

## A new species of the genus *Candonopsis* (Crustacea, Ostracoda) from Western Australia

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**Abstract** – A new species of stygobiont ostracod, *Candonopsis* (*Abcandonopsis*) *linnaei* sp. nov., is described from subterranean waters of the Murchison region in Western Australia. The new species can be easily distinguished from other representatives of the genus by 6-segmented antennula and incompletely divided penultimate segment of the walking leg. A key to the representatives of the genus *Candonopsis* in Australia is also provided.

**Key words:** *Abcandonopsis*, Candonopsini, taxonomy, stygobiont Ostracods, key to species

### INTRODUCTION

The genus *Candonopsis* Vávra 1891 was recently revised by Karanovic (2004), who synonymized three species and brought the total number to 24. Karanovic (2007) described another three new species from subterranean waters of the Pilbara region in Western Australia. The genus is currently divided into two subgenera: *Candonopsis* s. str. and *Abcandonopsis* Karanovic 2004 (see Karanovic 2004). The nominotypical subgenus has the following five species in Australia: *Candonopsis* (*C.*) *tenuis* (Brady 1886), *C. (C.) murchisoni* Karanovic and Marmonier 2002, *C. (C.) dani* Karanovic and Marmonier 2002, *C. (C.) kimberleyi* Karanovic and Marmonier 2002 and *C. (C.) westaustraliensis* Karanovic and Marmonier 2002. The first species was reported from New South Wales (Brady 1886; Sars 1896) and Western Australia (Karanovic 2007; Karanovic and Marmonier 2002), and I have also found it in a sample from Queensland (unpublished data). *Candonopsis tenuis* is also reported from Sumatra (Klie 1932). *Candonopsis murchisoni*, *C. dani* and *C. westaustraliensis* were described and only known from the Murchison region, while *C. kimberleyi* is endemic to the Kimberley region. The subgenus *Abcandonopsis* also has six species in Australia: *C. (A.) williamsi* Karanovic and Marmonier 2002, *C. (A.) aula* Karanovic 2004, *C. (A.) indoles* Karanovic 2004, *C. (A.) dedeckeri* Karanovic 2007, *C. (A.) inaffecta* Karanovic 2007 and *C. (A.) pilbarae* Karanovic 2007. The first species, which is the type species of the subgenus, was described from the Murchison region in Western Australia. The following two species were described from the Kimberley, while the last three species were

reported from the Pilbara region. Except for *C. (C.) tenuis*, which can be found in springs as well as in subterranean waters, all the other species of the genus *Candonopsis* in Australia are stygobionts. In the present paper, one other species of the subgenus *Abcandonopsis* collected from boreholes in the Murchison region is described.

The genus *Candonopsis* has its greatest diversity in the southern hemisphere. In the northern hemisphere the genus is generally regarded as a Tertiary relict (Danielopol 1980a), with six species mainly living in the underground waters of Europe (Karanovic and Marmonier 2002). While the subgenus *Abcandonopsis* is endemic to Australia, the nominotypical subgenus is distributed in Central America, Africa, India, Sumatra, Java, Solomon Islands and Australia (Karanovic 2004), where the species live predominantly in surface waters. However, almost all of the species have a restricted distribution. This is also the case with other genera of the tribe Candonopsini, to which *Candonopsis* belongs. *Cubacandona* Broodbakker 1983 and *Caribecandona* Broodbakker 1983 are known from Cuba and West Indies (Broodbakker 1983; Danielopol 1980a), *Marococandona* Marmonier, Boulal and Idbennacer 2005 from Morocco and *Pioneeracandonopsis* Karanovic 2005a from Queensland. I have another new genus, with at least six species from New South Wales, which is awaiting description (Karanovic, unpublished data). With the addition of the new species described here, the genus *Candonopsis* presently has 12 living species in Australia, the majority of them being short-range endemics in the Murchison and Pilbara regions. Therefore, Australia may be considered to be the center of biodiversity for the

genus *Candonopsis*, and maybe even for the entire tribe Candonopsini.

