSKI & GROCHOWSKI, 1894
705	CHYDORIDAE	LEYDIGIA LEYDIGI	SCHOEDLER, 1862
180	CHYDORIDAE	OXYURELLA SP.	DYBOWSKI & GROCHOWSKI, 1894
181	CHYDORIDAE	PLEUROXUS SP.	BAIRD, 1843
153	CHYDORIDAE	PSEUDOCHYDORUS GLOBOSUS	BAIRD, 1843
183		PSEUDOCHYDORUS SP.	FRYER, 1968
348	CHYDORIDAE	RHYNCHOTALONA FALCATA	SARS, 1861
111	DAPHNIIDAE	CERIODAPHNIA LACUSTRIS	BIRGE, 1893
112		CERIODAPHNIA MEGALOPS	SARS, 1861
113		CERIODAPHNIA PULCHELLA	SARS, 1862
114		CERIODAPHNIA RETICULATA	JURINE, 1820
115		CERIODAPHNIA SP.	DANA, 1853
151		CERIODAPHNIA QUADRANGULA	O.F. MÜLLER, 1785
143	DAPHNIIDAE	SCAPHOLEBERIS AURITA	FISCHER, 1849
144		SCAPHOLEBERIS KINGI	SARS, 1903
184		SCAPHOLEBERIS SP.	SCHOEDLER, 1858
146	DAPHNIIDAE	SIMOCEPHALUS SERRULATUS	KOCH, 1841
147		SIMOCEPHALUS VETULUS	SCHOEDLER, 1858
186		SIMOCEPHALUS SP.	SCHOEDLER, 1858

EMRB SPECIES CODE	FAMILY	GENUS (SUBGENUS) / SPECIES NAME	ORIGIN_AUTHOR / CITATION
168	DAPHNIIDAE	DAPHNIA SP.	O.F. MÜLLER, 1785
119	DAPHNIIDAE	DAPHNIA ***(DAPHNIA)*** AMBIGUA	SCOURFIELD, 1947 ***EMEND. COLBOURNE & HEBERT, 1996***
120		DAPHNIA ***(DAPHNIA)*** CATAWBA	COKER, 1926 ***EMEND. COLBOURNE & HEBERT, 1996***
124		DAPHNIA ***(DAPHNIA)*** PULICARIA	FORBES, 1893 ***EMEND. COLBOURNE & HEBERT, 1996***
125		DAPHNIA ***(DAPHNIA)*** PARVULA	FORDYCE, 1901 ***EMEND. COLBOURNE & HEBERT, 1996***
126		DAPHNIA ***(DAPHNIA)*** PULEX	LEYDIG, 1860 ***EMEND. RICHARD, 1896 EMEND. COLBOURNE & HEBERT, 1996***
127		DAPHNIA ***(DAPHNIA)*** RETROCURVA	FORBES, 1882 ***EMEND. COLBOURNE & HEBERT, 1996***
187		DAPHNIA ***(DAPHNIA)*** MIDDENDORFFIANA	FISCHER, 1851 ***EMEND. COLBOURNE & HEBERT, 1996***
223		DAPHNIA (DAPHNIA) MINNEHAHA	HERRICK, 1884
710		DAPHNIA (DAPHNIA) SP.	O.F. MÜLLER, 1785 ***EMEND. COLBOURNE & HEBERT, 1996***
121	DAPHNIIDAE	DAPHNIA ***(HYALODAPHNIA)*** DUBIA	HERRICK, 1895 ***EMEND. COLBOURNE & HEBERT, 1996***
122		DAPHNIA ***(HYALODAPHNIA)*** MENDOTAE	BIRGE, 1918 ***EMEND. TAYLOR & HEBERT, 1993***
123		DAPHNIA ***(HYALODAPHNIA)*** LONGIREMIS	SARS, 1861 ***EMEND. COLBOURNE & HEBERT, 1996***
159		DAPHNIA ***(HYALODAPHNIA)*** DENTIFERA	FORBES, 1893 ***EMEND. COLBOURNE & HEBERT, 1996***
197		DAPHNIA ***(HYALODAPHNIA)*** LONGISPINA	O.F. MÜLLER, 1785 ***EMEND. COLBOURNE & HEBERT, 1996***
711		DAPHNIA ***(HYALODAPHNIA)*** SP.	O.F. MÜLLER, 1785 ***EMEND. COLBOURNE & HEBERT, 1996***
135	HOLOPEDIIDAE	HOLOPEDIUM ***GLACIALIS***	ZADDACH, 1855 ***EMEND. ROWE, 2000***
173		HOLOPEDIUM SP.	ZADDACH, 1855
138	LEPTODORIDAE	LEPTODORA KINDTII	FOCKE, 1844
177		LEPTODORA SP.	LILLJEBORG, 1860
101	MACROTHRICIDAE	ACANTHOLEBERIS CURVIROSTRIS	O.F. MÜLLER, 1776
160		ACANTHOLEBERIS SP.	LILLJEBORG, 1853
136	MACROTHRICIDAE	ILYOCRYPTUS SPINIFER	HERRICK, 1884
174		ILYOCRYPTUS SP.	SARS, 1861
139	MACROTHRICIDAE	MACROTHRIX LATICORNIS	JURINE, 1820 ***(FISCHER, 1851) in Smirnov, 1992***
178		MACROTHRIX SP.	BAIRD, 1843
140	MACROTHRICIDAE	OPHRYOXUS GRACILIS	SARS, 1861 ***(G.O. SARS, 1862) in Smirnov, 1992***
179		OPHRYOXUS SP.	SARS, 1861
148	MACROTHRICIDAE	STREBLOCERUS SERRICAUDATUS	FISCHER, 1849
198		***STREBLOCERUS SP.***	***SARS, 1862***
142	POLYPHEMIDAE	POLYPHEMUS PEDICULUS	LINNÉ, 1761
182		POLYPHEMUS SP.	O.F. MÜLLER, 1785
152	SIDIDAE	DIAPHANOSOMA BIRGEI	KOŘÍNEK, 1981
169		DIAPHANOSOMA SP.	FISCHER, 1850
137	SIDIDAE	LATONA SETIFERA	O.F. MÜLLER, 1785
176		LATONA SP.	STRAUS, 1820
145	SIDIDAE	SIDA CRYSTALLINA	O.F. MÜLLER, 1776
185		SIDA SP.	STRAUS, 1820
149	CERCOPAGIDAE	BYTHOTREPHES CEDERSTROEMI	SCHOEDLER, 1877
158	(invading exotics)	***BYTHOTREPHES LONGIMANUS***	***LEYDIG, 1860 EMEND. BERG & GARTON, 1994 EMEND. THERRIAULT ET AL., 2002***
165		BYTHOTREPHES SP.	LEYDIG, 1860
154	CERCOPAGIDAE	***CERCOPAGIS PENGOI***	***OSTROUMOV, 1891***
201	IMMATURE	CALANOID COPEPODID	
215	CALANOIDA	CALANOID NAUPLIUS	
220		NAUPLIUS - CALANOID OR CYCLOPOID	
221		COPEPODID - CALANOID OR CYCLOPOID	
222		UNIDENTIFIED CALANOIDA	MAUCHLINE, 1988
212	CENTROPAGIDAE	LIMNOCALANUS MACRURUS	SARS, 1863
218		LIMNOCALANUS MACRURUS COPEPODID	SARS, 1863
219		LIMNOCALANUS MACRURUS NAUPLIUS	SARS, 1863
231		LIMNOCALANUS SP.	SARS, 1863
203	DIAPTOMIDAE	***AGLAO***DIAPTOMUS LEPTOPUS	S.A. FORBES, 1882 ***EMEND. LIGHT, 1938 EMEND. DUSSART & DEFAYE, 1995***
225		***AGLAO***DIAPTOMUS SP.	LIGHT, 1938
217	DIAPTOMIDAE	DIAPTOMUS STAGNALIS	S.A. FORBES, 1882
226		DIAPTOMUS SP.	WESTWOOD, 1836
229	DIAPTOMIDAE	***HESPERO***DIAPTOMUS SP.	LIGHT, 1938
202	DIAPTOMIDAE	***LEPTO***DIAPTOMUS ASHLANDI	MARSH, 1893 ***EMEND. LIGHT, 1938 EMEND. DUSSART & DEFAYE, 1995***
204		***LEPTO***DIAPTOMUS MINUTUS	LILLJEBORG, 1889 ***EMEND. LIGHT, 1938 EMEND. DUSSART & DEFAYE, 1995***
208		***LEPTO***DIAPTOMUS SICILIS	S.A. FORBES, 1882 ***EMEND. LIGHT, 1938 EMEND. DUSSART & DEFAYE, 1995***
209		***LEPTO***DIAPTOMUS SICILOIDES	LILLJEBORG, 1889 ***EMEND. LIGHT, 1938 EMEND. DUSSART & DEFAYE, 1995***
230		***LEPTO***DIAPTOMUS SP.	LIGHT, 1938
207	DIAPTOMIDAE	***ONYCHO***DIAPTOMUS SANGUINEUS	S.A. FORBES, 1876 ***EMEND. LIGHT, 1939 EMEND. DUSSART & DEFAYE, 1995***
232		***ONYCHO***DIAPTOMUS SP.	LIGHT, 1939

EMRB SPECIES CODE	FAMILY	GENUS (SUBGENUS) / SPECIES NAME	ORIGIN_AUTHOR / CITATION
205	DIAPTOMIDAE	***SKISTO***DIAPTOMUS OREGONENSIS	LILLJEBORG, 1889 ***EMEND. LIGHT, 1939 EMEND. DUSSART & DEFAYE, 1995***
206		***SKISTO***DIAPTOMUS REIGHARDI	MARSH, 1895 ***EMEND. LIGHT, 1939 EMEND. DUSSART & DEFAYE, 1995***
234		***SKISTO***DIAPTOMUS SP.	LIGHT, 1939
213	PSEUDOCALANIDAE	SENECELLA CALANOIDES	JUDAY, 1923
214		SENECELLA CALANOIDES COPEPODID	JUDAY, 1923
216		SENECELLA CALANOIDES NAUPLIUS	JUDAY, 1923
233		SENECELLA SP.	JUDAY, 1923
210	TEMORIDAE	EPISCHURA LACUSTRIS	S.A. FORBES, 1882
211		EPISCHURA LACUSTRIS COPEPODID	S.A. FORBES, 1882
227		EPISCHURA SP.	S.A. FORBES, 1882
228	TEMORIDAE	EURYTEMORA SP.	GIESBRECHT, 1881
301	IMMATURE CYCLOPOIDA	CYCLOPOID COPEPODID	O.F. MÜLLER, 1785
313		CYCLOPOID NAUPLIUS	O.F. MÜLLER, 1785
304	CYCLOPIDAE	***ACANTHO***CYCLOPS VERNALIS ***COMPLEX***	FISCHER, 1853 ***EMEND. KIEFER, 1978 EMEND. HUDSON ET AL., 1998***
320		ACANTHOCYCLOPS SP.	KIEFER, 1927
339		ACANTHOCYCLOPS ROBUSTUS	SARS, 1863 ***EMEND. HUDSON ET AL., 1998***
340		ACANTHOCYCLOPS VENUSTOIDES	COKER, 1934
341		ACANTHOCYCLOPS VENUSTOIDES BISPINOSUS	YEATMAN, 1951
342		ACANTHOCYCLOPS CAROLINIANUS	YEATMAN, 1944
346		***ACANTHOCYCLOPS BREVISPINOSIS***	***HERRICK 1895, EMEND. HUDSON ET AL., 1998***
303	CYCLOPIDAE	CYCLOPS SCUTIFER	SARS, 1863
321		CYCLOPS SP.	O.F. MÜLLER, 1785
302	CYCLOPIDAE	***DIA***CYCLOPS BICUSPIDATUS THOMASI	S.A. FORBES, 1882 ***EMEND. DUSSART, 1969***
322		DIACYCLOPS SP.	KIEFER, 1927
323	CYCLOPIDAE	ECTOCYCLOPS SP.	BRADY, 1904
332		ECTOCYCLOPS POLYSPINOSUS	HARADA, 1931
306	CYCLOPIDAE	EUCYCLOPS AGILIS	KOCH, 1838 ***EMEND. TORKE, 1976***
325		EUCYCLOPS SP.	CLAUS, 1893
335		EUCYCLOPS MACRUROIDES DENTICULATUS	GRAETER, 1903
336		EUCYCLOPS PRIONOPHORUS	KIEFER, 1931
347		***EUCYCLOPS ELEGANS***	***HERRICK, 1884 EMEND. HUDSON ET AL., 1998***
308	CYCLOPIDAE	MACROCYCLOPS ALBIDUS	JURINE, 1820
326		MACROCYCLOPS SP.	CLAUS, 1893
309	CYCLOPIDAE	MESOCYCLOPS EDAX	S.A. FORBES, 1891
327		MESOCYCLOPS SP.	SARS, 1914
343		MESOCYCLOPS AMERICANUS	DUSSART, 1985
328	CYCLOPIDAE	MICROCYCLOPS SP.	CLAUS, 1893
310	CYCLOPIDAE	ORTHOCYCLOPS MODESTUS	HERRICK, 1883
329		ORTHOCYCLOPS SP.	FORBES, 1897
311	CYCLOPIDAE	PARACYCLOPS POPPEI	REHBERG, 1880 ***EMEND. FRENZEL, 1977 IN HUDSON ET AL., 1998***
330		PARACYCLOPS SP.	CLAUS, 1893
312	CYCLOPIDAE	TROPOCYCLOPS PRASINUS MEXICANUS	KIEFER, 1938
331		TROPOCYCLOPS SP.	KIEFER, 1927
337		TROPOCYCLOPS PRASINUS PRASINUS	FISCHER, 1860 ***EMEND. KIEFER, 1978***
338		TROPOCYCLOPS EXTENSUS	KIEFER, 1931
324	ERGASILIDAE	ERGASILUS SP.	NORDMANN, 1832
344	ORDER HARPACTICOIDA	***HARPACTICOIDA NAUPLIUS***	***LANG, 1948***
345		***HARPACTICOIDA SP.***	***LANG, 1948***

Section 4. References commonly used to identify crustacean zooplankton

The following sources provide excellent zooplankton identification keys and/or detailed diagrams of species. You may come across other useful papers as your work develops. Although Thorp and Covich (1991) provide good details on the ecology of species, their keys only go down to the genus level. Pennak (1989) also covers this aspect and the keys in the *Third edition* are more detailed, going down to the species level. Edmondson (1959), though a bit dated with respect to taxonomic changes, remains one of the most comprehensive keys for freshwater crustacean zooplankton.

> *Note that most keys only refer to females for the Cladocera. During most of the year, populations entirely consist of parthenogenetic females; hence males are usually quite rare (Pennak, 1989).*

General:

Balcer, M.D., N.L. Korda and S.I. Dodson. 1984. Zooplankton of the Great Lakes: A guide to the identification and ecology of the common crustacean species. The University of Wisconsin Press. Madison, Wisconsin.

Pennak, R.W. 1989. Freshwater invertebrates of the United States. Third edition. John Wiley and Sons, Inc., New York.

Torke, B.G. 1974. An illustrated guide to the identification of the planktonic Crustacea of Lake Michigan with notes on their ecology. The University of Wisconsin Press. Milwaukee, Wisconsin. Special Report No. 17.

Cladocera:

Brandlova, J., Z. Brandl and C.H. Fernando. 1972. The Cladocera of Ontario with remarks on some species and distribution. Can. J. Zool. 50: 1373-1403.

Brooks, J.L. 1959. Cladocera. Pp. 587-656 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.

Dodson, S.I. and D.G. Frey. 1991. Cladocera and other Branchiopoda. Pp. 723-786 in J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press. San Diego.

Copepoda:

Dussart, B.H. and C.H. Fernando. 1990. Crustaces copepodes de l'Ontario. University of Waterloo, Department of Biology.

Hudson, P.L., J.W. Reid, L.T. Lesko and J.H. Selgeby. 1998. Cyclopoid and harpacticoid copepods of the Laurentian Great Lakes. Ohio Biological Survey Bulletin NS 12(2). Columbus, Ohio.

Smith, K. and C.H. Fernando. 1978. A guide to the freshwater calanoid and cyclopoid copepod Crustacea of Ontario. University of Waterloo, Department of Biology. Ser. No. 18.

Williamson, C.E. 1991. Copepoda. Pp. 787-822 in J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press. San Diego.

Wilson, M.S. 1959. Calanoida. Pp. 738-795 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.

Yeatman, H.C. 1959. Cyclopoida. Pp. 796-814 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.

Daphniidae:

Brooks, J.L. 1957. The systematics of North American *Daphnia*. Mem. Conn. Acad. Arts & Sciences 13: 1-180.

Hebert, P.D.N. 1995. The *Daphnia* of North America – An Illustrated Fauna. CD-ROM and website (http://www.cladocera.uoguelph.ca/taxonomy/daphnia/default.htm). University of Guelph, Guelph.

Bosminidae:

De Melo, R. and P.D.N. Hebert. 1994. A taxonomic reevaluation of North American Bosminidae. Can. J. Zool. 72: 1808-1825.

Taylor, D. J., C.R. Ishikane and R.A. Haney. 2002. The systematics of Holarctic bosminids and a revision that reconciles molecular and morphological evolution. Limnol. Oceanogr. 47 (5): 1486-1495.

Section 5. Basics of zooplankton identification

Essential anatomical terminology must be learned in order to positively identify an organism. General elements that need to be assessed for all zooplankton groups are:

- body shape and size
- relative length of various appendages, including antennae, legs, and setae
- presence and relative sizes of spines

Although several anatomical features used to differentiate species are listed in the literature, this Guide only makes mention of the key details which taxonomists use for rapid identifications. The attempt was to keep the list of features to a minimum while ensuring accurate species assignments. Although some dissection may be required, this Guide generally only depicts anatomical details that can be viewed under a dissection microscope. For more detailed information on certain features (ex. cyclopoid 5^{th} legs), refer to the sources listed in Section 4.

