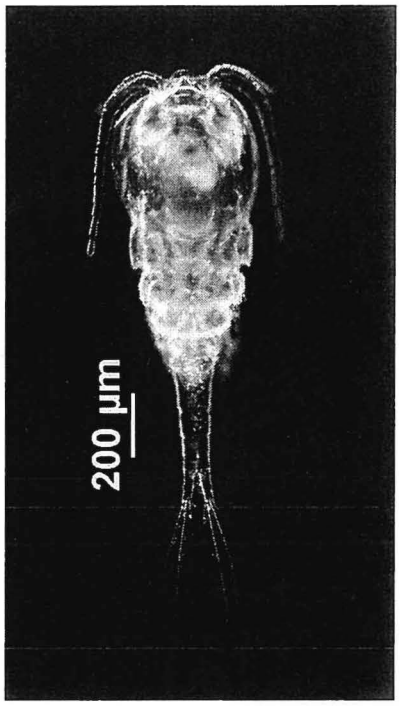
CYCLOPOID COPEPODS FROM THE YANCHEP NATIONAL PARK CAVES, WESTERN AUSTRALIA



Report prepared for
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1. EXECUTIVE SUMMARY

The following six cyclopoid species, all belonging to the family Cyclopidae, were identified in this study from samples obtained from 13 Yanchep Caves: *Australoeucyclops* n. sp. Karanovic, in prep, *Macrocyclops albidus* (Jurine, 1820), *Mesocyclops brooksi* Pesce, De Laurentiis and Humphreys, 1996, *Mixocyclops* cf. *crozentensis* Kiefer, 1944, *Paracyclops chiltoni* (Thomson, 1882) and *Tropocyclops* sp.

These cyclopoid taxa were not distributed evenly within the Yanchep Cave system, as *Australoeucyclops* n. sp. was found in 11 of the 13 caves, *P. chiltoni* in four caves, *M. brooksi* and *M. cf. crozentensis* in two caves each and *M. albidus* and *Tropocyclops* sp. in one cave each.

Spillway Cave contained the highest cyclopoid diversity (4 species), followed closely by Cave on Lot 51 (3 species). The remaining caves contained either 1 or 2 cyclopoid species. Additionally, the abundance of copepod species in nearly all samples were relatively low (ranging from 1 to 24 individuals).

Annotated digital images of the diagnostic features, as well as a taxonomic key, are provided to facilitate identification of the cyclopoid species inhabiting the Yanchep Caves.

Australoeucyclops n. sp., *M. albidus*, *M. brooksi*, *M.* cf. *crozentensis* and *P. chiltoni* are considered to be stygophiles of low conservation value based on their distribution and habitat records. Comments on the conservation value of the *Tropocyclops* species cannot be made with confidence until the species identity is determined.

2. INTRODUCTION

The caves in the Yanchep National Park is one of only five cave systems in Western Australia known to contain aquatic root mats. This aquatic vegetation (*Eucalyptus gomphocephala*) is ecologically significant as it provides an important source of energy for a diverse invertebrate subterranean fauna (Jasinska *et al.*, 1996; Jasinska and Knott, 2000). Unfortunately, this unique cave community is being threatened by declining water levels due principally to water abstraction from the Gnangara Mound for urban, rural and industry needs of the Perth region (Jasinska and Knott, 2000; Knott *et al.*, 2006).

Although the aquatic invertebrate fauna of the Yanchep National Park Caves have been monitored since 1996, the specific identity of many of these invertebrates remains unknown (Knott *et al.*, 2006). This is rather unfortunate as many of these invertebrates may represent species of high conservation value. Clearly, knowledge of species identities is valuable not only from a zoological standpoint, but more importantly with regards to the threatened Yanchep caves, for management purposes as well. The current work, which identifies formally the number of species from the copepod crustacean group, is the first step in resolving this issue. Only the cyclopoid copepods are presented herein; the harpacticoid copepods will be dealt with in another report.

3. OBJECTIVES

The objectives of this taxonomic effort were to:

1) Document the cyclopoid copepods sampled from the Yanchep National Park Caves;

2) Provide a summary of the distinguishing features, including annotated digital images, of the cyclopoid species for laboratory identification purposes;

3) Develop a taxonomic key for laboratory identification purposes;

4) Clarify the conservation status of each cyclopoid species.

4. CAVES

Thirty samples obtained from a total of 13 caves (Table 1) contained cyclopoid copepods. The number of samples was not consistent between caves, with most caves (9/13 or 69%) having 1 or 2 samples, whilst a few (3/13 or 31%) contained between 3–6 samples.

Table 1. Yanchep National Park Caves containing cyclopoid samples.

Cave	Code	Number of samples
Boomerang	YN99	2
Cabaret	YN30	6
Carpark	YN18	2
Boomerang Gorge	YN7	1
Lot 51	YN555	5
Fridge Grotto	YN81	1
Gilgie	YN27	2
Jackhammer	YN438	1
Mire Bowl	YN61	4
Orpheus	YN256	1
Spillway	YN565	1
Twilight	YN194	3
Water	YN11	1

5. RESULTS

5.1 Cyclopoid species identified

A total of six cyclopoid species, all belonging to the family Cyclopidae and classified into six genera, were identified in this study:

Subfamily Eucyclopinae
Macrocyclops albidus (Jurine, 1820)
Paracyclops chiltoni (Thomson, 1882)
Australoeucyclops n. sp. Karanovic, in prep
Tropocyclops sp.