### MATERIAL AND METHODS

Samples were taken from bores using plankton net of suitable diameter (47  $\mu$ m, 97  $\mu$ m, 147  $\mu$ m, or 197  $\mu$ m) to match the bore. The net, with a weighted McCartney vial attached, was lowered to the base of the bore and then agitated up and down couple of times to disturb the bottom. Entire samples were preserved in 100% ethanol.

Specimens were dissected and mounted on microscope slides in Faure's medium, which was prepared following the procedure of Stock and Vaupel Klein (1996), and dissected appendages were then covered with a coverslip. All drawings were prepared using a drawing tube attached to a Leica DMLS bright-field compound microscope with C-PLAN achromatic objectives. Specimens that were not drawn were examined in a mixture of equal parts of distilled water and glycerol and, after examination, were again preserved in 70% ethanol. All examined material is deposited in the Western Australian Museum (WAM).

Terminology of A1 follows Karanovic (2005b). Martens (1987) revised the terminology for A2 given originally by Broodbakker and Danielopol (1982). The present paper follows Martens (1987) except that the short claw on the male terminal segment is considered to be homologous with the female GM claw, while the long one is homologous with the female Gm claw. This is because GM claw is situated internally, while Gm is inserted externally. The terminology for the Md follows Broodbakker and Danielopol (1982), and for the T3 Meisch (1996). Lobes on the hemipenis are labeled according to Danielopol (1969).

### SYSTEMATICS

Family Candonidae Kaufmann 1900

Subfamily Candoninae Kaufmann 1900

Tribe Candonopsini Karanovic 2004

Genus *Candonopsis* Vávra 1891

Subgenus *Candonopsis* (*Abcandonopsis*)  
Karanovic 2004

*Candonopsis* (*Abcandonopsis*) *linnaei* sp. nov.

Figures 1–3

#### Material examined

##### Holotype

**Australia: Western Australia:**  $\delta$ , Murchison region, Lake Way, bore NLV 16, 26°50'4"S, 120°19'38"E, 19 July 2007, collected by staff from Outback Ecology (Perth) (WAM C35715, dissected on one slide) [ecological data: water depth = 3.7 m;

pH = 7.8; Salinity = 5.9 ppt; Electrical Conductivity = 10.48 mS/cm; t = 23.7° C; Dissolved Oxygen = 7.03 ppm.]

##### Paratype

**Australia: Western Australia:** 1  $\delta$ , collected with holotype (WAM C35716, in alcohol).

##### Other material

**Australia: Western Australia:** 1  $\text{♀}$ , Murchison region, Lake Way, bore NVCT0612, 26°50'46"S, 120°21'47"E, 17 July 2007, collected by staff from Outback Ecology (Perth) (WAM C35717, dissected on one slide) [ecological data: water depth = 1 m; pH = 7.55; Electrical Conductivity = 65.70 mS/cm; t = 21.9°C; Dissolved Oxygen = 7.43 ppm]; 1  $\text{♀}$ , (WAM C35718, dissected on one slide), Murchison region, Lake Way, bore NLW18, 26°49'17"S, 120°19'41"E, 19 August 2007, collected by staff from Outback Ecology (Perth) [ecological data: water depth = 4.5 m; pH = 7.4; salinity = 60.50 ppt; Electrical Conductivity = 85.40 mS/cm; t = 25° C; Dissolved Oxygen = 5.28 ppm]; 1  $\text{♀}$ , 3 disintegrated  $\delta$  and 3 disintegrated juveniles (WAM C35719, in alcohol).