After gaining some experience, you will develop a mental picture of what a typical specimen of each common species looks like. Therefore, although first identifications will take time in order to consult the literature and keys, this will not always be a necessary step. Each zooplankton group has a series of major characteristics used for positive identification. Once you memorize what to look for the speed of processing will dramatically increase. If ever in doubt, always refer to the keys.

If an identification is still uncertain after following these steps, it is always best to adopt a more general designation rather than take a "guess". For example, the taxonomy of *Bosmina* is notoriously complicated by the elements mentioned in the introduction to this Guide. Very fine distinctions separate members of the 5 species found within the Sudbury Region. Therefore, if in doubt, assign a member of this family to the proper genus (i.e. *Eubosmina* or *Bosmina*) rather than attempting a tentative species designation.

Identification to the family (for Cladocera) or order (for Copepoda) level is fairly easy. From there you must refer to the main identification characteristics for each group, outlined in the following Sections.

Section 6. Zooplankton dissection techniques

Before delving into taxonomic details, here is a general outline of how to dissect zooplankton specimens. Very fine needles (00 entomological or other type), mounted in suitable holders, are used to manipulate specimens and for dissection. Organisms to be dissected are typically transferred to a drop of glycerine on a microscope slide by using fine tweezers. Care must be taken not to crush or lose structures in the transfer. Certain features must be examined before attempting a dissection. For the Copepoda, these include the form and size of the metasomal wings and the length of the antennules in relation to the total body length.

Once the specimen has been placed on a slide, abdomen side up, hold a needle holder in each hand and pin the organism down with your least used hand (i.e. if right handed, use your left hand). With your most dexterous hand, carefully remove the body parts containing essential elements for identification.

- generally, the only cladocerans which may require dissection are the *Daphnia* (postabdomen). You must assess the relative sizes of the abdominal processes before proceeding as these are very fragile and easily damaged.
- most calanoid copepods can be identified without dissection, if you can get a clear view of the 5th legs
- for cyclopoid copepods, the antennules and 5th legs need to be closely examined. Carefully remove the antennules from the head then separate the metasome from the urosome just under the 4th legs to reveal the 5th legs (see Figure 1). Refer to the sources listed in Section 4 to view diagrams and details related to these features.

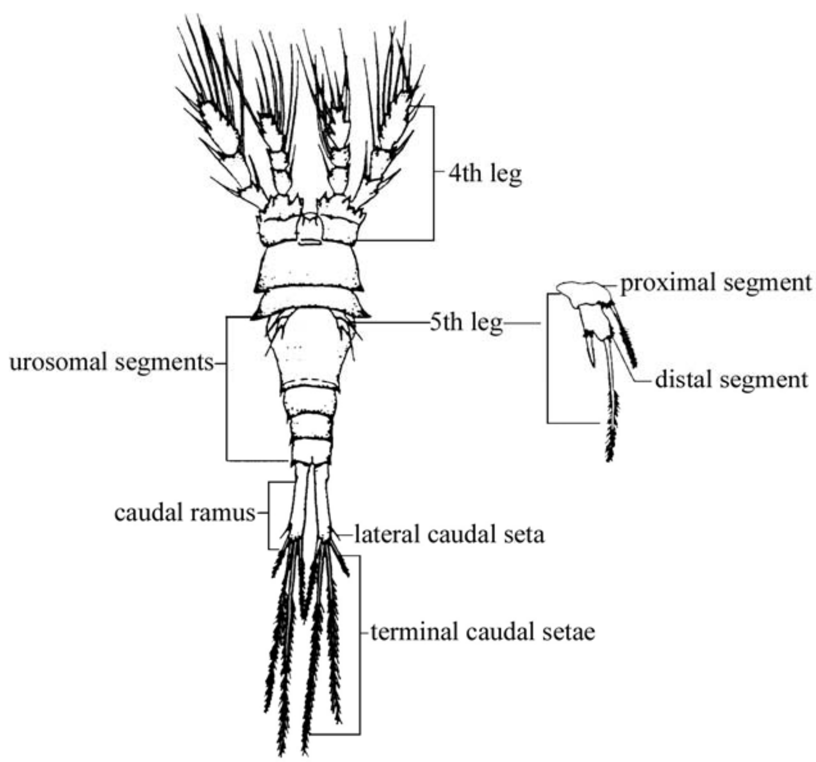


Figure 1. Ventral view of posterior segments and appendages in a typical cyclopoid copepod showing key identification structures (modified from Hudson et al., 1998)

Refer to the following Sections for more detailed information on these and other characteristics.

Section 7. Identification of Cladocera

[Details for the introduction to this section derived from Pennak (1989)]

It should be understood that the term “Cladocera”, although widely used, has no taxonomic value. Rather, it is comprised of members belonging to the following four orders: Anomopoda, Ctenopoda, Haplopoda, and Onychopoda. The reader is referred to Section 2 of this Guide for an outline of the zooplankton classification scheme.

Reproduction for this group is primarily parthenogenetic. Therefore, males are usually extremely rare in samples. Most keys refer only to the females. Males of most cladoceran families can be readily identified due to their notably very enlarged antennules (first antennae) and smaller size relative to the females. These aspects are clearly shown in Section 9 of this manual, dealing with *Daphnia* taxonomy.

All of the local Cladocera are enclosed in a translucent carapace made up of a single valve that folds over the body and is open ventrally at the thoracic and abdominal regions (except for *Leptodora* and *Polyphemus* where the carapace is reduced to a brood chamber only). A single large compound eye is conspicuous and some species have a small ocellus (black dot) beneath the eye. The first antennae (antennules) are inserted on the ventral side of the head and are quite small (except in Bosminidae and Macrothricidae). The rostrum (i.e. “beak”) is found just above the antennules. The second antennae, the major swimming appendages, are large and consist of a stout basal segment and two segmented rami (dorsal and ventral), each of which bears various setae. One species of Sididae, *Latona setifera*, is unusual in that its second antennae are each split into three branches. The fornix is a solidifying structure lying above the base of each second antenna. Lastly, the abdomen ends in a single large postabdomen bearing 2 claws at the anterior end and various other critical taxonomic structures (processes and spines).

Refer to Figure 2 for a visual representation of the main structures used to identify cladocerans. The following text outlines “General” and “Specific” features used for each of the families found within the Sudbury Region. The “General” points and the accompanying figures will enable users to rapidly differentiate the families. The “Specific” points are those most commonly used in zooplankton keys (see Section 4) for identification to the genus or species level. Unless otherwise indicated, details for these points were derived from Pennak (1989), Dodson and Frey (1991), and Balcer et al. (1984).

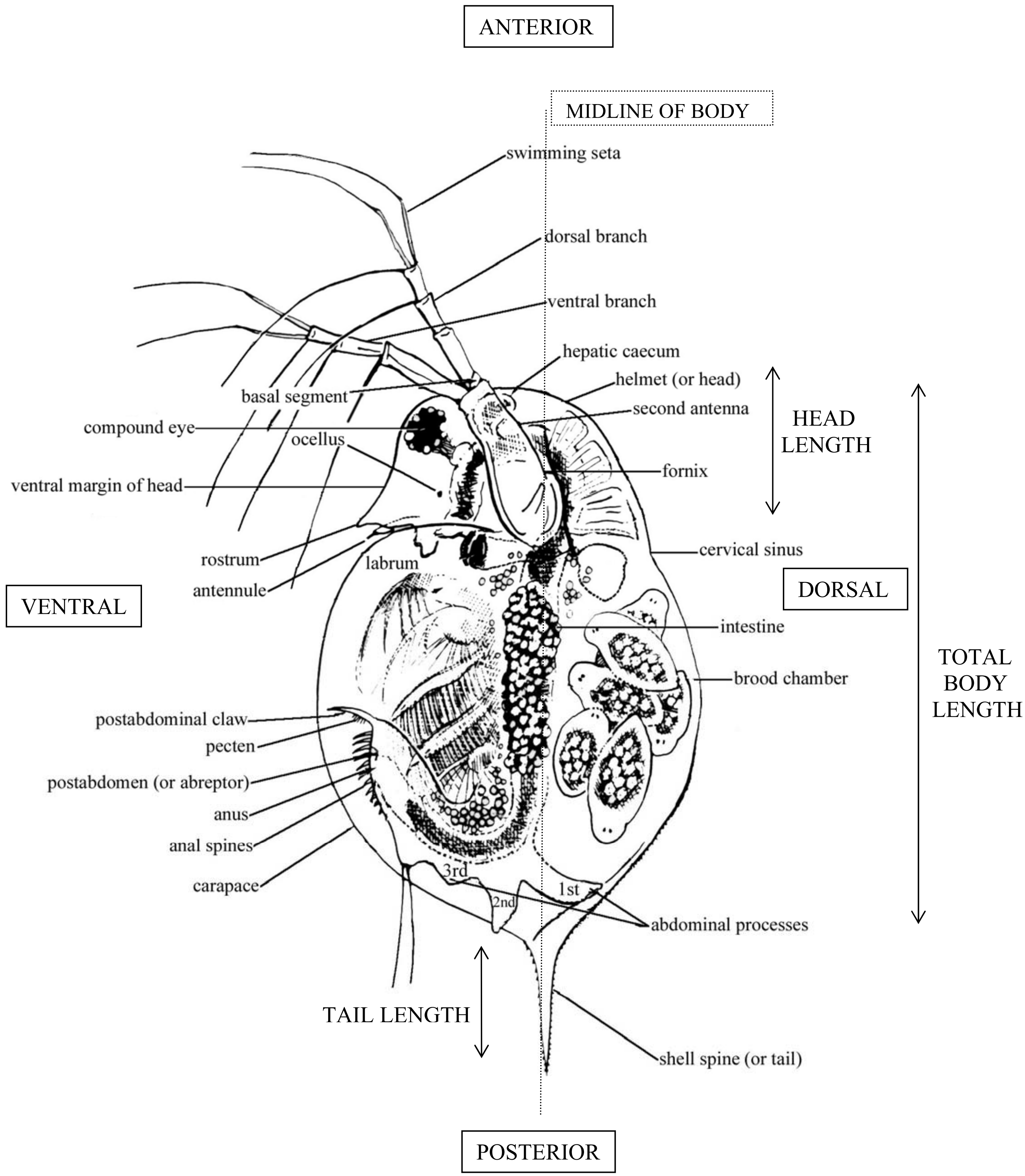


Figure 2. General anatomy of a cladoceran (modified from Dodson and Frey, 1991)

A. Bosminidae (details derived from De Melo and Hebert (1994)):

General - body enclosed in a carapace
(Figure 3) - rostrum and antennules are fused to form a "tusk-like" structure which is fixed

Specific - transition between the rostrum and the antennules (smooth or with a dip) (see Figure 4)
- length of the rostrum (see Figure 4)
- presence/absence of a mucro
- length of the mucro
- form of the antennules (fairly straight or sharply recurved)
- position of the sensory seta (at the base of the rostrum or midway to the eye)

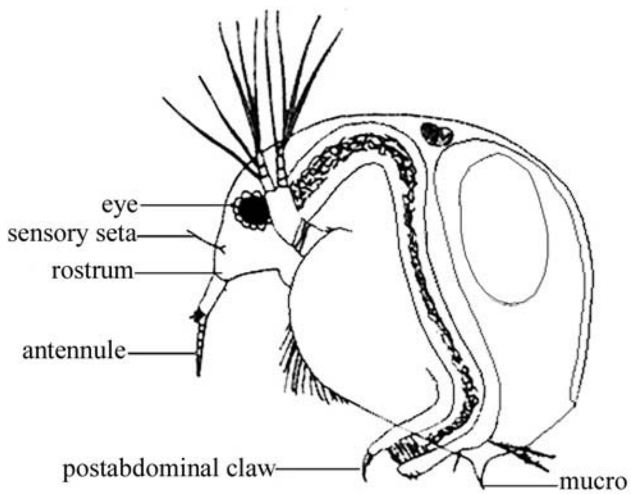


Figure 3. General diagram of a member of the family Bosminidae (modified from Pennak, 1989)

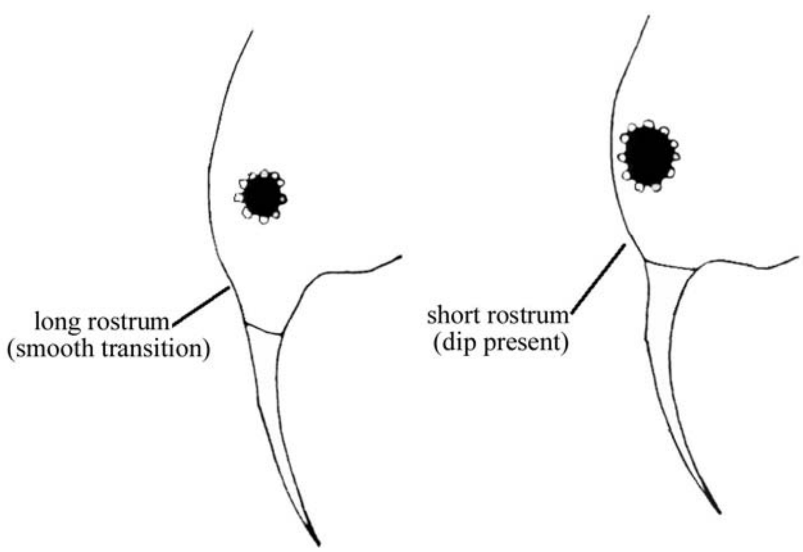


Figure 4. Alternative shapes of Bosminidae rostrums (modified from De Melo and Hebert, 1994)

B. Chydoridae:

General - body enclosed in a carapace
(Figure 5) - fornices extended to cover the antennules and united with rostrum into a "beak"

Specific - location of the anus (terminal or sub-terminal)
- height of the posterior margin in relation to the total body height
- presence/absence of marginal and/or lateral denticles on the postabdomen
- length and form of the rostrum
- presence/absence of teeth on various margins of the carapace (see Figure 6)
- form of the labrum
- form of the postabdomen

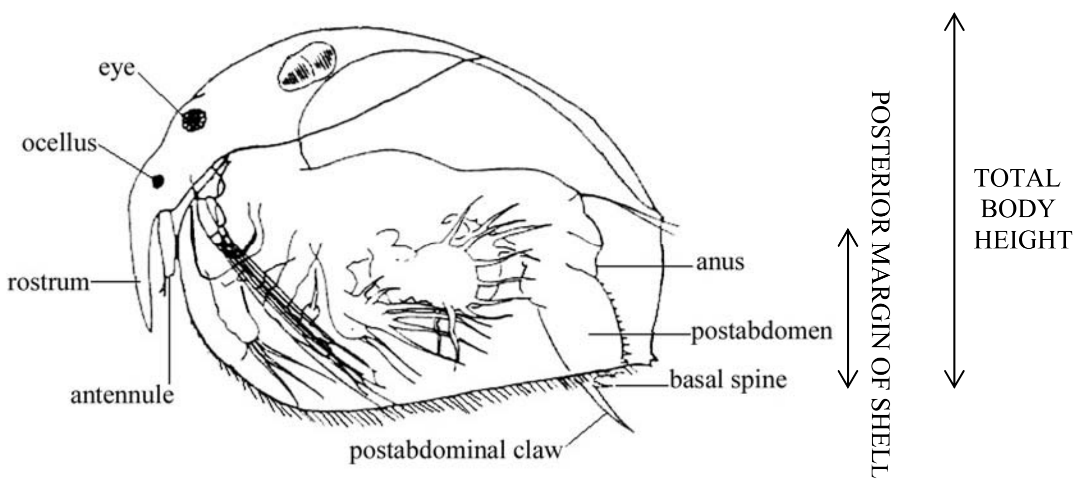


Figure 5. General diagram of a member of the family Chydoridae (modified from Dodson and Frey, 1991)

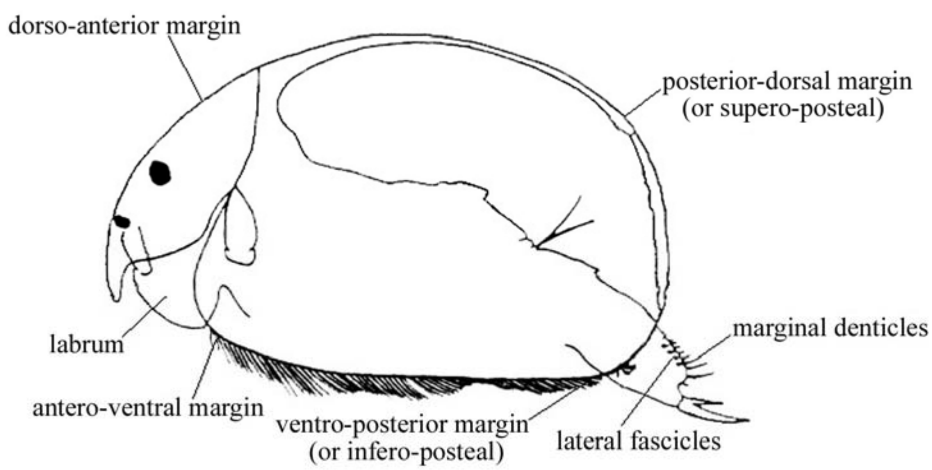


Figure 6. Diagram depicting the various margins important for identifying members of the family Chydoridae (modified from Dodson and Frey, 1991)

C. Daphniidae:

General - body enclosed in a carapace
(Figure 7) - members of the genus *Daphnia* possess a prominent shell spine (i.e. "tail"), the only group of local cladocerans with this trait