Subfamily Cyclopinae
Mesocyclops brooksi Pesce, De Laurentiis and Humphreys, 1996
Mixocyclops cf. *crozentensis* Kiefer, 1944

Specimens of *M. albidus*, *P. chiltoni* and *M. brooksi* examined in this study agree morphologically with published descriptions (Ueda *et al.*, 1996; Karaytug, 1999; Holyńska *et al.*, 2003). In contrast, specimens of *Australoeucyclops* n. sp. from Yanchep Caves display slight variations (i.e. setation pattern of the antennule and ornamentation pattern of the cephalothoracic appendages and swimming legs) from the drawings of this species provided by Dr Tom Karanovic (WA Museum). These differences most likely reflect geographic rather than interspecific variation (Dr Tom Karanovic, pers. comm.). Additionally, the specimens of *Mixocyclops* cf. *crozetensis* vary slightly from the original description, which may be attributed to the fact that the

original description was based on damaged specimens. These issues will be addressed in more detail in the formal publication.

The *Tropocyclops* specimens could not be identified to species level at present, as pertinent taxonomic literature has not yet arrived from UWA interlibrary loan.

5.2 Distribution and abundance within the Yanchep Cave system

The cyclopoid taxa were not distributed evenly within the Yanchep Cave system: *Australoeucyclops* n. sp. was found in nearly all caves, *P. chiltoni* in four caves, *M. brooksi* and *M. cf. crozentensis* in two caves each and *M. albidus* and *Tropocyclops* sp. in one cave each (Table 2).

Spillway Cave contained the highest cyclopoid diversity (4 species), followed by Lot 51 (3 species). The remaining caves contained either 1 or 2 cyclopoid species (Table 2). Furthermore with the exception of the sample from Jackhammer Cave, the abundance of copepod species in most samples were relatively low (ranging from 1 to 24 individuals) (Table 2).

Table 2. Distribution and abundance of cyclopoid species within the Yanchep Cave system.

Copepod species	Cave Site(s)	Collection Date	Counts
Macrocyclops albidus	Spillway Cave	11/08/2005	24
Paracyclops chiltoni	Boomerang Cave	14/11/1996	1
	Cabaret Cave	6/01/1990	1
		19/6/1990	3
	Spillway Cave	11/08/2005	2
	Twilight Cave	27/11/1996	5
Australoeucyclops n. sp.	Cabaret Cave	6/01/1990	15
		27/1/1991	16
		2/05/1992	10
		29/7/1993	1
		?	15
	Carpark Cave	?	4
	Cave on Lot 51	18/09/2003	1
		22/09/2003	9
		10/06/2004	5
	Gilgie Cave	17/3/1993	8
		28/8/1994	11
	Fridge Grotto	17/7/1992	3
	Jackhammer Cave	10/04/2003	409
	Mire Bowl	17/7/1992	2
		18/09/2002	1
		22/09/2003	2
		11/08/2005	4
	Orpheus Cave	17/7/1992	1
	Spillway Cave	11/08/2005	2
	Twilight Cave	6/02/1996	1
		27/11/1996	4
		27/11/1996	1
	Water Cave	1/09/2003	13
Tropocyclops sp.	Cave on Lot 51	22/09/2003	2
Mesocyclops brooksi	Spillway Cave	11/08/2005	1
	Cave on Lot 51	22/09/2003	1
		10/06/2004	4
Mixocyclops cf. *crozetensis*	Boomerang Gorge	17/7/1992	3
	Gilgie Cave	17/3/1993	1

5.3 Diagnostic features

The cyclopoid species inhabiting the Yanchep Caves can be identified, using a compound microscope, fairly rapidly by body size and structural features of the appendages, in particular those involving the antennule and swimming legs. Definitions for morphological terms used in the following text (indicated in italics) are given in Appendix 1 to facilitate the identification process. Please note the following features are based on the adult female stage only, as the adult male has not been described for all species identified, was absent for some species in the collection and is usually collected far less frequently than the adult female.

5.3.1 *Australoeucyclops* n. sp.

1. Total body length, from the tip of the *cephalothorax* to the posterior margin of the *caudal rami*, approximately 0.75 mm (Fig. A2.1a).

2. *Antennule* 12-segmented, extending to posterior margin of *cephalothorax* (Fig. A2.1b).

3. First *exopod* segment of leg 4 lacking an inner *seta* (Fig. A2.1c).

4. Leg 5 one-segmented, bearing two outer *setae* and an inner *spine* (Fig. A2.1d).

5.3.2 *Macrocyclops albidus*

1. Total body length about 1.40 mm (Fig. A2.2a).

2. *Antennule* 17-segmented, extending to second leg-bearing *somite* (Fig. A2.2b).