#### Diagnosis

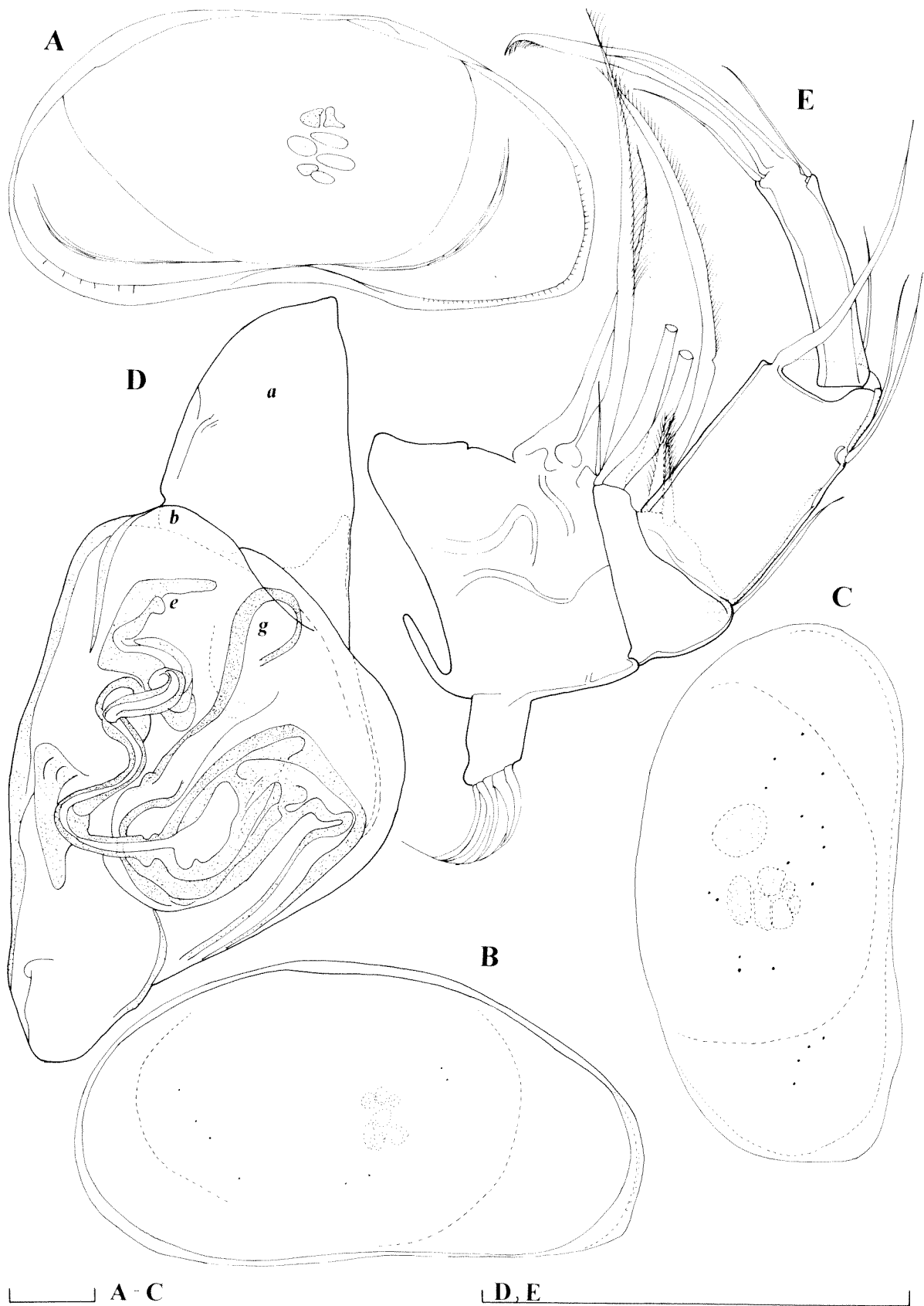
Valves asymmetrical. Left valve larger than right valve, anterior and ventral margin connected at almost right angle. Antennula 6-segmented. Walking leg without basal seta; cleaning leg without Tf seta. Both claws on caudal ramus well developed, hemipenis with triangular lobe "a", genital field rounded.