Specific - shape of the head
- shape of the ventral margin of the head (concave or straight...many variations exist)
- position of the optic vesicle relative to the ventral margin of the head
- position of the eye within the head (relatively low or high)
- presence/absence of an ocellus
- presence/absence of a rostrum
- shape of the rostrum
- presence/absence of a cervical sinus
- presence/absence of teeth at the back of the neck (i.e. "neck teeth")
- shape of the fornices (large and triangular or smoothly rounded)
- length of the second antennae relative to the total body length
- length of the swimming hairs on the second antennae
- presence/absence of a shell spine
- length and orientation of the shell spine
- relative sizes of the abdominal processes
- level of pubescence (i.e. "hairiness") of the abdominal processes
- relative sizes of the pecten (i.e. "teeth") on the postabdominal claw
- habitat (pond, lake, or both)

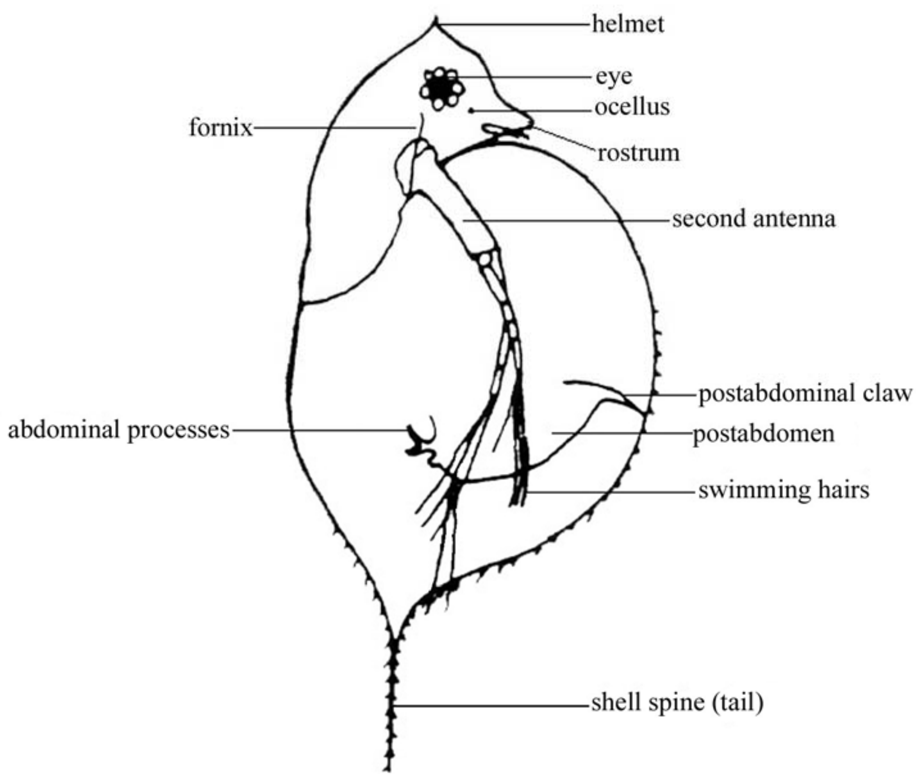


Figure 7. General diagram of a member of the family Daphniidae (modified from Balcer et al., 1984)

D. Holopediidae:

General - body enclosed in a carapace
(Figure 8) - enclosed in a gelatinous sheath (may be lost in preserved samples)
- hump-backed
- specimens very uniform in shape, immediately recognizable

Specific - only one species found within the Sudbury Region *(Holopedium glacialis)*

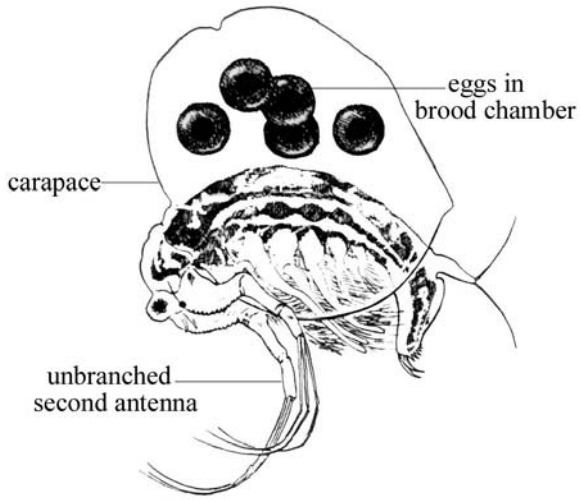


Figure 8. Diagram of *Holopedium glacialis* (family Holopediidae) (modified from Dodson and Frey, 1991)

E. Leptodoridae:

General - carapace much reduced, not covering the entire body, forming the brood chamber
(Figure 9) - extremely large (up to 18 mm which far exceeds all other local species)
- body very long and slender but translucent, tending to float in a sample
- specimens very uniform in shape, immediately recognizable

Specific - only one species in this Family *(Leptodora kindtii)*

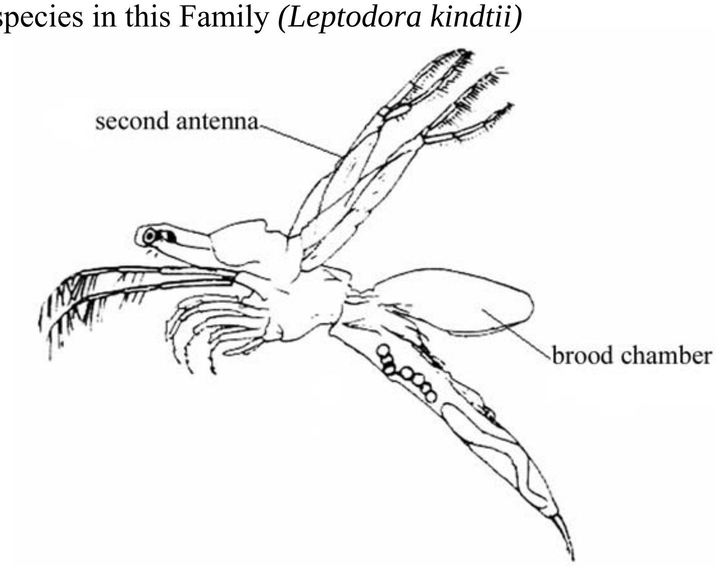


Figure 9. Diagram of *Leptodora kindtii* (family Leptodoridae) (modified from Dodson and Frey, 1991)

F. Macrothricidae (rare in these samples):

General - body enclosed in a carapace
(Figure 10) - antennules almost as long as the head, attached near the front of the head
- antennules freely movable
- typically have strong spinescence on the ventral margin of the carapace

Specific - form of the intestine (convoluted or simple)
- presence/absence of structures (i.e. teeth, spines) on various margins of the carapace
- antennal setae formula
[This shows the number of setae on each joint of each branch of the 2nd antennae, starting with the proximal joint, with the dorsal branch occupying the place of the numerator. For example, the below pictured species has an antennal setae formula of $\frac{0\text{-}0\text{-}0\text{-}3}{1\text{-}1\text{-}3}$*, meaning that it has 4 segments on its dorsal branch (the first 3 have no setae and the last has 3) and 3 segments on its ventral branch (the first two have 1 setae each and the last has 3)].*
- posterior narrowing of the valves (i.e. carapace)
- presence/absence of spines on the postabdomen
- presence/absence of hepatic caeca (small sacs at the anterior end of the intestine)
- form of the head

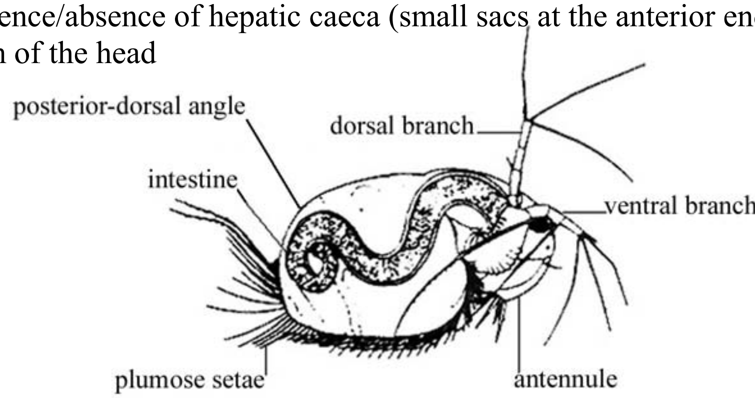


Figure 10. General diagram of a member of the family Macrothricidae (modified from Dodson and Frey, 1991)

G. Polyphemidae:

General - carapace much reduced, not covering the entire body, forming the brood chamber
(Figure 11) - body very rounded, short with elongate "tail"
- huge compound eye
- specimens very uniform in shape, immediately recognizable

Specific - only one species found within the Sudbury Region *(Polyphemus pediculus)*

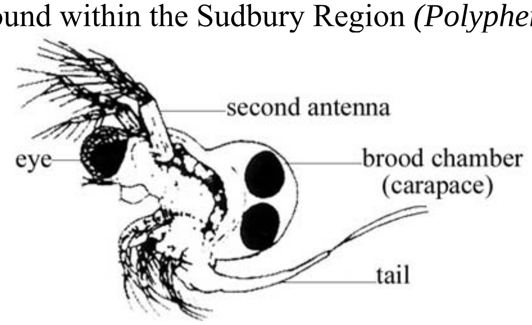


Figure 11. Diagram of *Polyphemus pediculus* (family Polyphemidae) (modified from Dodson and Frey, 1991)

H. Sididae:

General (Figure 12)
- body enclosed in a carapace
- very large and flattened second antennae
- no shell spine
- many (over 14) swimming setae arranged in a row along one side of the dorsal rami of each second antenna

Specific
- length of the basal segment of each second antenna
- lateral expansion of the basal segment of each second antenna
- length of the head in relation to the total body length
- presence/absence of a rostrum
- number of branches in each second antenna
- presence/absence of long setae along the margin of the carapace

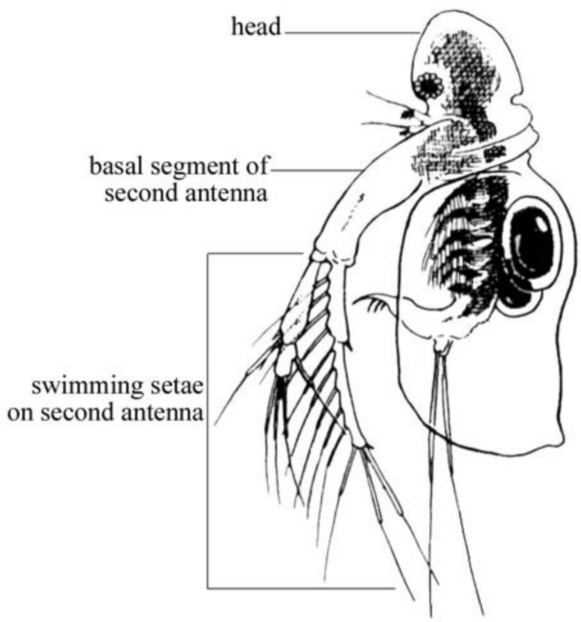


Figure 12. General diagram of a member of the family Sididae (modified from Dodson and Frey, 1991)

Section 8. Identification of Copepoda

[Details for the introduction to this section derived from Williamson (1991)]

Reproduction for this group is always sexual, leading to development through 12 life stages. The first 6 are termed "nauplii", the next 5 are "copepodids", and the last life stage is the adult. The nauplii are very small, often extremely numerous, and do not resemble the final body shape (they look like small mites). At the copepodid stages, the organisms begin to look like the adult form. Adult males and females can be differentiated based upon the shape of the antennules (one or both are geniculate (i.e. "bent") in males), the presence of a 6^{th} leg in male cyclopoids, and the generally larger body size of females, a feature that is more pronounced in the cyclopoids.

As seen in Figure 13, the adult body is clearly segmented, more or less elongated, and is divided into two basic regions: the metasome (head and thorax) and the urosome (abdomen). The first antennae (antennules) are very conspicuous, are fairly long, and serve for locomotion. As well, copepods possess 5 sets of legs (6 sets in male cyclopoids). Although all can be useful for identification, the 5^{th} legs are the primary recourse for separating species. These are quite large and easily seen in the calanoids, but much reduced in the cyclopoids making them generally much more difficult to identify. The last urosomal segment bears 2 caudal rami with various forms and numbers of setae attached to them.

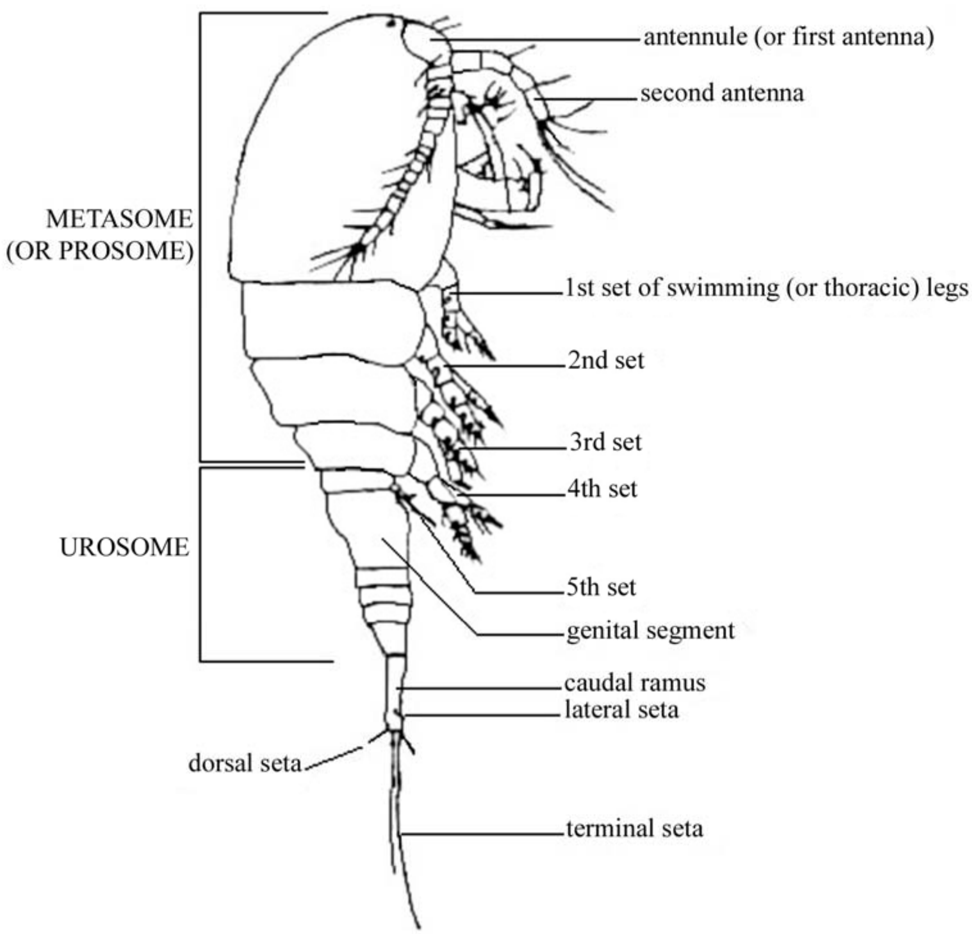


Figure 13. Lateral view of a cyclopoid (modified from Smith and Fernando, 1978)

A. Identifying the copepod orders (details derived from Williamson, 1991):

The 3 copepod orders (shown in Figure 14) are easily differentiated based upon the length of the antennules, relative sizes of the metasome and urosome, and the structure of the 5th legs.

1) Calanoida - antennules are very long (23-25 segments), often reaching to or beyond the caudal rami
   - right antennule is geniculate (i.e. "bent") in males (except for *Senecella* sp. where the left antennule is geniculate)
   - body narrows between the segment bearing the 5th legs and the genital segment
   - 5th legs are quite large and distinct, symmetrical in females, asymmetrical in males

2) Cyclopoida - antennules of medium length (6-17 segments)
   - both antennules are geniculate in males
   - body narrows between the segments bearing the 4th and 5th legs
   - 5th legs are vestigial. Males possess an even smaller set of 6th legs which could be confused for the 5th legs. Dissection required to view these features.