3. Third *endopod* segment of leg 4 bearing a reduced (short) distal-medial *seta* (Fig. A2.2c).

4. Leg 5 two-segmented, with the second segment bearing three apical *setae/spines* (Fig. A2.2d).

5.3.3 *Mesocyclops brooksi*

1. Total body length roughly 1.20 mm (Fig. A2.3a).

2. *Antennule* 17-segmented, extending to second leg-bearing *somite* (Fig. A2.3b).

3. The body and *cephalic* appendages, particularly the *antennule* (Fig. A2.3c), *antenna* and *maxilla*, covered with pits on the surface of the cuticle.

4. Leg 5 two-segmented, with the second segment bearing an apical *seta* and inner *spine* (Fig. A2.3d).

5.3.4 *Mixocyclops* cf. *crozetensis*

1. Total body length approximately 0.33 mm (Fig. A2.4a).
2. *Antennule* 11-segmented, extending to middle of *cephalothorax* (Fig. A2.4b).
3. Legs 1–4 with 2-segmented *rami* (Fig. A2.4c).
4. Leg 5 two-segmented, with the second segment bearing a long apical *seta* (Fig. A2.4d).

5.3.5 *Paracyclops chiltoni*

1. Total body length roughly 0.75 mm (Fig. A2.5a).
2. *Antennule* 8-segmented, extending to nearly the middle of *cephalothorax* (Fig. A2.5b).
3. First *exopod* segment of leg 4 bearing an inner *seta* (Fig. A2.5c).
4. Leg 5 one-segmented, bearing two outer *setae* and an inner *spine* (Fig. A2.5d).

5.3.6 *Tropocyclops* sp.

1. Total body length approximately 0.68 mm (Fig. A2.6a).
2. *Antennule* 12-segmented, extending to second leg-bearing *somite* (Fig. A2.6b).
3. Third *endopod* segment of leg 4 bearing relatively long and thin *setae/spines* (Fig. A2.6c).
4. Leg 5 one-segmented, bearing three *setae* (lateral, apical and medial) (Fig. A2.6d).

6. TAXONOMIC KEY

It is worth mentioning here several attributes that will enable you to recognize rapidly a copepod crustacean prior to using this key. The copepods you may encounter will have the opposite members (i.e. right and left sides) of the first four leg pairs joined medially by a flat plate called an *intercoxal sclerite*. Test this by using a fine needle to move one leg pair; both the right and left legs should move in unison. Another copepod attribute is the absence of appendages on the abdominal somites, except the posteriormost (last) somite which bears a single pair of unsegmented appendages known as the *caudal rami*. If these two characters are not found in your specimen(s), then you have another type of arthropod/animal. The next course of action would be to either use other keys, such as those presented in Williams (1980), or consult with taxonomic specialists to identify your material.

The characters used in the following key can be observed without the need for dissection(s) using a compound microscope and applies to the adult female only. After keying out your copepod specimen(s), it is essential to confirm the identification(s) by comparing with the suite of features listed above and, more importantly (where applicable), the publication listed in brackets following the species name.

1. Antennule 8-segmented; leg 5 1-segmented .....
.....*Paracyclops chiltoni* [Karaytug, 1999]

— Antennule 11-segmented; leg 5 2-segmented.....
..... *Mixocyclops* cf. *crozetensis* [Kiefer, 1944]

— Antennule 12-segmented; leg 5 1-segmented.....2

— Antennule 17-segmented; leg 5 2-segmented.....3

2. First exopod segment of leg 4 lacking an inner seta .....
..... *Australoeucyclops* n. sp.

— First exopod segment of leg 4 bearing an inner seta.....
..... *Tropocyclops* sp.

3. Second segment of leg 5 bearing three apical setae/spines .....
..... *Macrocyclops albidus* [Ueda *et al.*, 1996]

— Second segment of leg 5 bearing an apical seta and inner spine.....
..... *Mesocyclops brooksi* [Holyńska *et al.*, 2003]

7. CONSERVATION STATUS

The following five taxa are considered to be stygophiles of low conservation value based on their distribution and habitat records:

- *Australoeucyclops* n. sp. has also been collected from two springs and one dam in the Margaret River region of Western Australia (Dr Tom Karanovic, pers. comm.).

- *Macrocyclops albidus* is a cosmopolitan species found in many freshwater habitats (Reid, 1992).

- *Mesocyclops brooksi* has been has been found in subterranean (bores and wells) and surface water (swamp, marsh, lake and river) environments within Queensland and the Pilbara, Murchison and southwest corner of Western Australia (Pesce *et al.*, 1996; De Laurentiis *et al.*, 1999; Holyńska and Brown, 2003; Karanovic, 2004; Karanovic, 2006).

- *Mixocyclops* cf. *crozetensis* has been reported from a freshwater habitat in the Crozet Island (Kiefer, 1944).

- *Paracyclops chiltoni* is another cosmopolitan species found in many freshwater habitats (Karaytug, 1999).

Comments on the conservation value of the *Tropocyclops* species cannot be made with confidence until the species identity is determined. It must be noted, however, that most species of *Tropocyclops* are planktonic and epibenthic in ponds and lakes (Reid and Janetzky, 1996). Thus, the likelihood of this species being an epigean form is high.