#### Description

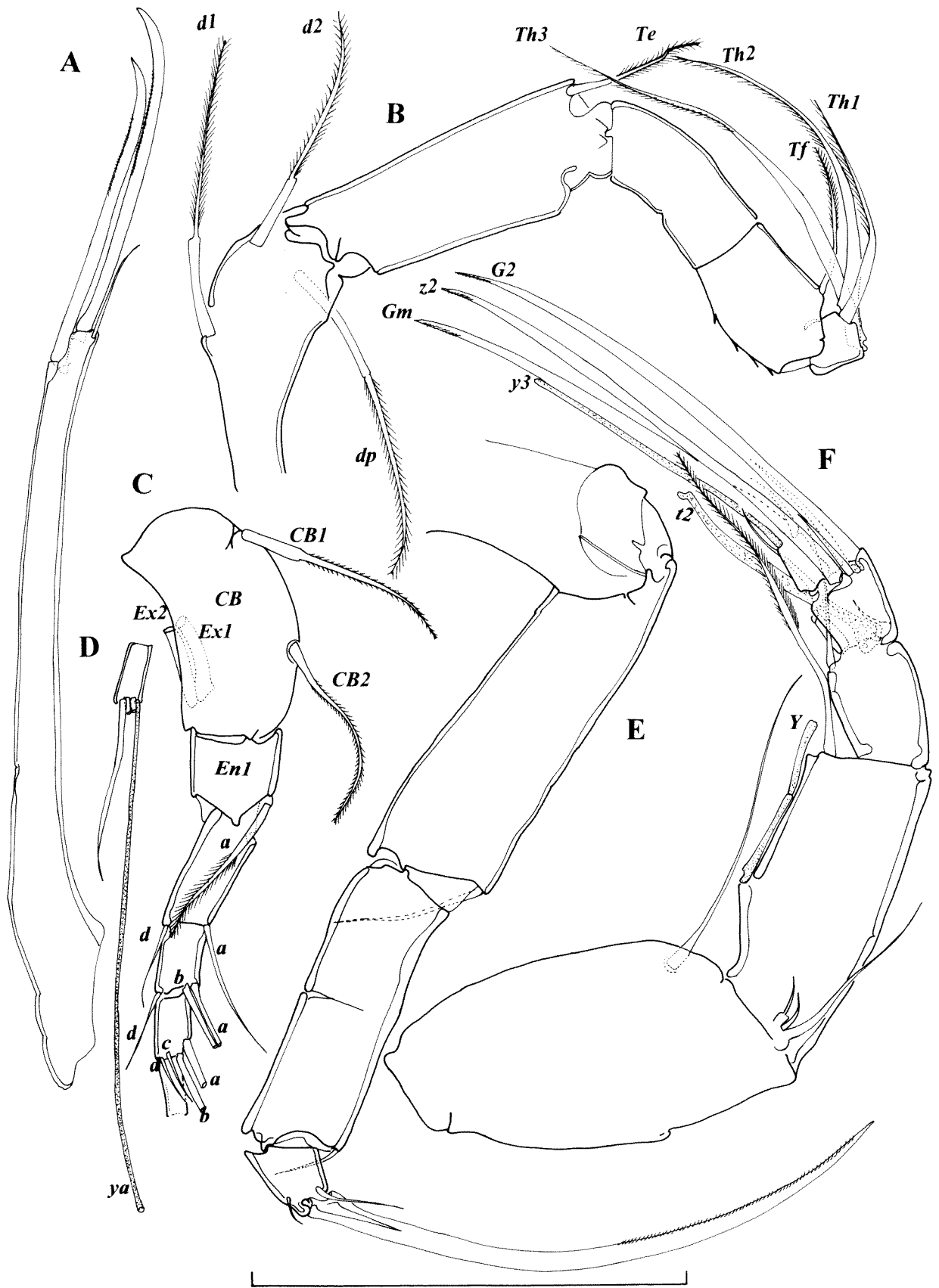
##### Male (holotype)

Length of carapace 0.66 mm. Greatest height around middle, equaling 50% of total length. Carapace asymmetrical (Figure 1B) with left valve overlapping right valve on all free margins. Left valve with anterior and ventral margin connected at almost right angle, while same margin rounded on right valve. Dorsal margin on both valves straight in the middle, rounded towards posterior end, and inclined towards anterior (Figure 1A). Ventral margin concave in the middle. Marginal pore canals very short, straight, and more dense anteriorly. Inner calcified lamella broad, equaling 25% of total length anteriorly and 20% posteriorly. Surface of carapace smooth with sparse setae.