3) Harpacticoida - antennules are very short (5-9 segments)
   - both antennules are geniculate in males
   - metasome and urosome are of similar widths (no narrowing point)
   - almost exclusively littoral so they are very rarely seen in these zooplankton samples

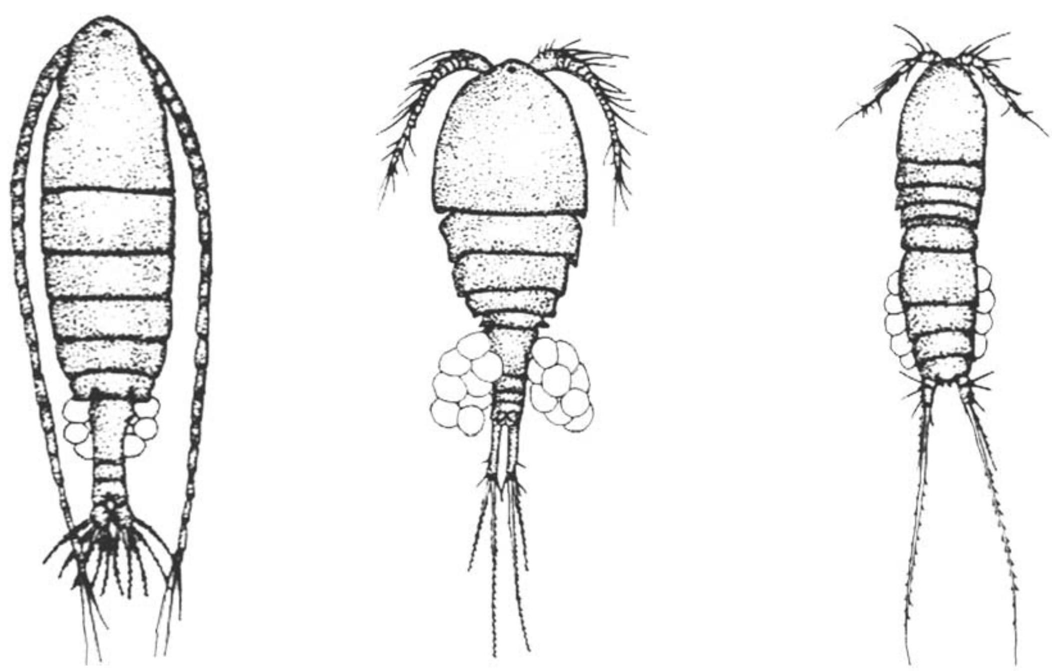


Figure 14. Representatives of the major groups of Copepoda (modified from Smith and Fernando, 1978)

B. Identifying the immature life stages (pers. comm., D. Geiling, 2000):

1) Copepod nauplii (Figure 15)
- can identify as being either calanoid or cyclopoid only
- shape of the base (pointed vs. flat)
- body shape (tapered vs. ovoid)
- shape of first antennae (larger at the apex or same size throughout)
- relative length of the antennae (first antennae shorter than the others or the same length)

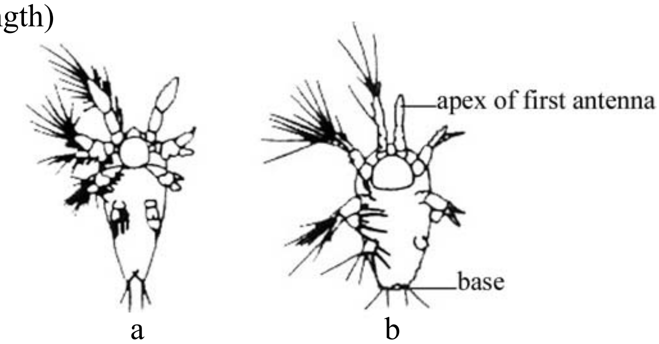


Figure 15. General diagrams depicting a calanoid (a) and cyclopoid (b) nauplius (modified from Ravera, 1953)

2) Copepodids vs. adults
- can identify copepodids as being either calanoid or cyclopoid only (except for the calanoids *Senecella calanoides* and *Epischura lacustris* that can be identified to species even as copepodids)
- indistinct features vs. fully defined. This is especially useful for calanoid 5th legs that are clearly visible under a dissection microscope (see Figure 16).
- relative sizes of the last two urosome segments (in copepodids, the last segment before the rami is longer that the previous one). This is the primary method used to differentiate immature vs. mature cyclopoids (see Figure 17).

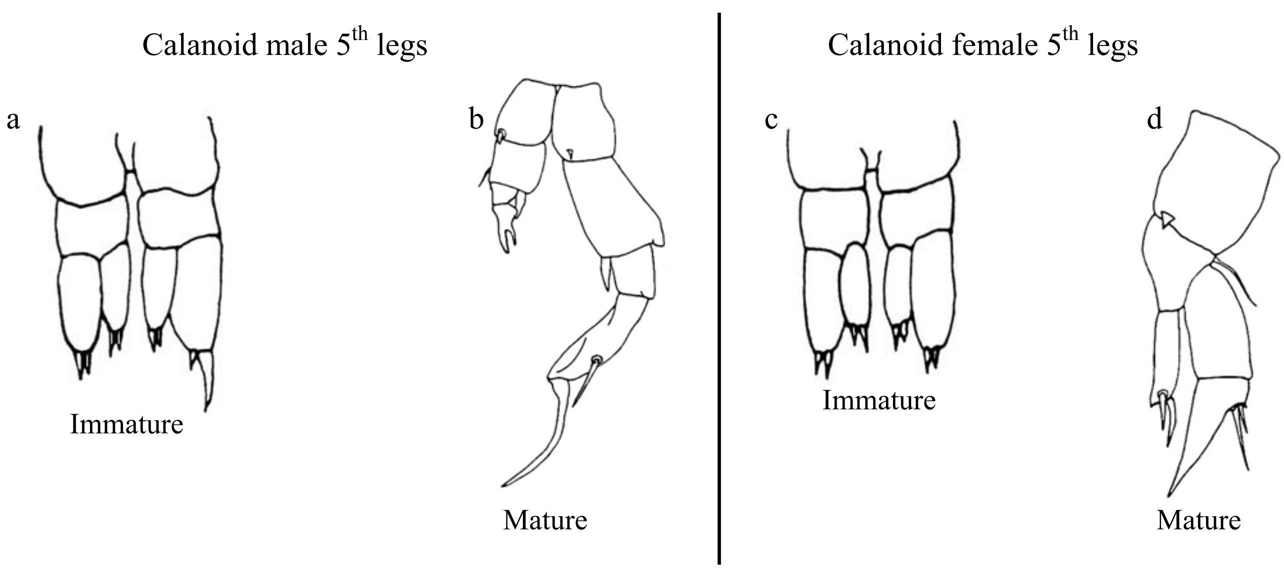


Figure 16. Comparative representations of calanoid 5th legs showing immature vs. mature specimens (a & c modified from Torke, 1974; b & d modified from Smith and Fernando, 1978)

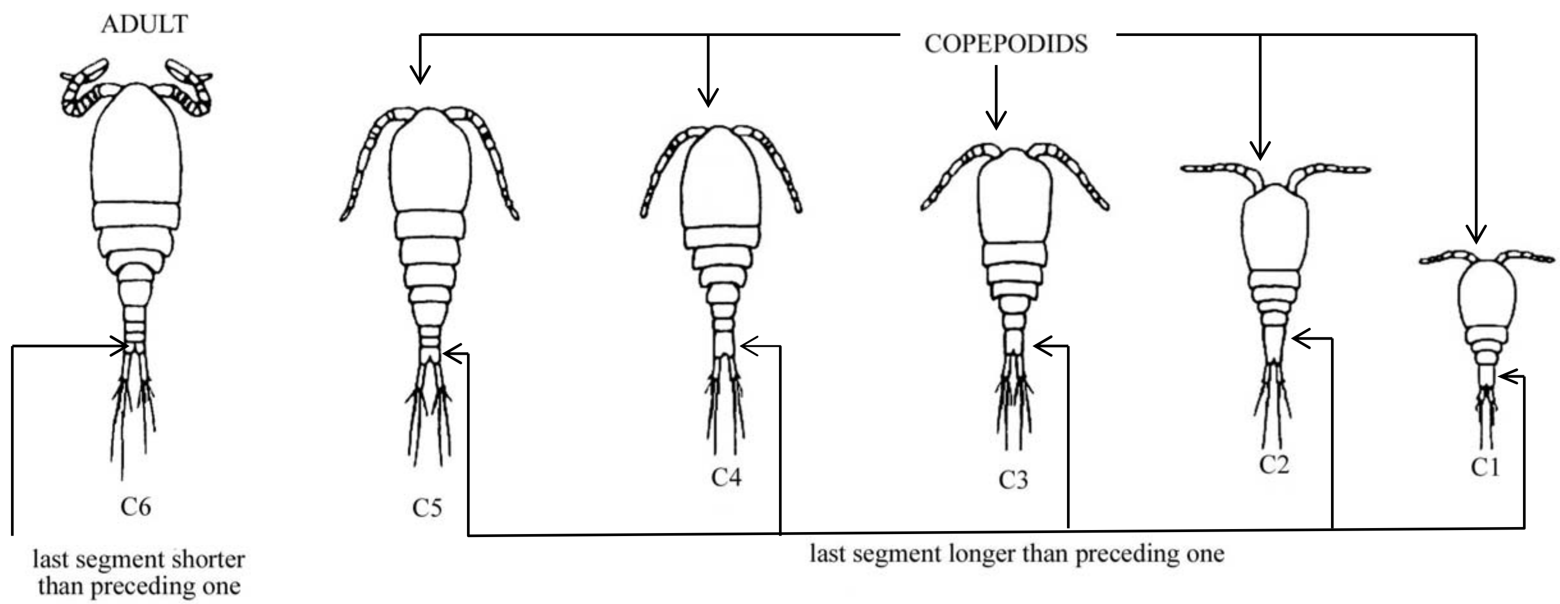


Figure 17. Comparative representations of a cyclopoid male member from each copepodid life stage (modified from Ravera, 1953)

C. Specific calanoid identification features (details derived from Smith & Fernando (1978). See Figure 18):

- body size
- number and relative lengths of the terminal setae on the caudal rami
- form and symmetry of the metasomal wings in females
- symmetry of the urosome (straight or twisted)
- structure of the antennules in males (see Figure 19). Dissection may be required to view this feature.
- position of the lateral spine on the male 5th leg (see Figure 20)
- form of the endopod and terminal claw on the female 5th leg (see Figure 21)
- length of the caudal rami

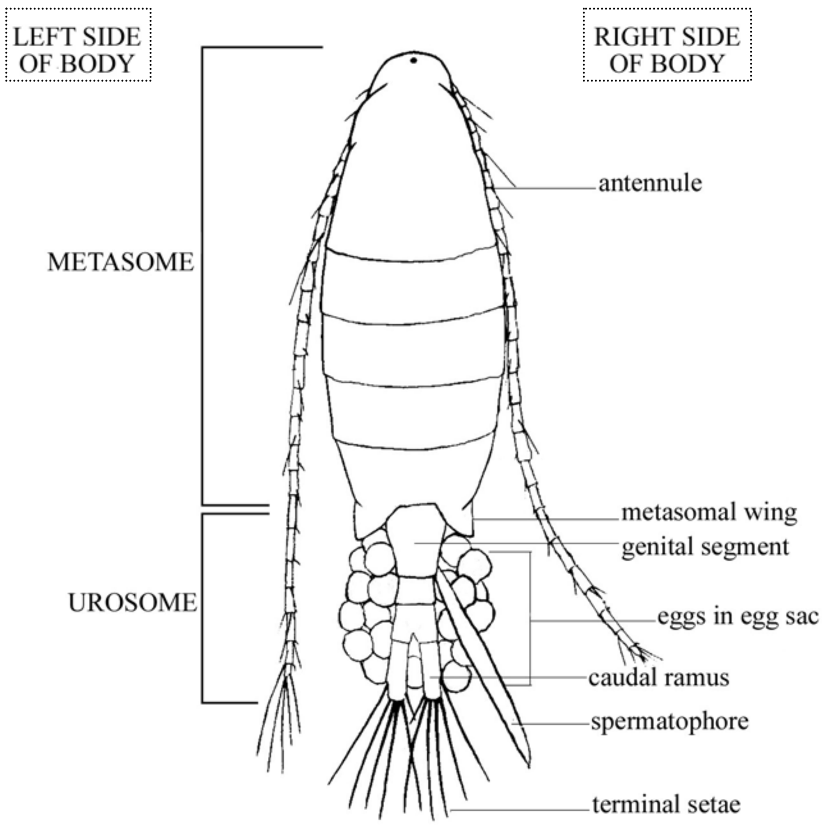


Figure 18. General anatomy of a female calanoid copepod (modified from Balcer et al., 1984)

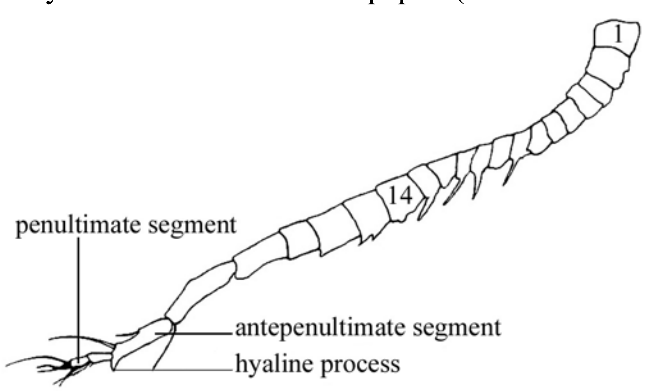


Figure 19. Details of the right geniculate antennule of a male calanoid copepod (modified from Smith and Fernando, 1978)

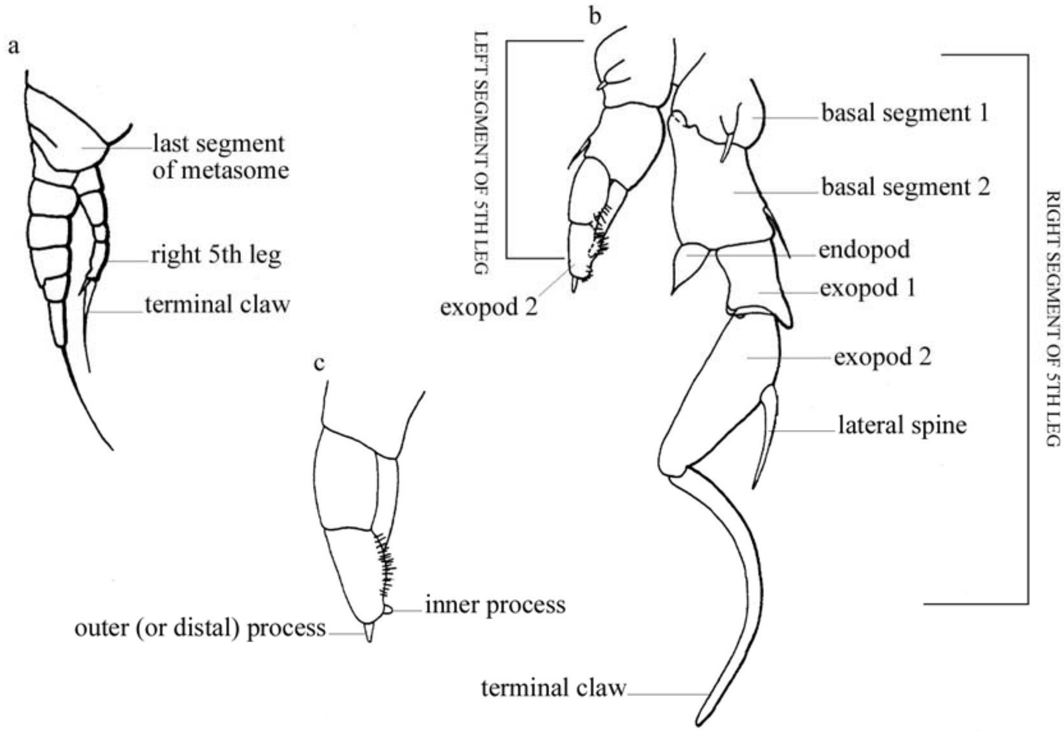


Figure 20. a) Posterior part of the male diaptomid body showing the location of the 5th legs, right side
b) Male 5th legs, posterior view
c) Left 5th leg, exopod 2, detail of inner and outer processes
(modified from Sandercock and Scudder, 1996)

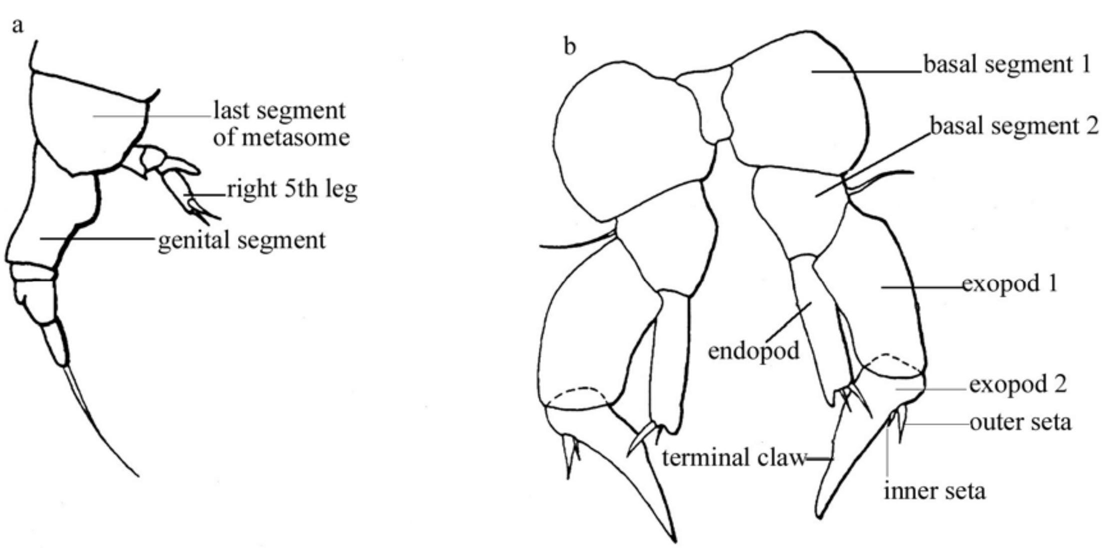


Figure 21. a) Posterior part of the female diaptomid body showing the location of the 5th legs, right side
b) Female 5th legs, posterior view
(modified from Sandercock and Scudder, 1996)

Below are diagrams of some of the most commonly found members of the calanoid family "Diaptomidae" within the Sudbury Region. Since these are among the most widely distributed and abundant calanoids in North America (Wilson, 1959), having a good grasp of their identification is crucial.