8. ACKNOWLEDGEMENTS

I thank Dr Tom Karanovic (WA Museum) for providing his unpublished drawings of the new *Australoeucyclops* species, and Dr Janet W. Reid for providing an unpublished key to species of *Macrocyclops*.

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10. APPENDIX 1 – DEFINITIONS OF MORPHOLOGICAL TERMS (FROM BOXSHALL AND HALSEY, 2004)

Antenna: the second cephalic appendage.

Antennule: the first cephalic appendage.

Caudal rami: the paired articulated structures carried on the anal somite.

Cephalic: the head.

Cephalothorax: the anterior region of the copepod body in which the first leg-bearing somite is incorporated into the first 5 cephalic somites.

Endopod: the inner ramus (branch) of a biramous appendage.

Exopod: the outer ramus (branch) of a biramous appendage.

Intercoxal sclerite: a flat chitinous plate connecting the base of a pair of swimming legs.

Maxilla: the fifth and last pair of cephalic appendages.

Rami (singular = ramus): the two branches (exopod and endopod) of an appendage.

Seta (plural = setae): a slender, flexible armature element with internal tissue connection through the integument.

Somite: a segment or division of the body.

Spine: a stout, rigid armature element with internal tissue connection through the integument.

11. APPENDIX 2 – PHOTOGRAPHIC VOUCHER

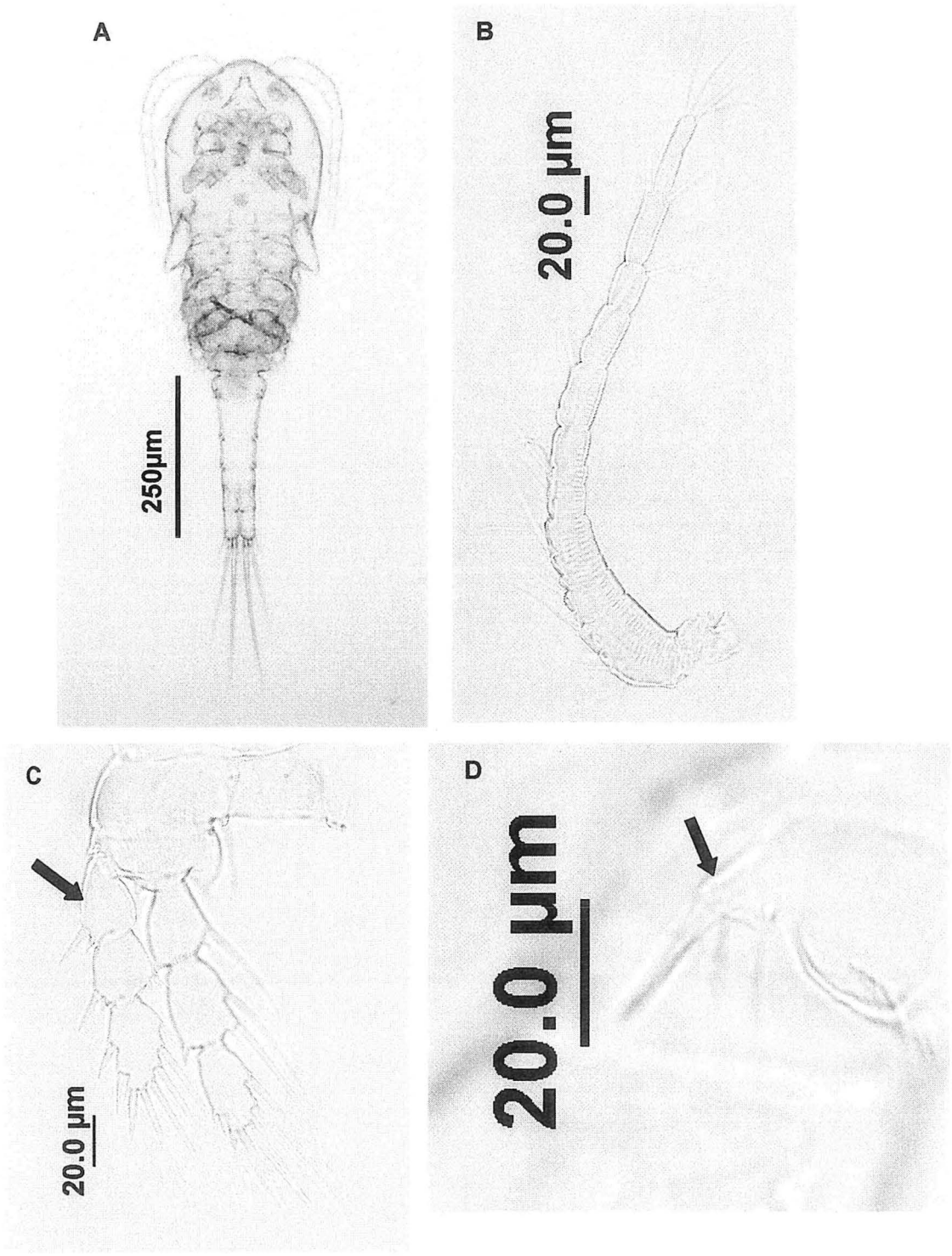

Figure A2.1. *Australoeucyclops* n. sp.: a) dorsal habitus; b) antennule; c) right leg 4, showing absence of inner seta on first exopod segment (arrowed); d) leg 5 (arrowed).