*Antennula* (Figure 2C, D): 6-segmented. First segment representing fused coxa and basis. Exopod reduced to two setae (Ex1 and Ex2). Both setae on coxobasis present (CB1 and CB2). Endopod 5-segmented. First, fourth, fifth and sixth segments free; second and third segments



**Figure 1** *Candonopsis limnaei* sp. nov., A, B, D, E, holotype male; C, female (0.63 mm): A, left valve, internal view; B, carapace, lateral view from the right side; C, carapace, lateral view from the left side; D, hemipenis; E, mandibular palp. Scale lines = 0.1 mm.



**Figure 2** *Candonopsis linnaei* sp. nov., holotype male: A, caudal ramus; B, cleaning leg; C, antennula; D, terminal segment of antennula; E, walking leg; F, antenna. Scale lines = 0.1 mm.

fused. First segment with one anterior seta ("a") which pappose and overpassing distal margin of fused second and third segments. Fused segments with one anterior seta "a", extending beyond distal margin of penultimate segment, and posterior seta "d" extending beyond distal margin of following segment. Fourth endopodal segment with two long anterior setae ("a" and "b") and one short posterior seta "d" which extending beyond distal margin of fifth segment. Fifth segment with both anterior setae and posterior setae present. Posterior setae short, anterior ones long. Terminal segment with posterior seta 2.9 times longer than same segment, two long setae, and aesthetasc ya, which eight times longer than terminal segment. Length ratio of endopodal segments equaling 1.5 : 2.3 : 1.15 : 1 : 1.

*Antenna* (Figure 2F): exopod consisting of a plate with two short and one long seta. Second endopodal segment subdivided and with two male bristles (t2 and t3 setae) present. Seta z1 short only slightly overpassing terminal segment, seta z2 transformed into long claw, which 1.8 times longer than first endopodal segment. Claw G2 as long as z2; claws G1 and G3 reduced; first one about two times longer than terminal segment, latter transformed into seta and only slightly shorter than G2. Claw GM on terminal segment reduced and about as long as terminal segment, claw Gm well developed and 1.6 times longer than first endopodal segment. Aesthetasc Y 0.6 times as long as first endopodal segment, y3 approximately as long as same segment. Length ratios of endopodal segments equaling 4.4 : 1.8 : 1.4.

*Mandibula* (Figure 1E): exopod with numerous short rays. Basal segment with both "S" setae well developed and pappose and with short alpha seta. Following segment with two outer setae, reaching middle of following segment, and 3+2 setae in inner bunch. Three setae pappose and long, beta seta and other short seta plumped. Penultimate segment with two outer setae not reaching middle of terminal segment, one distal seta and one inner distal seta which almost reaching middle of terminal claw. Terminal segment elongated 4.5 times longer than wide. Terminal claw fused with segment and accompanied with two thin setae on each side, subequally long and reaching middle of terminal claw.

*Maxillula* (Figure 3F): palp with four pappose setae on penultimate segment. Same segment wide and with distal row of small setae. Terminal segment with three claws and one seta.

*Prehensile palps* (Figure 3D, E): palps asymmetrical, right palp plumper than left one. Right palp with second subapical structure present, but much shorter than the left one. Left

palp elongated with only one subapical structure observed. Same palp dorsally with one chitinous extension.

*Walking leg* (Figure 2E): basal segment without any seta. First endopodal segment with one distal seta. Second and third endopodal segment partially fused with no medial setae present. Distal seta short. Terminal segment with two short setae and one claw which 1.5 times longer than three distal segments combined. Length ratios of three endopodal segments 5.5 : 4.3 : 1.

*Cleaning leg* (Figure 2B): basal segment with all three setae present. Seta Te on first endopodal segment present, as well as seta Tg, while Tf seta on second endopodal segment absent. Terminal segment with two long (Th2 and Th3) setae and one short seta (Th1). Length ratio of three setae 1 : 1.6 : 2.

*Caudal ramus* (Figure 2D): posterior seta absent, anterior seta present and about 2.5 times shorter than anterior claw. Both claws without prominent spines, only gently serrated. Length ratios between anterior margin, anterior claw and posterior claw equaling 1.8 : 1 : 1.

