

DESCRIPTION OF THE ANCHIALINE OSTRACODE, *DANIELOPOLINA*
SP. CF. *D. KORNICKERI* FROM CHRISTMAS ISLAND, INDIAN OCEAN

BY

LOUIS S. KORNICKER^{1,4}), DAN L. DANIELOPOL^{2,5}) and WILLIAM F. HUMPHREYS^{3,6})

¹) Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20013-7012, U.S.A.

²) Institute of Limnology, Austrian Academy of Sciences, Mondseestrasse 9, A-5310 Mondsee, Austria

³) Western Australian Museum, Locked Bag 49, Welshpool DC, WA-6986, Australia

ABSTRACT

The morphology and the systematic affinities of a unique juvenile specimen (post embryonic stage 1) of the ostracode, *Danielopolina* (family Thaumatoocyprididae) are described. It was found in an anchialine cave of Christmas Island, an isolated seamount, and this is the second record of a *Danielopolina* species in the Indian Ocean. A comparative study of this individual with those belonging to the other 11 *Danielopolina* species suggests closer morphological affinities to the Australian species, *D. kornickeri*. In addition, our study allows the separation of the species of *Danielopolina* into the two new subgenera, *Danielopolina* and *Humphreysella*. Tabular keys are provided for the identification of the species belonging to these subgenera.

RÉSUMÉ

La morphologie et les affinités systématiques d'un spécimen juvénile unique (1er stade post-embryonnaire) d'un ostracode appartenant au genre *Danielopolina* (famille des Thaumatoocyprididae) sont décrites. Cet ostracode a été trouvé dans une grotte anchialine de l'île Christmas, un mont sous-marin isolé, et c'est la seconde espèce de *Danielopolina* rencontrée dans l'océan Indien. Une étude comparée de cet exemplaire et des 11 espèces du genre *Danielopolina* suggère des affinités morphologiques plus étroites avec l'espèce australienne *D. kornickeri*. De plus, notre étude a permis de séparer les espèces de ce genre en deux sous-genres nouveaux, *Danielopolina* et *Humphreysella*. Des clés d'identification des espèces de ces sous-genres sont présentées.

⁴) e-mail: kornickl@si.edu

⁵) e-mail: Dan.danielopol@oeaw.ac.at

⁶) e-mail: Bill.humphreys@museum.wa.gov.au

INTRODUCTION

The exploration of an anchialine cave on the seamount, Christmas Island, in the Indian Ocean, allowed the collection of a unique specimen of a minute ostracode identified as a post embryonic stage 1 of a thaumatocypridid belonging to the genus *Danielopolina* Kornicker & Sohn, 1976. Most of the stygobitic species of this genus occur at Caribbean and Atlantic sites with only one species, *D. kornickeri* Danielopol, Baltanàs & Humphreys, 2000 known from the Indian Ocean, i.e., in Western Australia, and hence much closer to Christmas Island (~1,700 km) than the other species, which are located at more than 12,000 km (Humphreys & Danielopol, 2006).

The Christmas Island material includes only the first instar of the species, so it was not possible to identify it with certainty at the species level. However, because the specimen is the only anchialine thaumatocypridid from a seamount locality in the Indian Ocean, it is deemed of sufficient importance to describe it. The elongate carapace of the specimen is shared only with that of *Danielopolina kornickeri*, known only from an anchialine cave in Western Australia (Danielopol et al., 2000). Therefore, this first instar is tentatively identified herein as *Danielopolina* sp. cf. *D. kornickeri*. Additionally, we describe two new subgenera, *D. (Danielopolina)* and *D. (Humphreysella)*. The latter subgenus will be described here under the responsibility of L.S. Kornicker and D.L. Danielopol only.

MATERIAL AND METHODS

Locality (fig. 1). — Christmas Island, Indian Ocean, The Nineteenth Hole cave (karst number CI-19 in the karst index of Humphreys & Eberhard, 1998). The cave is located close to the eastern coast near North East Point, 10°25.4'S 105°42'00"E.

Description of the cave. — The inland entrance leads to a tidally influenced, anchialine habitat. The cave contains tree roots, plant litter, and soft sediments, and has a warm and humid environment. Aquatic and terrestrial fauna, including troglobites, are present (Volschenk et al., 2001). The cave is easily located and is only moderately vulnerable to caver impacts, but it was previously used for dumping rubbish. Despite this, the cave was considered to have a high biological significance (Humphreys & Eberhard, 1998). Additional information about the cave and cave system may be found in Namiotko et al. (2004).

Material. — One individual, instar I, collected 21 June 2004 by R.D. Brooks with a sweep net, and preserved in alcohol (endopod of right mandible missing). Registration number at the Western Australian Museum: C 35470.

Identification of the ostracode. — The appendages of the unique specimen investigated were all drawn while attached to the body inside the left valve. An