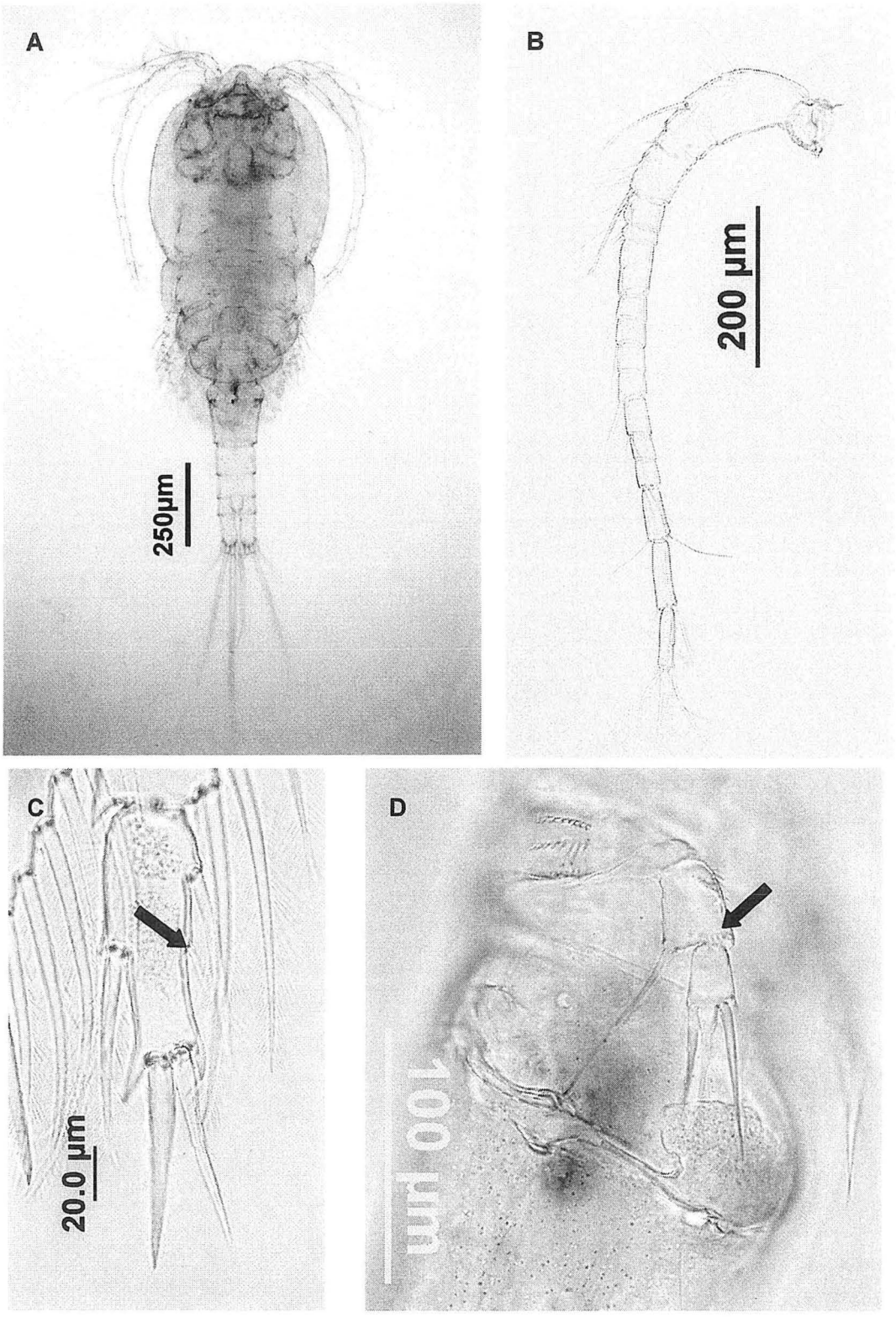

Figure A2.2. *Macrocyclops albidus*: a) dorsal habitus; b) antennule; c) terminal endopod segment of right leg 4, showing short distal-medial seta (arrowed); d) leg 5 (arrowed).