*Hemipenis* (Figure 1D): lobe "a" triangular and medially positioned, with pointed distal margin, lobe "b" rounded. Internal canals with double coils. Lobe "g" prominent and wounded.

*Female*. Length of carapace 0.63 mm. Greatest height 50% of length (Figure 1C). Carapace appearance similar to male, except for small convex part around mouth region, and slightly more setae on carapace surface.

*Antenna* (Figure 3A): setae z1 and z2 present, seta z3 absent. All terminal claws long, G1, G2 and G3 2.2 times longer than first endopodal segment. Claw GM on terminal segment also long and 1.9 times longer than first endopodal segment. Only one "t" seta observed.

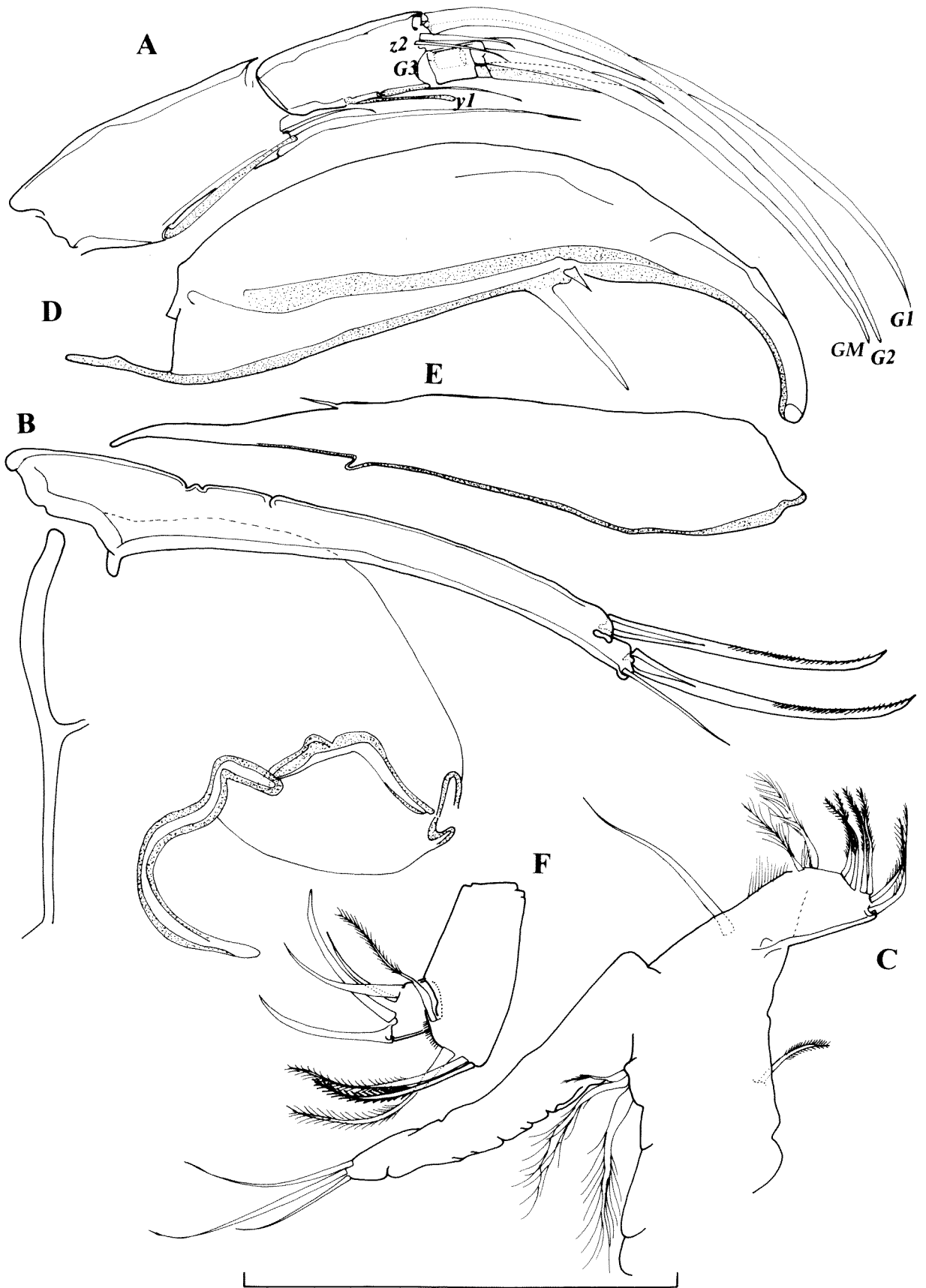
*First thoracopod* (Figure 3C): three setae on exopod, only one "a" seta present.