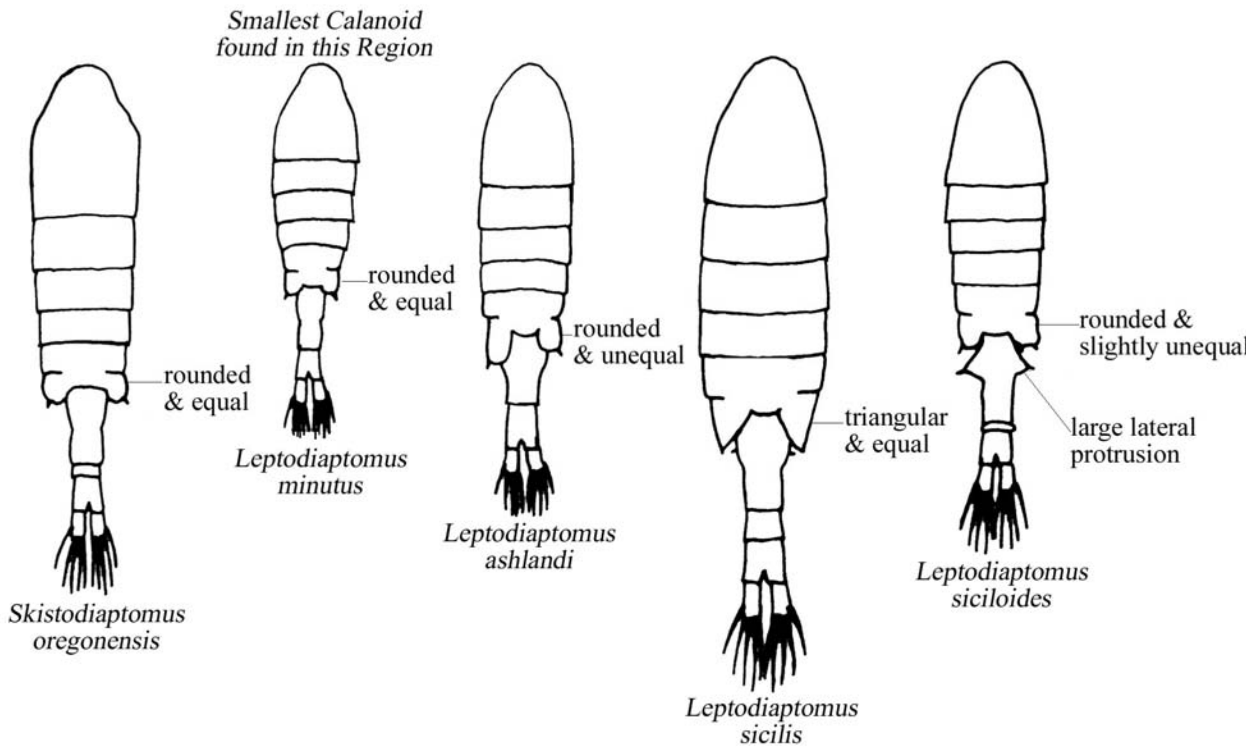


Figure 22. Comparative representations of common members of the calanoid "Diaptomidae" family showing female bodies (modified from Torke, 1974)

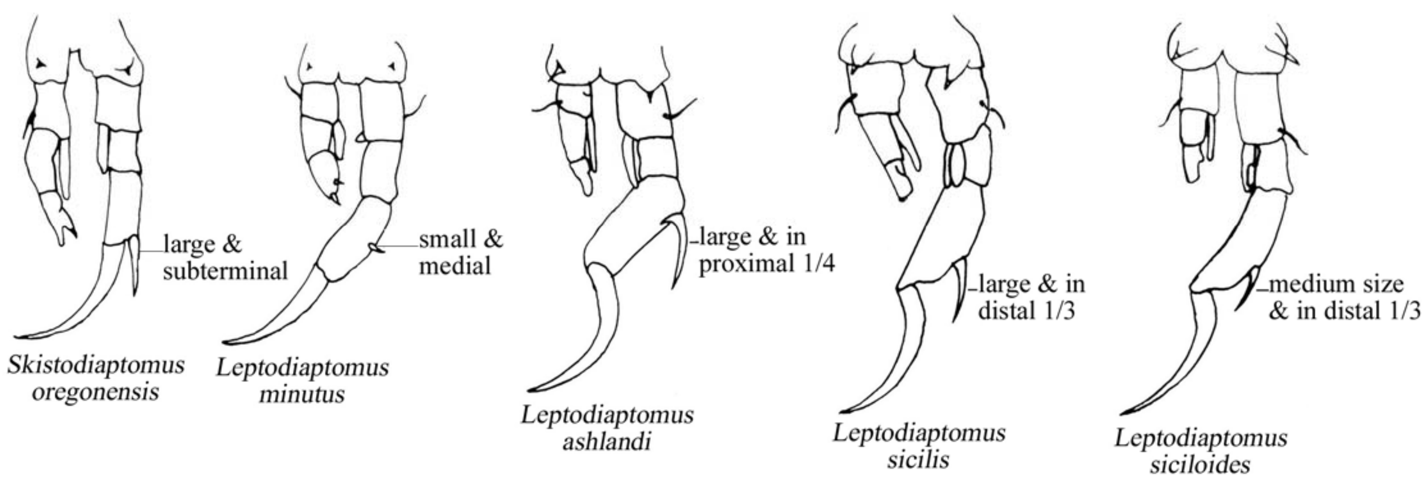


Figure 23. Comparative representations of common members of the calanoid "Diaptomidae" family showing male 5th legs (modified from Torke, 1974)

D. Specific cyclopoid identification features (details derived from Smith & Fernando (1978). See Figure 24):

- body size
- number of segments in the antennules (refer to Figure 19). Segments are numbered beginning at the point of insertion in the head. Dissection required to view this feature.
- length of the caudal rami
- point of insertion of the lateral setae on the caudal rami
- details of the caudal rami (hairs/spinules, dorsal ridges)
- relative lengths of the inner and outer caudal (or terminal) setae
- number of terminal setae on the caudal rami
- structure of the 5th legs. Dissection required to view this feature. Refer to the sources listed in Section 4 for more details on Cyclopoid 5th legs.

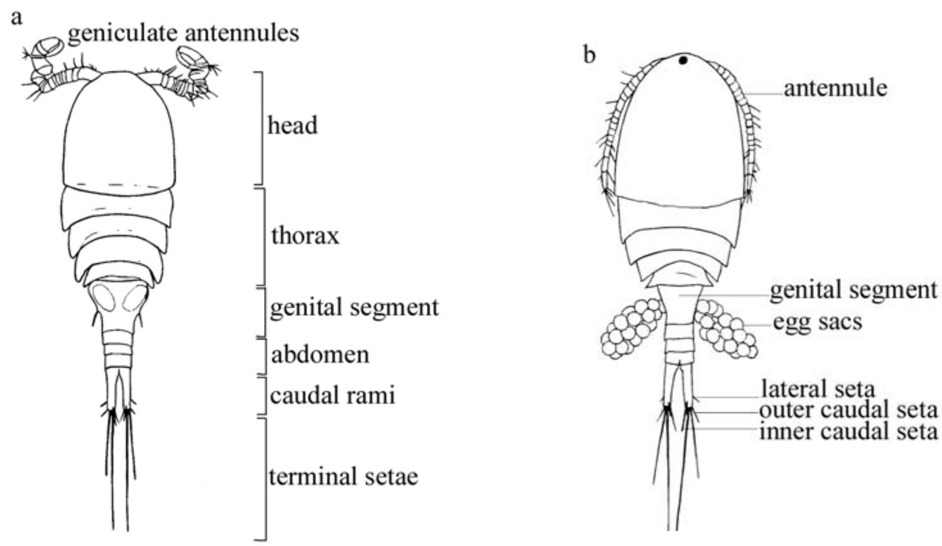


Figure 24. General anatomy of cyclopoid copepods showing key features in males (a) and females (b) (modified from Balcer et al., 1984)

Refer to Figure 25 for general depictions of species commonly found within the Sudbury Region. If a dissection is necessary, refer to Figure 1 and the keys mentioned in Section 4.

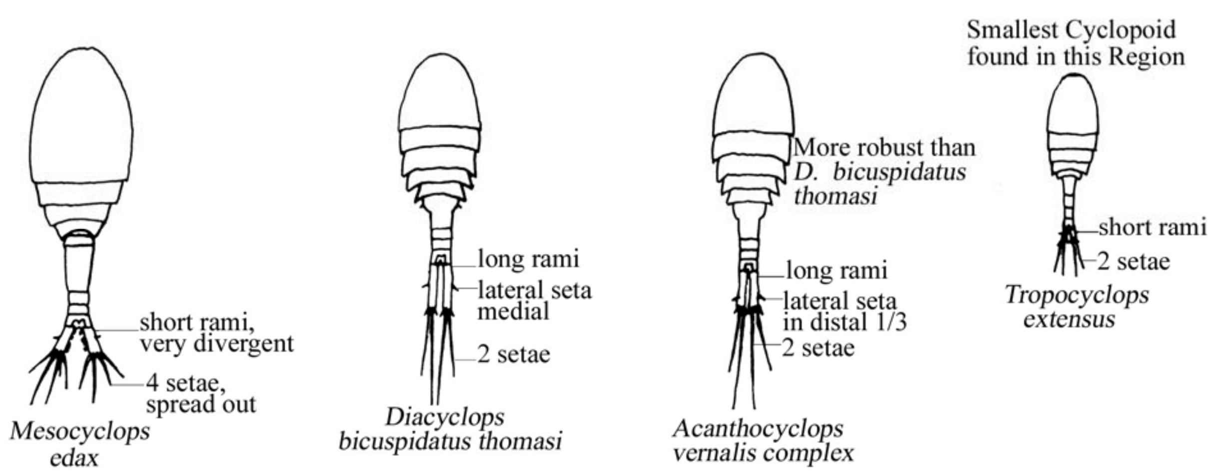


Figure 25. Comparative representations of common cyclopoid members (modified from Torke, 1974)

Section 9. *Daphnia* taxonomy

Traditionally, members of the genus *Daphnia* have been separated into 2 species complexes with additional species falling under the category of "orphan taxa" (uncertain lineages) (Colbourne and Hebert, 1996). This is how local species would be assigned, based upon this classification:

"Pulex group": *Daphnia pulex, Daphnia pulicaria, Daphnia catawba, Daphnia minnehaha*
"Longispina group": *Daphnia mendotae, Daphnia dentifera, Daphnia dubia, Daphnia longiremis*
"Orphan taxa": *Daphnia ambigua, Daphnia retrocurva, Daphnia parvula*

According to Colbourne and Hebert (1996), this scheme must be reanalysed due to recent genetic analyses. They propose the following classification for genus *Daphnia*, based upon "species complexes". These refer to sets of species known to, or likely to, hybridize with one another:

Subgenus *Daphnia*: - made up of 6 species complexes, 4 of which can be found within the Sudbury Region (only locally found species are listed)

1) Pulex complex - *Daphnia pulex, Daphnia pulicaria*
2) Catawba complex - *Daphnia catawba, Daphnia minnehaha*
3) Retrocurva complex - *Daphnia retrocurva, Daphnia parvula*
4) Ambigua complex - *Daphnia ambigua*

Subgenus *Hyalodaphnia*: - made up of 4 species complexes, 3 of which can be found within the Sudbury Region (only locally found species are listed)

1) Laevis complex - *Daphnia dubia*
2) Longiremis complex - *Daphnia longiremis*
3) Longispina complex - *Daphnia mendotae, Daphnia dentifera*

Of these lake inhabitants, *Daphnia pulex* and *Daphnia minnehaha* stand out as the only **strict** pond dwellers. *Daphnia pulex* is known to commonly hybridize with *Daphnia pulicaria* when these two species co-habitate permanent ponds (Hebert, 1995). As in the case of *Daphnia minnehaha* and *Daphnia catawba*, these two species can only be positively differentiated with genetic analysis (Hebert, 1995). However, if a member of the Pulex complex is found within a lake, the assignment to *Daphnia pulicaria* can be confidently made since *Daphnia pulex* only occurs in ponds. The same rule applies to the Catawba complex since *Daphnia minnehaha* is a strict pond dweller.

Although *Daphnia retrocurva* and *Daphnia parvula* are likely to hybridize due to similar genetics (Hebert, 1995), their morphology differs widely enough to permit for species identification. The last local species complex with more than one member, comprised of *Daphnia mendotae* and *Daphnia dentifera*, can only be separated if a specimen with a large helmet is found. Since *Daphnia dentifera* always has a rounded head, the assignment to *Daphnia mendotae* can be readily made. If a low helmeted specimen is found belonging to this complex, only genetic analysis could positively separate these two species (Hebert, 1995).

A. Review of the classification for family Daphniidae (details derived from Brooks (1959)):
[Note: Only the genera found thus far within the Sudbury Region are mentioned here]

1) <u>Genus *Ceriodaphnia* (Figure 26)</u>
- no rostrum
- cervical sinus present
- very short shell spine (seems absent)
- fairly small (0.4 to 1.4 mm)

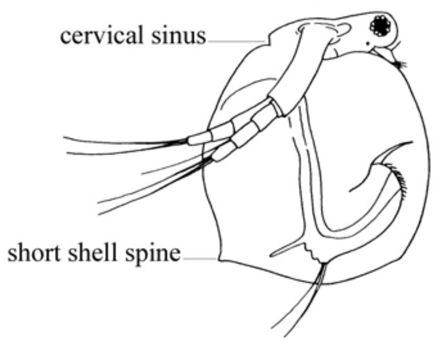


Figure 26. General depiction of a member of the genus *Ceriodaphnia* (modified from Balcer et al., 1984)

2) <u>Genus *Simocephalus* (Figure 27)</u>
- rostrum present
- cervical sinus present
- no shell spine
- large, heavy body with a thick carapace

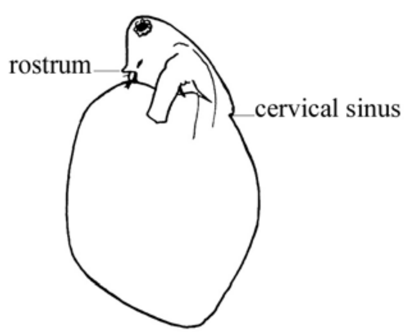


Figure 27. General depiction of a member of the genus *Simocephalus* (modified from Balcer et al., 1984)

3) <u>Genus *Daphnia* (Figure 28)</u>
- rostrum present
- no cervical sinus
- prominent shell spine

Subgenus *Daphnia*
Subgenus *Hyalodaphnia*

Therefore, it is important to realize that when one refers to "Daphnia", these organisms only comprise one of several genera falling under the family Daphniidae.

B. Anatomy:

The main characteristics used to differentiate the species of *Daphnia* are shown in Figure 28.

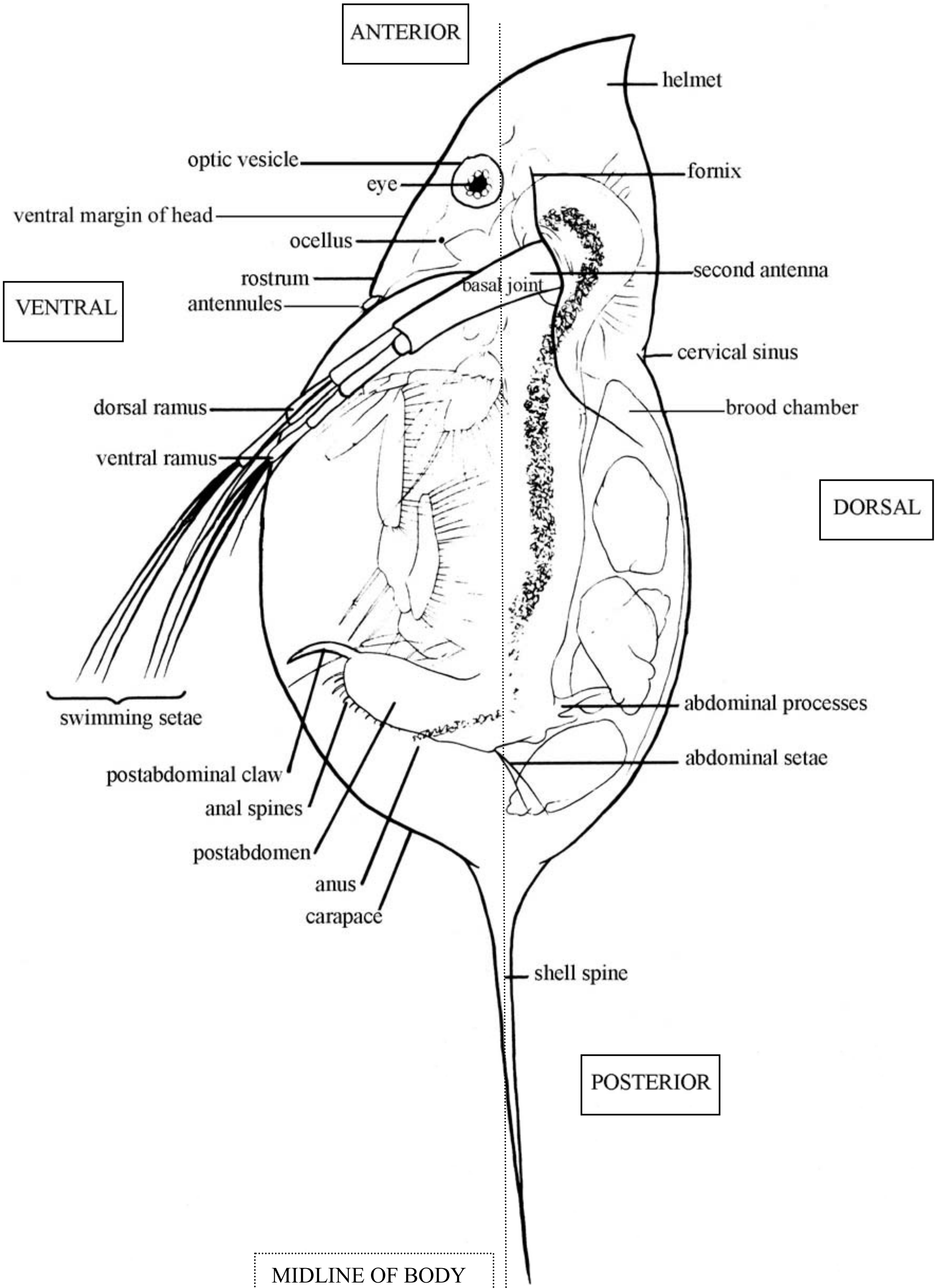


Figure 28. General anatomy of a daphnid (modified from Balcer et al., 1984)