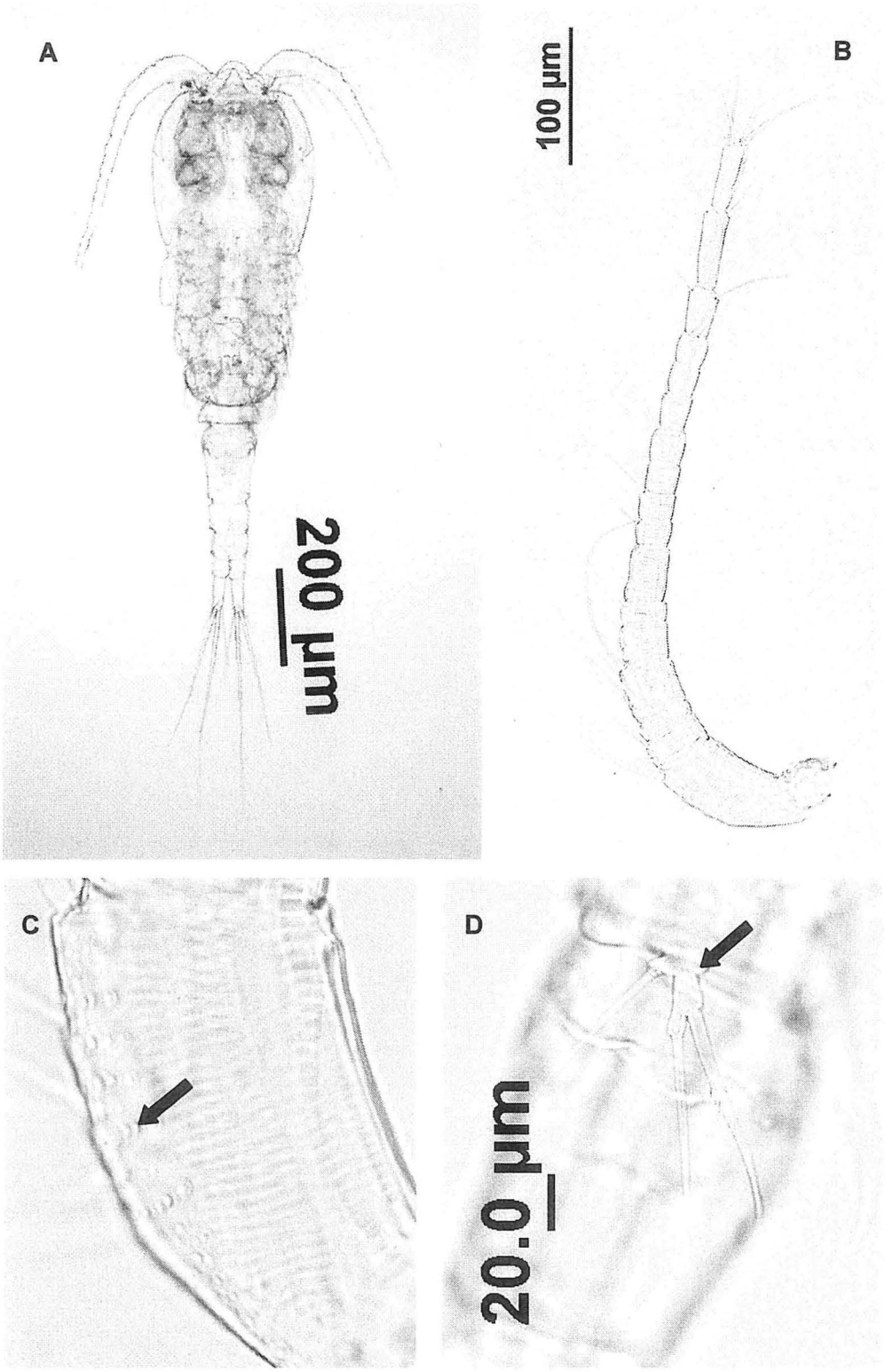

Figure A2.3. *Mesocyclops brooksi*: a) dorsal habitus; b) antennule; c) first antennular segment, showing cuticular pits (arrowed); d) leg 5 (arrowed).