*Caudal ramus and genital field* (Figure 3B): Length ratios between anterior margin, anterior and posterior claw equaling 1.85 : 1 : 1. Genital field rounded and without any protrusion.

Antennula, maxillula, mandibula, walking and cleaning legs same as in male.

#### Remarks and affinities

The new species can be easily distinguished from the remaining species of the *Candonopsis* species by the 6-segmented antennula and incompletely divided penultimate segment of the walking leg. The absence of a seta on the basal segment of the walking leg places *Candonopsis linnaei* within the subgenus *Abcandonopsis* Karanovic 2004. Almost all of the species of this



**Figure 3** *Candonopsis linnaei* sp. nov., A–C, female (0.63 mm); D–F, holotype male: A, antenna; B, caudal ramus with genital field; C, first thoracopod; D, right prehensile palp; E, left prehensile palp; F, maxillular palp. Scale lines = 0.1 mm.

subgenus lack the Tf seta on the penultimate segment of the walking leg, except for *C. (A.) pilbarae* Karanovic 2007. The latter species and two species from the Pilbara region, *C. (A.) dedeckkeri* Karanovic 2007, and *C. (A.) inaffecta* Karanovic 2007, have ornamented surface of the carapace, while it is smooth in the new species. A smooth carapace is also a characteristic of another species from the Murchison region, *C. (A.) williamsi* Karanovic and Marmonier 2002, as well as of both species from the Kimberly region: *C. (A.) aula* Karanovic 2004 and *C. (A.) indoles* Karanovic 2004. These three species, as well as the new one, have pronouncedly asymmetrical valves (left one being considerably larger than the right one), while in the species from the Pilbara this is not the case. In addition to the 6-segmented antennula and undivided penultimate segment on the walking leg, *C. (A.) linnaei* differs from *C. (A.) williamsi*, *C. (A.) indoles*, and *C. (A.) aula* also by the presence of the d2 seta on the basal segment of the cleaning leg. *Candonopsis aula* has only one claw on the caudal ramus.

### Etymology

The species name is dedicated to Carolus Linnaeus in celebration of the tercentenary of his birth in 1707 and the 250<sup>th</sup> anniversary of *Systema Naturae*.

### Key to Australian *Candonopsis* species

1. Basal segment of walking leg without seta .....2  
Basal segment of walking leg with one seta.....8
2. Antennula 6-segmented .....  
.....*Candonopsis (A.) linnaei* sp. nov.  
Antennula 7-segmented .....3
3. Caudal ramus with only one claw .....  
..... *Candonopsis (A.) aula* Karanovic 2004  
Caudal ramus with two claws.....4
4. Seta "d2" on basal segment of cleaning leg  
absent.....5  
– Seta "d2" on basal segment of cleaning leg  
present .....7
5. Carapace ornamented ventrally, and the  
greatest height in front of the middle .....  
.....*Candonopsis (A.) inaffecta* Karanovic 2007  
– Carapace smooth and greatest height around  
the middle or behind.....6
6. Dorsal margin of the carapace straight, lobe  
"a" on the hemipenis rounded, second and  
third endopodal segments of the cleaning leg  
incompletely divided .....  
.....*Candonopsis (A.) indoles* Karanovic 2004  
Dorsal margin of the carapace rounded,

lobe "a" of the hemipenis pointed distally,  
second and third endopodal segments on the  
cleaning leg completely divided.....  
.....*Candonopsis (A.)*  
*williamsi* Karanovic and Marmonier 2002