Among all of the features shown above, three are of particular taxonomic importance (details derived from Brooks (1957)). These are:

1) Postabdominal claw with its three pecten (i.e. "teeth") (see Figure 29)
   - pecten can either be uniform in size (i), with the middle pecten large but not more than twice as long as the distal pecten (ii), or with the middle pecten stout, at least 3 times as long as the distal pecten (iii) (diagrams of pecten from Pennak, 1989)

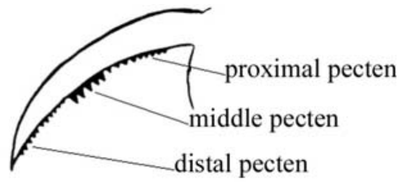
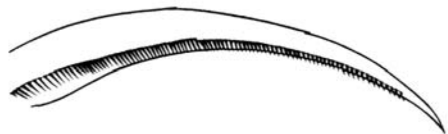


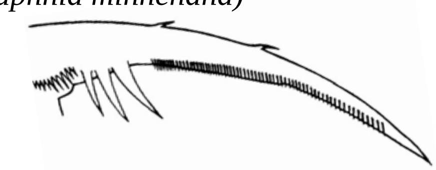
Figure 29. General depiction of the claw and pecten (modified from Balcer et al., 1984)

(i) Uniform pecten (ex. Daphnia ambigua, Daphnia dentifera, Daphnia mendotae, Daphnia dubia, and Daphnia longiremis)



(ii) Large middle pecten (ex. Daphnia parvula and Daphnia retrocurva)

(iii) Stout middle pecten (ex. Daphnia pulex, Daphnia pulicaria, Daphnia catawba, and *Daphnia minnehaha)*



2) Abdominal processes at the posterior end of the postabdomen (opposite end to the claws) (see Figure 30)
   - the second process either ¼ as long as the first one (i.e. short) (i) or ½ as long as the first one (i.e. long) (ii) (see Figure 31)

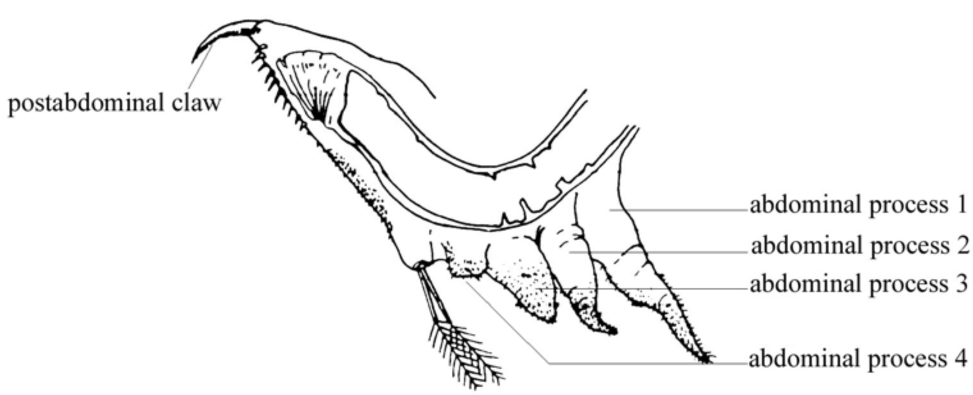
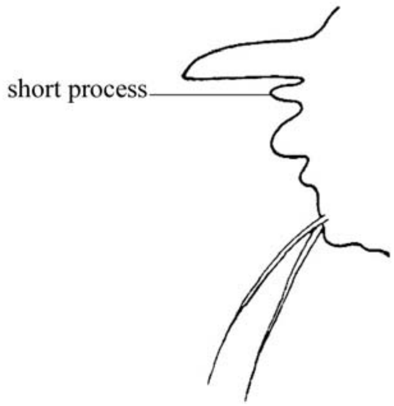


Figure 30. Lateral view of a daphnid postabdomen (modified from Hebert and Finston, 1993)

(i) Short 2nd abdominal process
(ex. Daphnia dubia)



(ii) Long 2nd abdominal process
(ex. Daphnia mendotae)

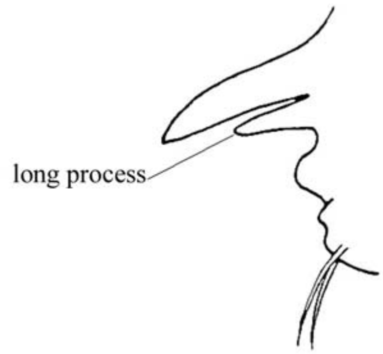
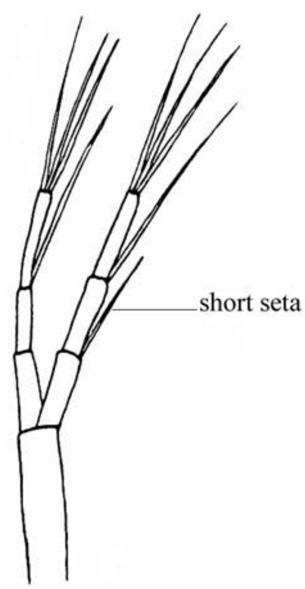


Figure 31. General depiction of a short vs. a long 2nd abdominal process (modified from Pennak, 1989)

3) <u>Swimming seta on each 2nd antenna (see Figure 32)</u>
- either the seta at the base of the second segment of the dorsal ramus of the 2nd antenna is shorter than the ramus (i) or it is longer (ii). This seta is only shorter in one species, namely *Daphnia longiremis*.

(i) Short 2nd swimming seta



(ii) Long 2nd swimming seta

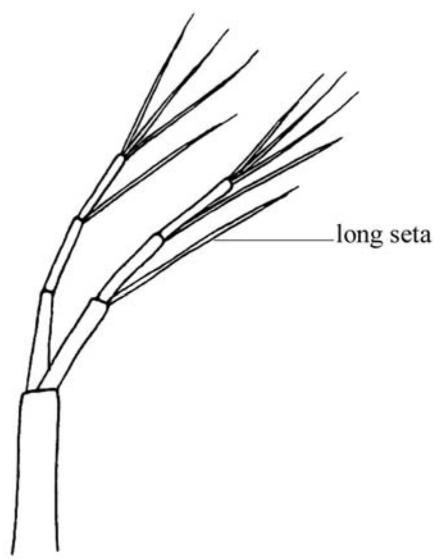


Figure 32. General depiction of a short vs. a long swimming seta on the 2nd antenna (modified from Pennak, 1989)

C. Detailed species taxonomic information (details derived from Hebert (1995) and Brooks (1957), based upon female anatomy):

1) <u>Subgenus *Daphnia*</u>

Daphnia pulex (see Figure 33): strict pond dweller
- females 1.1 to 3.5 mm long (very variable body size, but typically medium to large)
- stout middle pecten with 5-7 teeth
- ocellus present
- smooth helmet
- optic vesicle touches the margin of the head ("bulging eye" look)
- ventral margin of head deeply concave
- shell spine <¼ valve length (short)
- densely pubescent (i.e. "hairy") abdominal processes separate it from all other species, except for *Daphnia pulicaria.* These two are separated by habitat since ***Daphnia pulex* never occurs in lakes**. However, both can occur in permanent ponds where they are known to hybridize. In this case, only genetic analysis can positively separate the two.

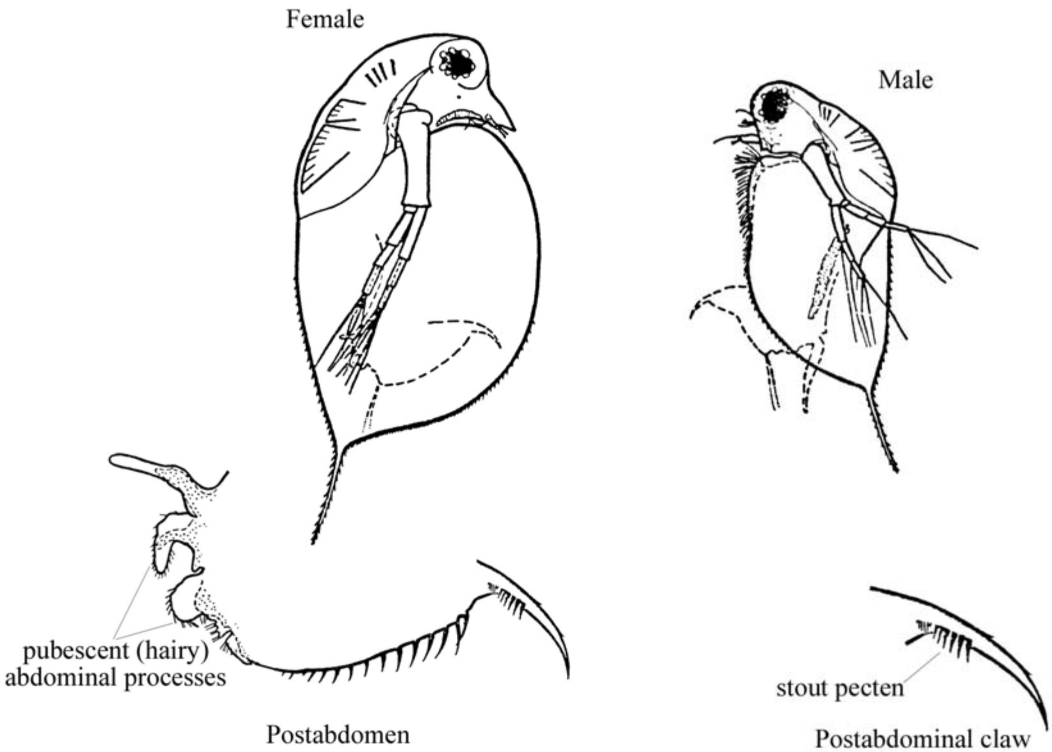


Figure 33. Compilation of critical anatomy for *Daphnia pulex* (derived from Brooks, 1957)

Daphnia pulicaria (refer to the above Figure for *Daphnia pulex*): permanent ponds and lakes
- females 1.4 to 3.2 mm long (very variable body size, but typically medium to large)
- stout middle pecten with 5-7 teeth
- ocellus present
- smooth helmet
- optic vesicle touches the margin of the head
- ventral margin of head nearly straight
- shell spine <¼ valve length (short)
- densely pubescent abdominal processes. This is a major characteristic used to separate smaller specimens of *Daphnia pulicaria* from larger specimens of *Daphnia catawba* (has few hairs).

Daphnia catawba (see Figure 34): lake dweller
- females 1.3 to 2.1 mm long (generally medium sized, smaller than *Daphnia pulicaria* and *Daphnia pulex*)
- stout middle pecten. Typically there are 3-4 teeth present vs. *Daphnia pulicaria* and *Daphnia pulex* that have more than 4 teeth in the middle pecten.
- ocellus present
- evenly rounded, broad helmet with a wide crest
- optic vesicle does not touch the margin of the head
- ventral margin of head straight or slightly concave
- shell spine >⅓ valve length (long) and slender, even at its base. It arises distinctly dorsal to the midline.
- abdominal processes smooth, with very sparse pubescence (i.e. few hairs)
- separated from *Daphnia minnehaha* based upon habitat since ***Daphnia minnehaha*** **never occurs in lakes**

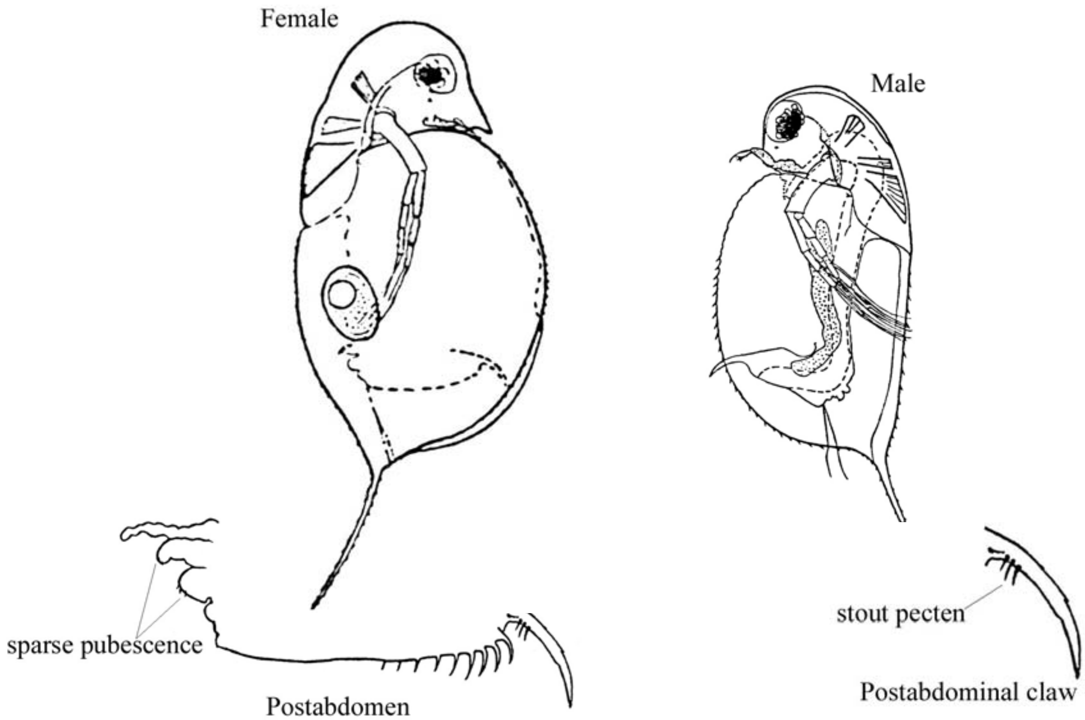


Figure 34. Compilation of critical anatomy for *Daphnia catawba* (derived from Brooks, 1957)

Daphnia minnehaha (refer to the above Figure for *Daphnia catawba*): strict pond dweller
- females 1.3 to 3.2 mm long (generally medium sized but can be quite a bit larger than Daphnia *catawba*, of similar size to *Daphnia pulicaria* and *Daphnia pulex*)
- stout middle pecten. Typically there are 3-4 teeth present vs. *Daphnia pulicaria* and *Daphnia pulex* that have more than 4 teeth in the middle pecten.
- ocellus present
- evenly rounded, broad helmet with a wide crest
- optic vesicle does not touch the margin of the head
- ventral margin of head straight or slightly concave
- shell spine >⅓ valve length (long) and slender, even at its base. It arises distinctly dorsal to the midline.
- abdominal processes smooth, with very sparse pubescence (i.e. few hairs)
- adult females are unique in often possessing prominent neck teeth

Daphnia retrocurva (see Figure 35): lake dweller
- females 1.0 to 1.8 mm long (small sized)
- large middle pecten (but not stout)
- no ocellus
- usually with a large, retrocurved helmet
- optic vesicle does not touch the margin of the head
- ventral margin of head straight
- shell spine >⅓ valve length (long), straight, and arises near the midline
- 2nd abdominal process long
- no hybrids found, but it is likely to hybridize with *Daphnia parvula*
- see notes under *Daphnia dubia* and *Daphnia mendotae* for tips on differentiating these species

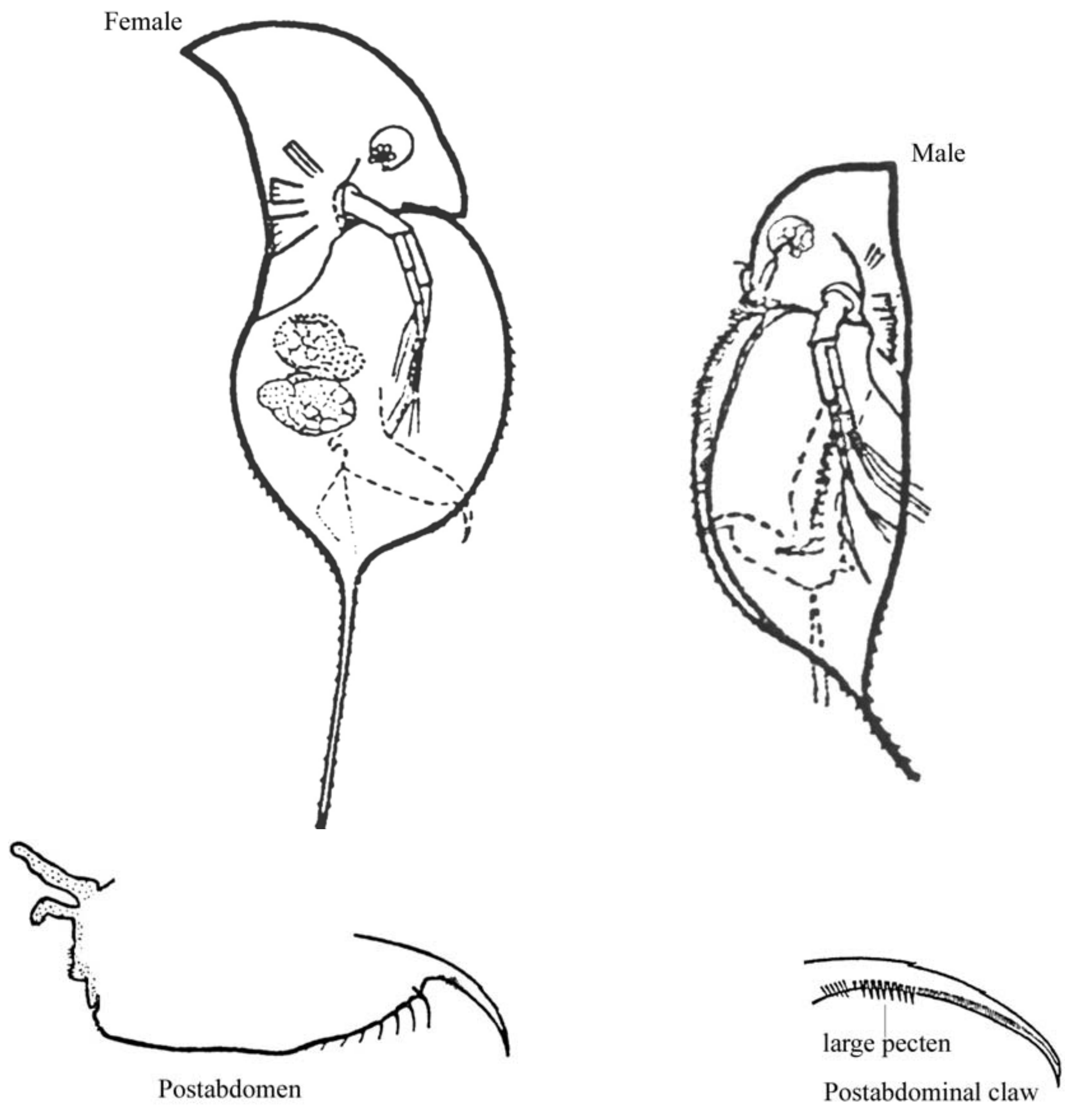


Figure 35. Compilation of critical anatomy for *Daphnia retrocurva* (derived from Brooks, 1957)