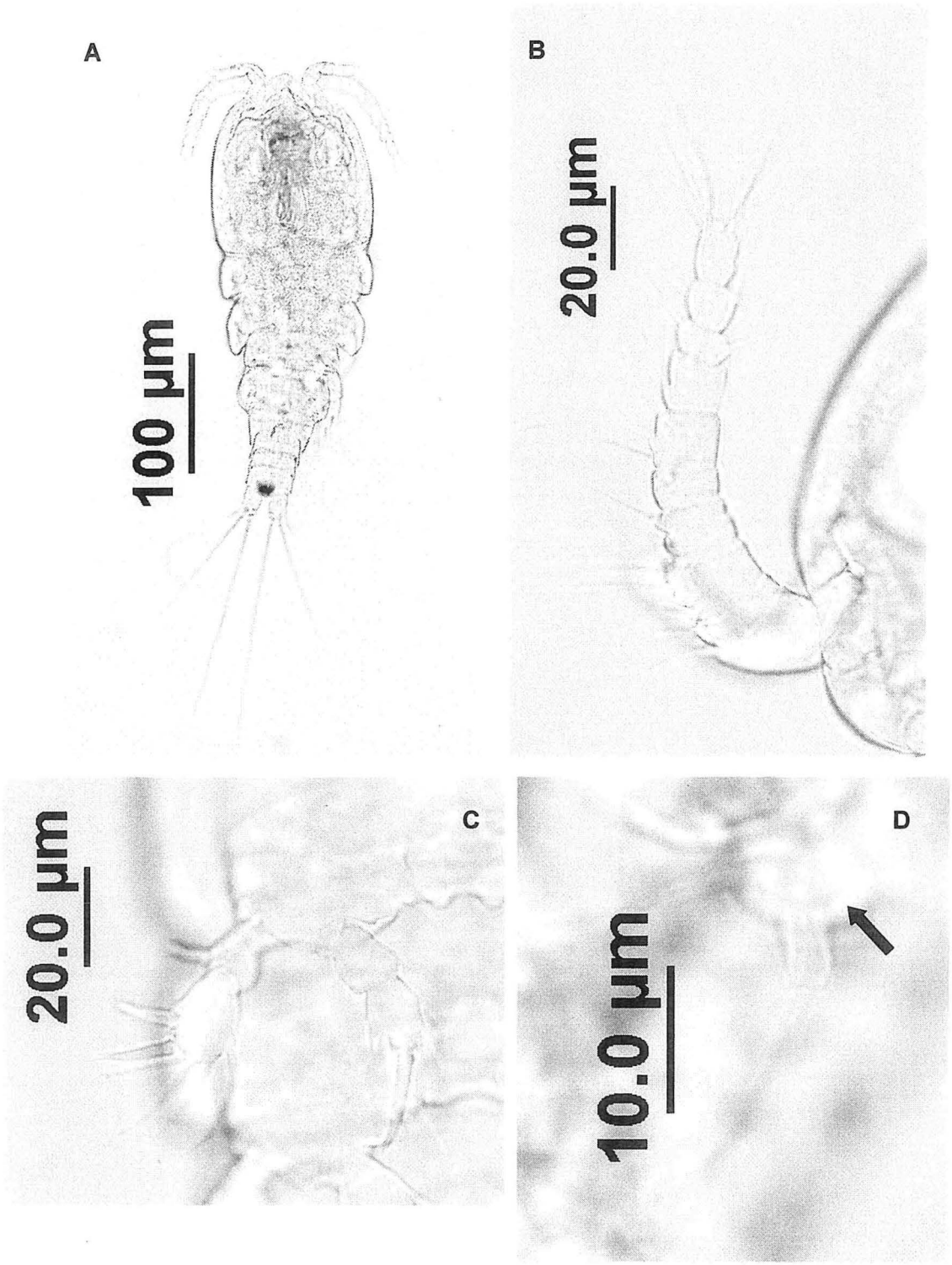

Figure A2.4. *Mixocyclops* cf. *crozetensis*: a) dorsal habitus; b) antennule; c) right leg 1; d) leg 5 (arrowed).