7. Seta Tf on the cleaning leg absent.....  
.....*Candonopsis (A.) dedeckkeri* Karanovic 2007  
– Seta Tf on the cleaning leg present.....  
.....*Candonopsis (A.) pilbarae* Karanovic 2007
8. Posterior claw on the caudal ramus reduced.....  
...*Candonopsis (C.) westaustraliensis* Karanovic  
and Marmonier 2002  
Posterior claw on the caudal ramus normally  
developed.....9
9. Carapace heavily ornamented with shallow but  
well expressed pits .....  
.....*Candonopsis (C.)*  
*kimberleyi* Karanovic and Marmonier 2002  
Carapace not heavily ornamented.....10
10. Valves asymmetrical, dorsally right valve  
overlaps left one with a flange.....11  
Valves symmetrical, no flange on the right  
valve developed.....  
..... *Candonopsis (C.) tenuis* (Brady 1886)
11. Claws on the caudal ramus subequal, or  
anterior one slightly longer than posterior ....  
.....*Candonopsis (C.)*  
*murchisoni* Karanovic and Marmonier 2002  
Anterior claw on the caudal ramus at least 1.4  
times longer than posterior one.....  
.....*Candonopsis (C.)*  
*dani* Karanovic and Marmonier 2002

### DISCUSSION

The tribe *Candonopsini* today comprises 38 valid Recent species, classified into five genera and one subgenus. The most diversified is the genus *Candonopsis* with 28 living species, followed by *Cubacandona* Broodbakker 1983, with four species, *Caribecandona* Broodbakker 1983, with three species, *Marococandona* Marmonier, Boulal and Idbennacer 2005, with two species, and *Pioneeracandonopsis* Karanovic 2005a, with only one species. The last three genera are stygobionts while *Cubacandona* and *Candonopsis* have both subterranean and surface water species (see Karanovic 2004). Among the *Candonopsini* genera, fossilized species are known only for *Candonopsis*, and it is considered that the earliest fossils date back to the Miocene (Danielopol 1980b). Partly because the fossil sediments of Eurasia are better investigated, data regarding the fossil *Candonopsis* mostly relate to this area (see Janz 1992; Krstic 2006). Fossils of lacustrine sediments in Australia are very

poorly known, and not a single fossil species of the genus *Candonopsis* or any of the genera of the tribe Candonopsini has been described from this continent. According to the present day ecological preferences of the species and the zoogeography of the genus, it may be that further research of lacustrine sediments in Australia may reveal some of the ancestors of the present day Candonopsini fauna. With the exception of *C. tenuis*, all the other Australian species of the genus are stygobionts. They may have started to colonize subterranean waters from the above-ground freshwater during the Miocene and Pliocene aridity (Frakes 1999). Most of the species have several morphological reductions, as a consequence of adaptation to the subterranean environment, and this is more pronounced in the subgenus *Abcandonopsis* Karanovic 2004 than in the nominotypical one. The morphological reductions are evident more so in the other four Candonopsini genera. For example, *Pioneercandonopsis hancocki* Karanovic 2007 has a 5-segmented antennula as well as one of the species of the genus *Marococandona* and all *Caribecandona*, in which the caudal ramus has only one claw. Karanovic (2005a) performed a cladistic analysis of the tribe Candonopsini, including all 32 species known at the time. The results clearly cluster the genus *Pioneercandonopsis* from Queensland with the South American genera, *Caribecandona* and *Cubacandona*, and not with the Australian Candonopsini. One, still undescribed, genus from northern New South Wales is also more closely related to the South American genera and the genus from Queensland than to the rest of Candonopsini from Western Australia, Africa and Europe. However, discussions on the zoogeography of the Australian subterranean ostracods, and other stygobiont invertebrates, will have to wait for more thorough investigations on these ecosystems in Australia. The gap in knowledge of the stygofauna of Australia (but also of Africa and South America) is not only a problem for biogeographical and evolutionary reconstruction, but also for groundwater management. This problem is emphasized especially in Australia, where mining processes often involve using water and lowering the water table, or completely dewatering calcrete bodies, for the purpose of further mineral explorations (Eberhard *et al.* 2004).

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