Daphnia parvula (see Figure 36): found in lakes and permanent ponds
- females 1.1 to 1.4 mm long (small sized)
- large middle pecten (but not stout)
- no ocellus
- helmet shape broadly rounded
- optic vesicle very near to or touching the margin of the head
- ventral margin of head concave
- shell spine <¼ valve length (short) and typically is directed slightly ventrally
- 2nd abdominal process long
- no hybrids found, but it is likely to hybridize with *Daphnia retrocurva*
- characterized by a reduced rostrum that makes it appear "pug-nosed"
- the large pecten, plus the lack of an ocellus, separates *Daphnia parvula* from all other species, except *Daphnia retrocurva*. Generally, this last species has a prominent, retrocurved helmet whereas *Daphnia parvula* has a smoothly rounded head shape and the tail length varies (short for *D. parvula*, long for *D. retrocurva*).
- could be confused with *D. ambigua* (has ocellus and uniform pecten) or *D. catawba* (has ocellus and stout pecten)

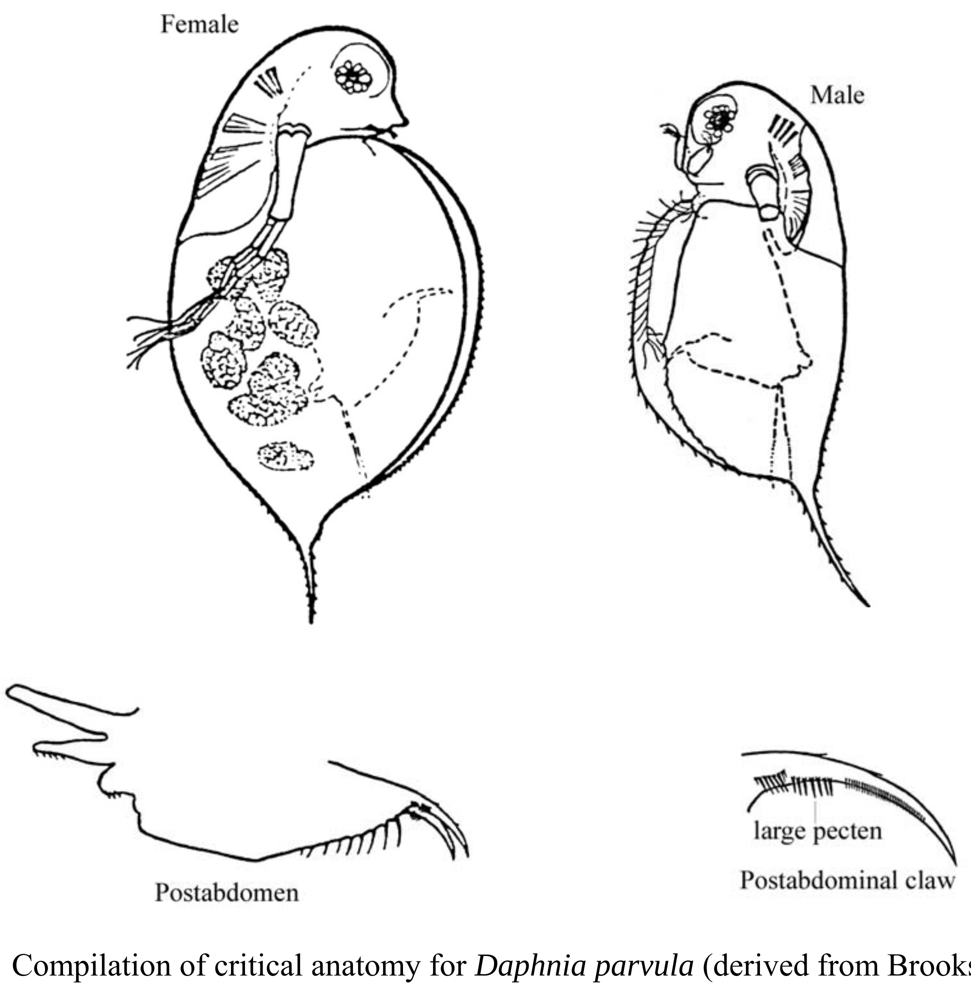


Figure 36. Compilation of critical anatomy for *Daphnia parvula* (derived from Brooks, 1957)

Daphnia ambigua (see Figure 37): found in lakes and permanent ponds
- females maximum of 1.3 mm (one of the smallest *Daphnia* species in North America)
- uniform pecten
- ocellus present
- adults often have a distinctive, unique "spine-like" helmet
- optic vesicle touches the margin of the head
- ventral margin of the head concave
- shell spine <⅓ valve length (short)
- 2nd abdominal process long, joined at its base to the 1st process
- no known hybridization
- characterized by a small head atop a relatively large, rounded body
- resembles *Daphnia parvula,* except that this last species has a large middle pecten and no ocellus

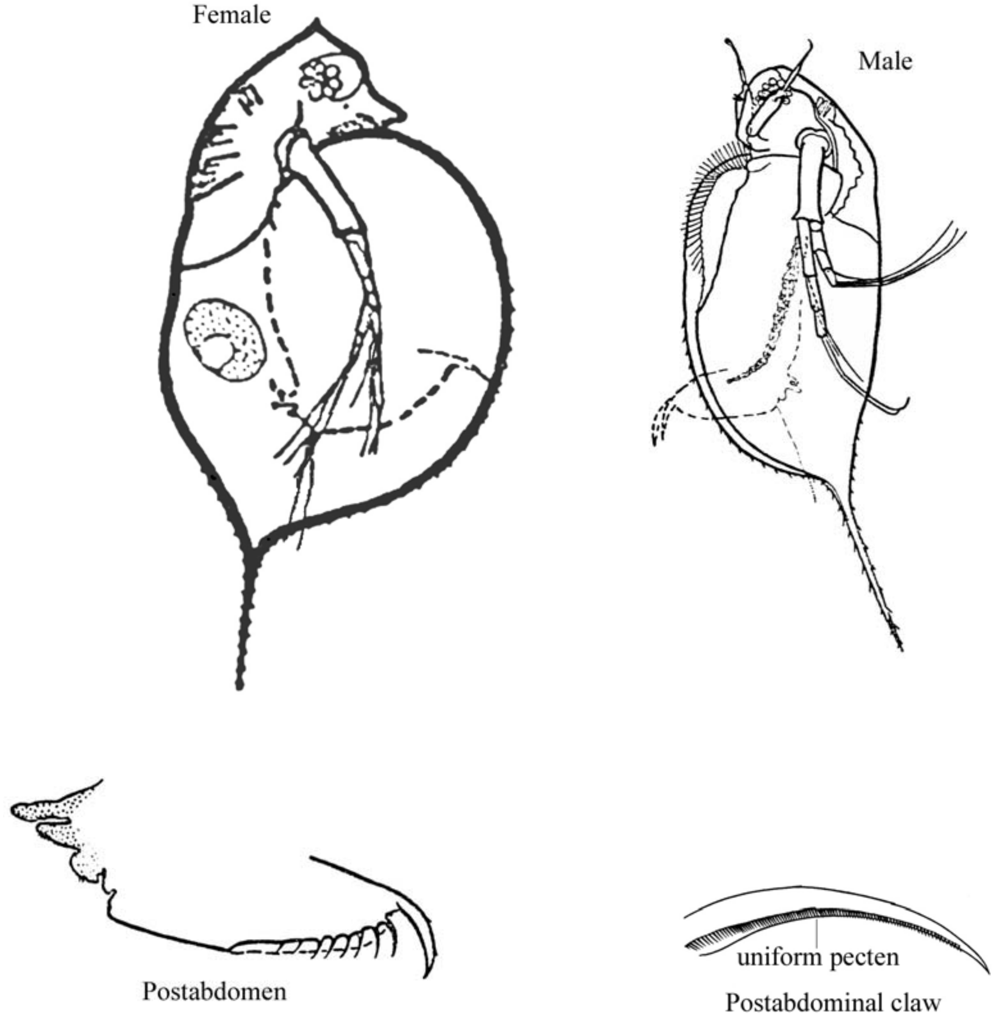


Figure 37. Compilation of critical anatomy for *Daphnia ambigua* (derived from Brooks, 1957)

2) Subgenus *Hyalodaphnia*

Daphnia dubia (see Figure 38): lake dweller
- females 1.1 to 1.9 mm long (medium sized)
- uniform pecten
- ocellus present
- usually with a large, sharply pointed helmet whose apex lies dorsal to the midline of the body, either with a fairly straight margin or retrocurved to varying degrees
- optic vesicle does not touch the margin of the head
- ventral margin of head fairly straight to slightly convex
- shell spine >⅓ valve length (very long). Longest tail of all local *Daphnia* species, usually directed posterior-dorsally.
- 2nd abdominal process about ¼ as long as the 1st one (i.e. short). It is the only species with a reduced 2nd abdominal process and an ocellus.
- no known hybridization
- rostrum very large, acutely pointed
- *Daphnia dubia* and *Daphnia retrocurva* are the only local species that could develop a retrocurved helmet. They are differentiated based upon the following traits: *D. dubia* is generally larger with an elongated body, it has a smaller eye placed higher up in the head, an ocellus is present (absent in *Daphnia retrocurva*), it has the longest tail of all local daphniids and it is directly posteriorly, its pecten are all uniform in size (middle pecten in *Daphnia retrocurva* are large), and the rostrum is usually very long and straight.
- the only other local species that it could be mistaken for are *Daphnia mendotae* or *Daphnia dentifera*. They are differentiated by the length of their 2nd abdominal process (short in *D. dubia*, long in *D. mendotae* and *D. dentifera*).

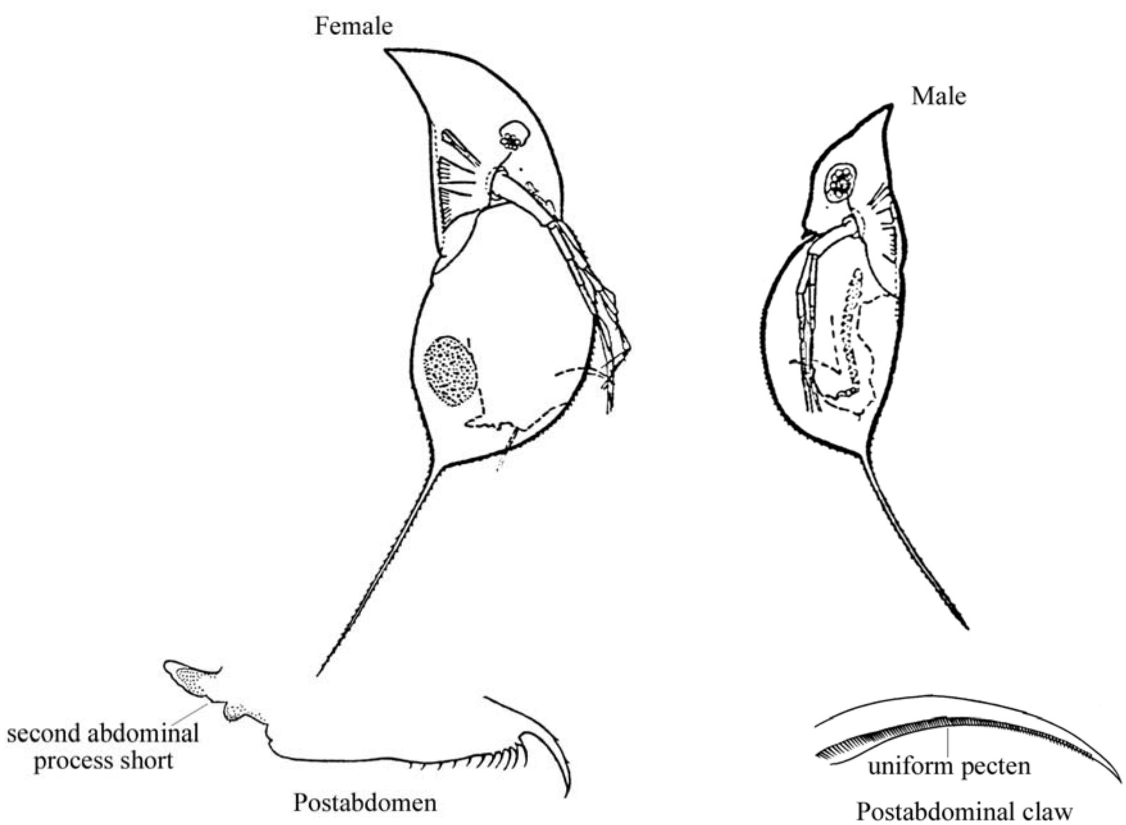


Figure 38. Compilation of critical anatomy for *Daphnia dubia* (derived from Brooks, 1957)

Daphnia longiremis (see Figure 39): lake dweller
- females 0.6 to 2.4 mm long (variable body size)
- uniform pecten
- no ocellus
- large variation in helmet shape, but usually rounded or "triangular"
- optic vesicle does not touch the margin of the head
- ventral margin of head straight
- shell spine >⅓ valve length (long), slightly curved dorsally
- 2nd abdominal process short. This is the only species with a reduced 2nd abdominal process and no ocellus.
- no known hybridization
- only species where the swimming seta at the base of the second segment of the dorsal ramus of each second antenna is shorter than the ramus
- this is also the only species whose antennae are longer relative to the length of the valves than any other local species. The rami often extend nearer to the posterior margin of the body than to the middle. The swimming setae extend beyond the posterior margin of the valves.

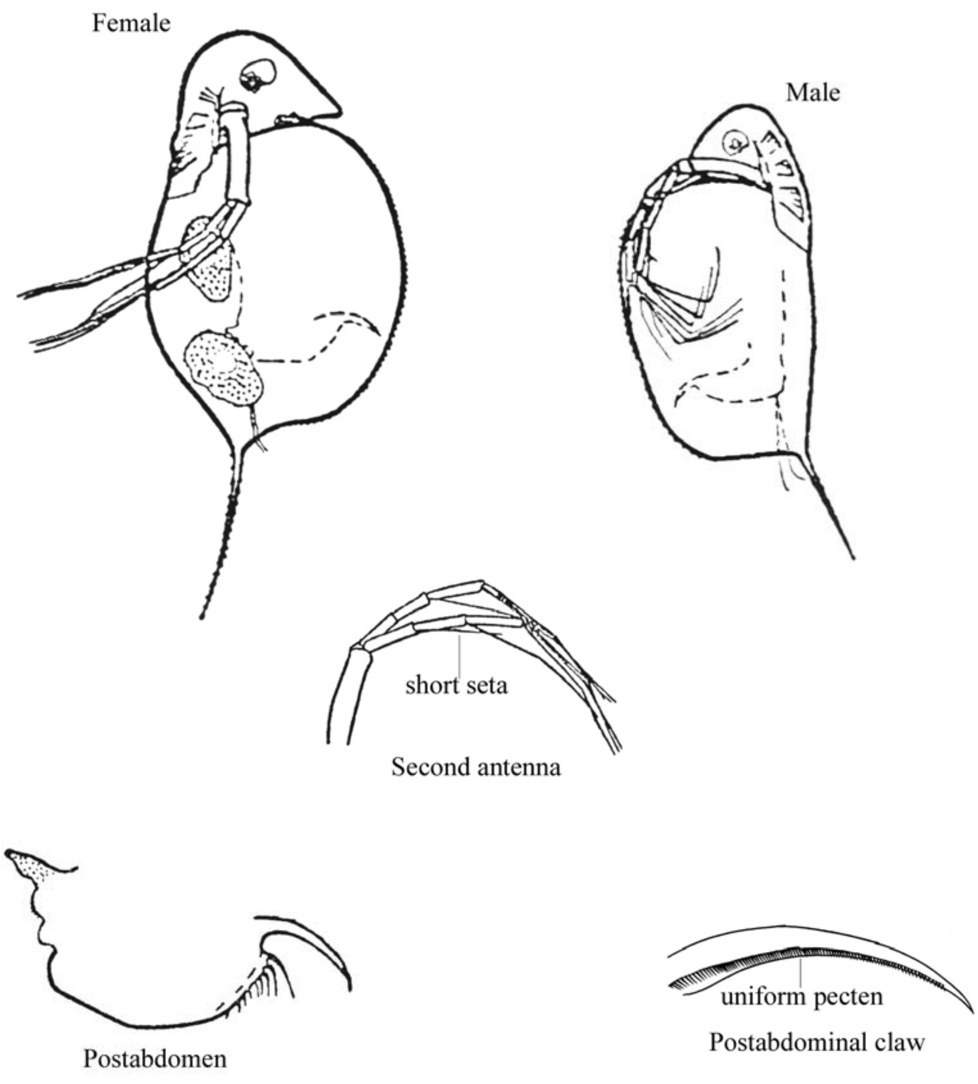


Figure 39. Compilation of critical anatomy for *Daphnia longiremis* (derived from Brooks, 1957)

Daphnia mendotae (see Figure 40): lake dweller
- females 1.2 to 2.8 mm long (large sized)
- uniform pecten
- ocellus present
- usually with a large helmet whose apex is near the midline of the body. However, helmet size varies considerably from very low to quite high.
- optic vesicle does not touch the margin of the head
- ventral margin of head fairly straight to slightly concave
- shell spine >⅓ valve length (long) and usually fairly straight
- 2nd abdominal process about ½ as long as the 1st one (i.e. long)
- known to hybridize with *Daphnia dentifera.* If a specimen with a large helmet is found, it would be *Daphnia mendotae* since *Daphnia dentifera* always has a rounded head. However, if a smoothly crested specimen is found, there is no way to differentiate the two since *Daphnia mendotae* can have a very low to a very angular helmet. Genetic analysis would be required for positive identification.
- the only local daphnid species which are known to have pronounced helmet development are: *Daphnia mendotae*, *Daphnia dubia,* and *Daphnia retrocurva*. Generally, *Daphnia mendotae* has a more robust body and is of larger size than the other two.