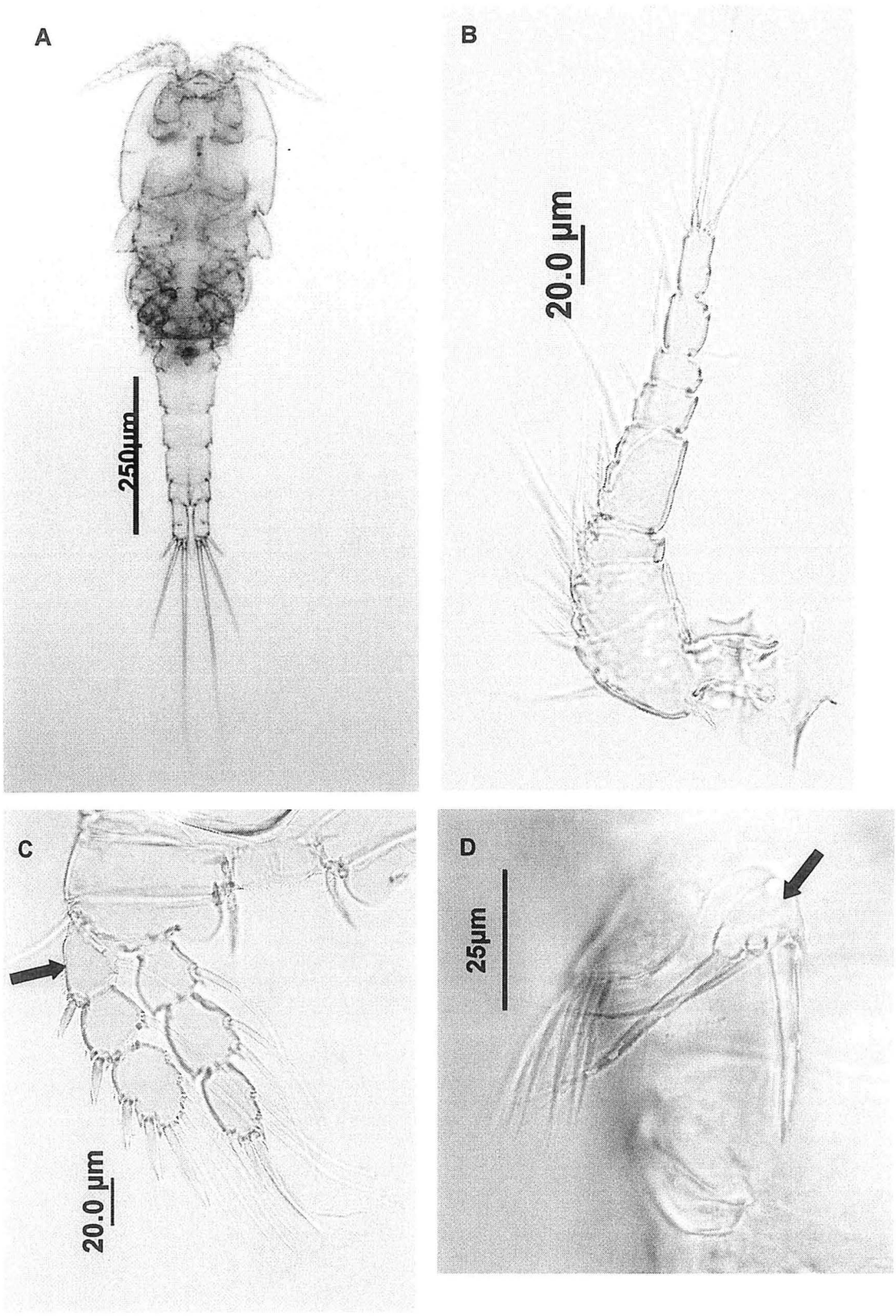

Figure A2.5. *Paracyclops chiltoni*: a) dorsal habitus; b) antennule; c) right leg 4, showing presence of inner seta on first exopod segment (arrowed); d) leg 5 (arrowed).

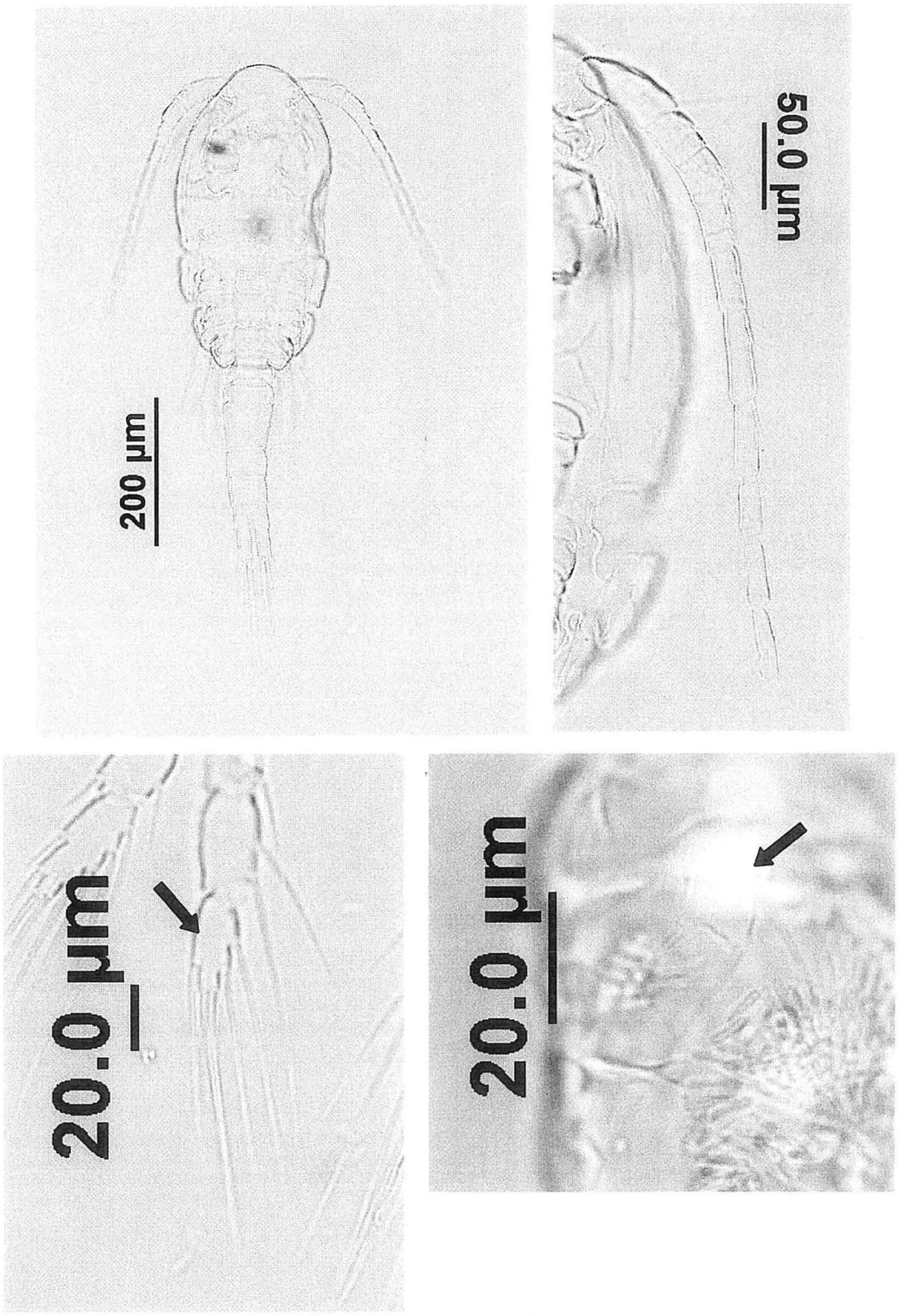

Figure A2.6. *Tropocyclops* sp.: a) dorsal habitus; b) antennule; c) right leg 4 endopod, showing long spines and setae on third segment (arrowed); d) leg 5 (arrowed).