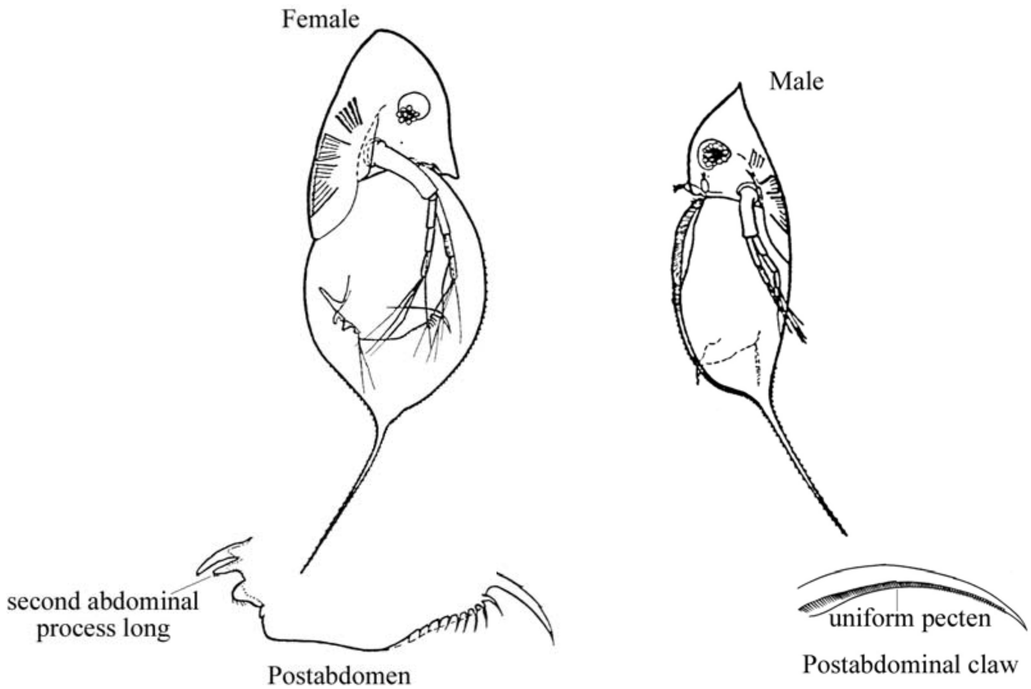


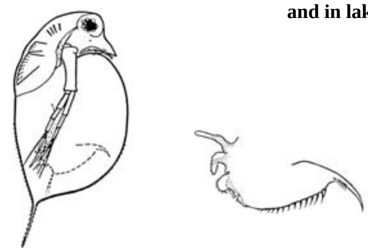
Figure 40. Compilation of critical anatomy for *Daphnia mendotae* (derived from Brooks, 1957)

Daphnia dentifera (see above Figure for *Daphnia mendotae*): found in lakes and permanent ponds
- females 0.9 to 2.2 mm long (very variable body size)
- uniform pecten
- ocellus present
- smoothly rounded helmet
- optic vesicle does not touch the margin of the head
- ventral margin of head fairly straight
- shell spine >⅓ valve length (long)
- 2nd abdominal process about ½ as long as the 1st one (i.e. long)
- known to hybridize with *Daphnia mendotae*

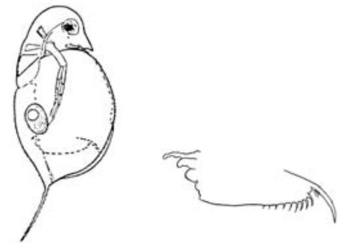
Summary of *Daphnia* species found in the Sudbury Region (figures compiled from Brooks (1957), details from Hebert (1995))

A. Subgenus *Daphnia*

Found only in ponds | **Found in permanent ponds and in lakes**



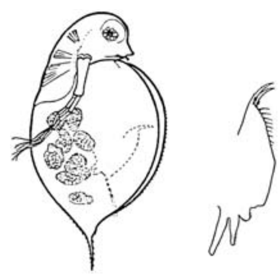
Found in lakes | **Found only in ponds**



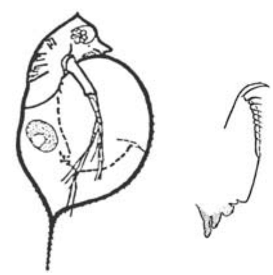
Species	*Daphnia pulex*	*Daphnia pulicaria*	*Daphnia catawba*	*Daphnia minnehaha*
Female size range	- 1.1 to 3.5 mm (medium to large)	- 1.4 to 3.2 mm (medium to large)	- 1.3 to 2.1 mm (medium)	- 1.1 to 3.2 mm (medium to large)
Size of pecten	- stout (5-7 teeth)	- stout (5-7 teeth)	- stout (3-4 teeth)	- stout (3-4 teeth)
Length of tail	- short	- short	- long (dorsal to midline, very slender)	- long (dorsal to midline, very slender
Shape of helmet	- smoothly rounded	- smoothly rounded	- smoothly rounded, broad	- smoothly rounded; may have neck teeth
Abdominal processes	- very pubescent	- very pubescent	- sparse pubescence	- sparse pubescence
Ocellus	- present	- present	- present	- present
Distinguishing features	- "bulging eye", ventral margin of head very concave - high level of pubescence is very unique to these two species		- low level of pubescence is very unique to these two species	

Found in lakes

Found in permanent ponds and in lakes



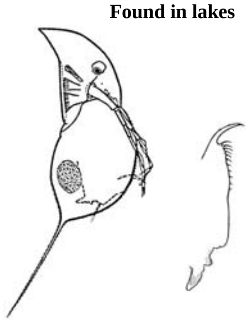
Found in permanent ponds and in lakes



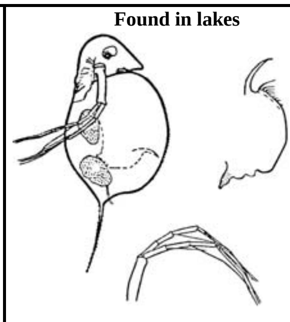
Species	*Daphnia retrocurva*	*Daphnia parvula*	*Daphnia ambigua*
Female size range	- 1.0 to 1.8 mm (small)	- 1.1 to 1.4 mm (very small)	- max of 1.3 mm (very small)
Size of pecten	- large	- large	- uniform
Length of tail	- long	- short	- short
Shape of helmet	- large, retrocurved helmet, with apex dorsal	- smoothly rounded	- often with small spine
Abdominal processes	- second one long	- second one long	- second one long
Ocellus	- no ocellus	- no ocellus	- present
Distinguishing features	- shape of helmet; no ocellus	- small rostrum ("pug nosed"); no ocellus	- small head on top of a big, round body

B. Subgenus *Hyalodaphnia*

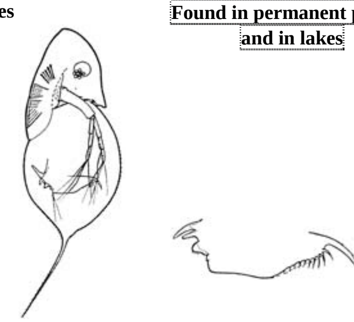
Found in lakes



Found in lakes



Found in lakes | **Found in permanent ponds and in lakes**

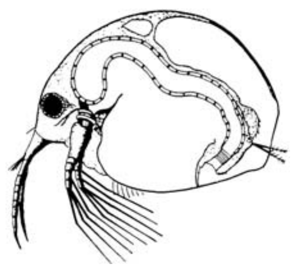
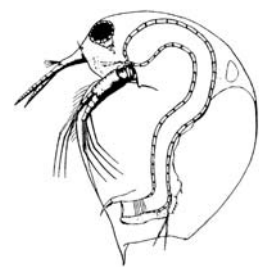
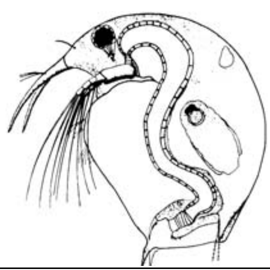
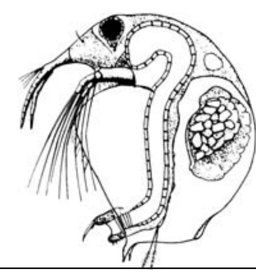


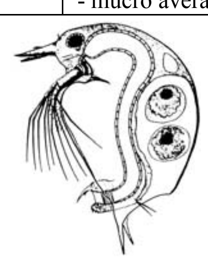
Species	*Daphnia dubia*	*Daphnia longiremis*	*Daphnia mendotae*	*Daphnia dentifera* (see *D. m.*)
Female size range	- 1.1 to 1.9 mm (medium)	- 0.6 to 2.4 mm (medium)	- 1.2 to 2.8 mm (large)	- 0.9 to 2.2 mm (medium)
Size of pecten	- uniform	- uniform	- uniform	- uniform
Length of tail	- long (often directed posteriorly)	- long	- long	- long
Shape of helmet	- large with apex dorsal	- smoothly rounded	- low or large with apex central	- smoothly rounded
Abdominal processes	- second one short	- second one short	- second one long	- second one long
Ocellus	- present	- no ocellus	- present	- present
Distinguishing features	- longest rostrum and tail	- 2nd swimming setae short	- large size; helmet shape	- smooth helmet

Section 10. Bosminidae taxonomy

Details for this group will not be as extensive as for *Daphnia*. A brief visual summary is provided here in order to clarify some of the confusion over the specific taxonomy. As was previously noted, the subgenus *Sinobosmina* was collectively referred to as *Bosmina longirostris* in the past (De Melo and Hebert, 1994) and has recently been changed to subgenus *Bosmina* (Taylor et al., 2002). Several researchers continue to identify specimens found within the Sudbury Region as *Bosmina longirostris*, despite genetic findings that this species does not occur anywhere in Canada (De Melo and Hebert, 1994).

Summary of Bosminidae species found in the Sudbury Region (figures and details compiled from De Melo and Hebert (1994))

	
Eubosmina (Eubosmina) coregoni	*Eubosmina (Eubosmina) longispina*
- 0.432 to 0.757 mm long	- 0.550 to 0.840 mm long
- antennules >50% body length, with a fairly straight edge	- antennules <50% body length, with a slight curve
- short rostrum	- short rostrum
- dip between head and antennules	- dip between head and antennules
- no mucro	- mucro averages 65 μm in length
	
Bosmina (Bosmina) freyi	*Bosmina (Bosmina) liederi*
- 0.390 to 0.590 mm long	- 0.324 to 0.480 mm long
- antennules <50% body length, with a slight curve	- antennules <50% body length, usually with tips recurved
- long rostrum	- long rostrum
- smooth transition between rostrum and antennules	- smooth transition between rostrum and antennules
- mucro averages 32 μm in length	- mucro averages 22 μm in length


Eubosmina (Neobosmina) tubicen
- 0.497 to 0.638 mm long
- antennules <25% body length (very short), usually with tips curved out
- rostrum short and blunt
- dip between head and antennules
- mucro averages 112 μm in length (very long)

Literature cited

Balcer, M.D., N.L. Korda and S.I. Dodson. 1984. Zooplankton of the Great Lakes: A guide to the identification and ecology of the common crustacean species. The University of Wisconsin Press. Madison, Wisconsin.

Brandlova, J., Z. Brandl and C.H. Fernando. 1972. The Cladocera of Ontario with remarks on some species and distribution. Can. J. Zool. 50: 1373-1403.

Brooks, J.L. 1957. The systematics of North American *Daphnia*. Mem. Conn. Acad. Arts & Sciences 13: 1-180.

Brooks, J.L. 1959. Cladocera. Pp. 587-656 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.

Colbourne, J.K and P.D.N. Hebert. 1996. The systematics of North American *Daphnia* (Crustacea: Anomopoda): A molecular phylogenetic approach. Trans. Roy. Soc. Ser. B 351: 349-360.

De Melo, R. and P.D.N. Hebert. 1994. A taxonomic reevaluation of North American Bosminidae. Can. J. Zool. 72: 1808-1825.

Dodson, S.I. and D.G. Frey. 1991. Cladocera and other Branchiopoda. Pp. 723-786 in J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press. San Diego.

Dussart, B.H. and C.H. Fernando. 1990. Crustaces copepodes de l'Ontario. University of Waterloo, Department of Biology.

Dussart, B.H. and D. Defaye. 1995. Copepoda: Introduction to the Copepoda. Coordinating editor: H.J.F. Dumond. The Hague: SPB Academic Publishing. III. The Netherlands. 277pp.

Fryer, G. 1971. Allocation of *Alonella acutirostris* (Birge) (Cladocera, Chydoridae) to the genus *Disparalona.* Crustaceana 21: 221-222.

Hebert, P.D.N. and T.L. Finston. 1993. A taxonomic reevaluation of North America *Daphnia* (Crustacea: Cladocera). I. The *Daphnia similis* complex. Can. J. Zool. 71: 908-925.

Hebert, P.D.N. 1995. The *Daphnia* of North America – An Illustrated Fauna. CD-ROM and website (http://www.cladocera.uoguelph.ca/taxonomy/daphnia/default.htm). University of Guelph, Guelph.

Hebert, P.D.N. and T.L. Finston. 1997. Taxon diversity in the genus *Holopedium* (Crustacea: Cladocera) from lakes of eastern North America. Can. J. Fish. Aquat. Sci. 54: 1928-1936.

Hudson, P.L., J.W. Reid, L.T. Lesko and J.H. Selgeby. 1998. Cyclopoid and harpacticoid copepods of the Laurentian Great Lakes. Ohio Biological Survey Bulletin NS 12(2). Columbus, Ohio.

Kořínek, V. 1981. *Diaphanosoma birgei* n. sp. (Crustacea, Cladocera). A new species from America and its widely distributed subspecies *Diaphanosoma birgei* ssp. *lacustris* n. ssp. Can. J. Zool. 59: 1115-1121.

Pennak, R.W. 1989. Freshwater invertebrates of the United States. Third edition. John Wiley and Sons, Inc., New York.

Ravera, O. 1953. Gli stadi di sviluppo dei copepodi pelagici del Lago Maggiore. Mem Ist. Ital. Idrobiol. 7: 129-151.

Rowe, C.L. 2000. Global distribution, phylogeny and taxonomy of the freshwater zooplankton genus *Holopedium*. Masters thesis. University of Guelph, Guelph, Ontario.

Sandercock, G.A. and G.G.E. Scudder. 1996. Key to the species of freshwater calanoid copepods of British Columbia. Resources Inventory Committee. Province of British Columbia.

Schwartz, S.S., D.J. Innes and P.D.N. Hebert. 1985. Morphological separation of *Daphnia pulex* and *Daphnia obtusa* in North America. Limnol. Oceanogr. 30 (1): 189-197.

Smith, D.G. 2001. Pennak's Freshwater invertebrates of the United States. Fourth edition. John Wiley and Sons, Inc., New York.

Smith, K. and C.H. Fernando. 1978. A guide to the freshwater calanoid and cyclopoid copepod Crustacea of Ontario. University of Waterloo, Department of Biology. Ser. No. 18.

Taylor, D.J. and P.D.N. Hebert. 1993. Cryptic intercontinental hybridization in *Daphnia* (Crustacea): the ghost of introductions past. Proc. R. Soc. London. Ser. B 254: 163-168.

Taylor, D.J., P.D.N. Hebert and J.K. Colbourne. 1996. Phylogenetics and evolution in the *Daphnia longispina* group (Crustacea) based on 12S rDNA sequence and allozyme variation. Molecular Phylogenetics and Evolution. 5 (3): 495-510.

Taylor, D. J., C.R. Ishikane and R.A. Haney. 2002. The systematics of Holarctic bosminids and a revision that reconciles molecular and morphological evolution. Limnol. Oceanogr. 47 (5): 1486-1495.

Torke, B.G. 1974. An illustrated guide to the identification of the planktonic Crustacea of Lake Michigan with notes on their ecology. The University of Wisconsin Press. Milwaukee, Wisconsin. Special Report No. 17.

Torke, B.G. 1976. A key to the identification of the cyclopoid copepods of Wisconsin with notes on their distribution and ecology. Wisconsin Department of Natural Resources Research Report No. 88. Madison, Wisconsin.

Williamson, C.E. 1991. Copepoda. Pp. 787-822 in J.H. Thorp and A.P. Covich (eds.). Ecology and classification of North American freshwater invertebrates. Academic Press. San Diego.

Wilson, M.S. 1959. Calanoida. Pp. 738-795 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.

Yeatman, H.C. 1959. Cyclopoida. Pp. 796-814 in W.T. Edmondson (ed.). Freshwater Biology. Second Edition. John Wiley and Sons, Inc., New York.