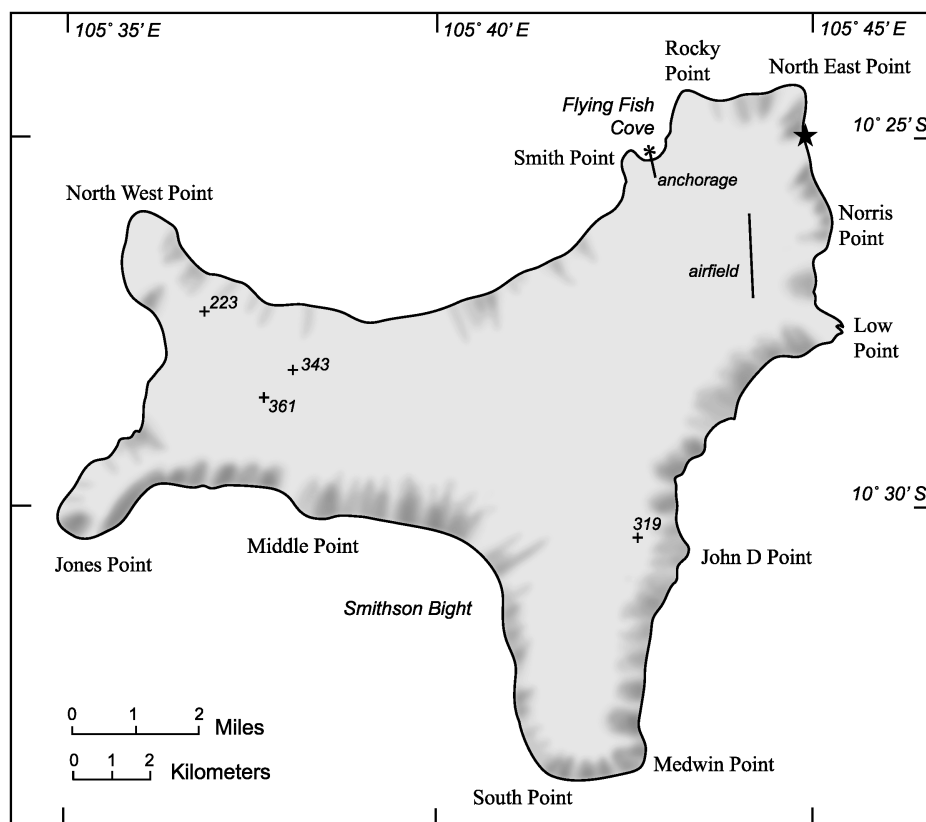


Fig. 1. Map of Christmas Island showing collecting locality (star).

exception is the left 2nd antenna, which remained inside the right valve. The specimen was drawn while in a thin drop of glycerine on a flat slide. All drawings were made using a camera lucida, a 40× objective lens, and 15× ocular lens on a Wild microscope. The appendages were not removed from the body nor examined with an oil immersion lens while under a cover slip. This practice may have resulted in some details of the appendages being unobserved, but it was deemed more desirable to permanently preserve the undissected specimen in alcohol.

Appendages not under cover slip when drawn: the appendages illustrated in figs. 3B, C, E and 4A, B are attached to the body, which is located in the left valve on the slide; the appendage illustrated in fig. 3 D is located in the right valve on the slide. The nomenclature for the antennular setae follows that used for *D. bahamensis* (cf. fig. 2d in Kornicker & Iliffe, 1989).

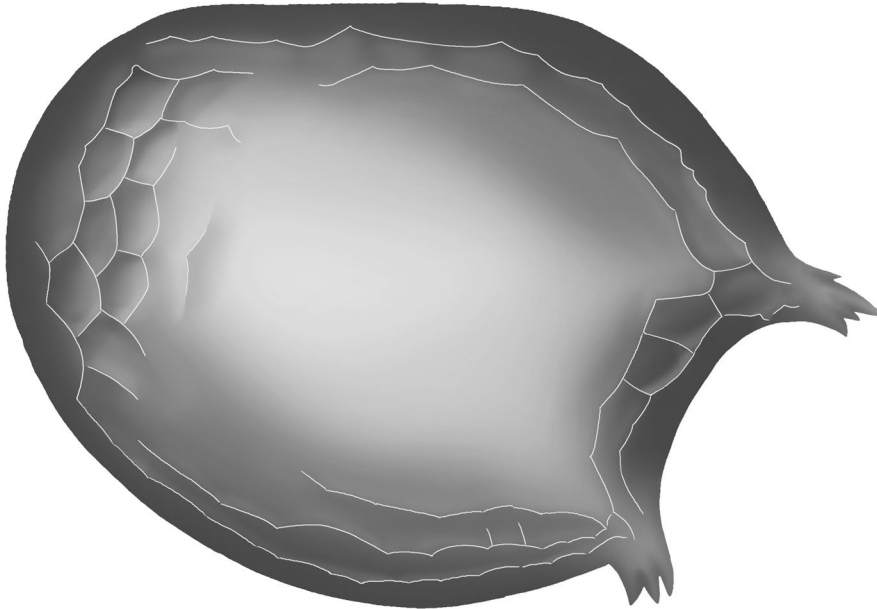


Fig. 2. Carapace of *Danielopolina* sp. cf. *D. kornickeri* (drawing based on fig. 1 in Humphreys & Danielopol, 2006). Carapace is preserved in alcohol and has most fringes on the two anterior processes missing.

SYSTEMATICS

Superorder MYODOCOPA G. O. Sars, 1866

Order HALOCYPRIDA Dana, 1853

Suborder HALOCYPRIDINA Dana, 1853

Superfamily THAUMATOCYPRIDOIDEA Müller, 1906

Family THAUMATOCYPRIDIDAE Müller, 1906

Genus *Danielopolina* Kornicker & Sohn, 1976

Type species. — *Danielopolina carolinae* Kornicker & Sohn, 1976.

Humphreysella new subgenus ¹⁾

Type species. — *Danielopolina orghidani* (Danielopol, 1972).

Diagnosis. — Protopod of second antenna without posterior bristle.

Derivatio nominis. — The new subgenus is named after Dr. William (Bill) F. Humphreys in honour of his important contribution to our knowledge of the subterranean fauna of Western Australia and Christmas Island.

¹⁾ This new subgenus is described herein under the responsibility of L. S. Kornicker & D. L. Danielopol only.

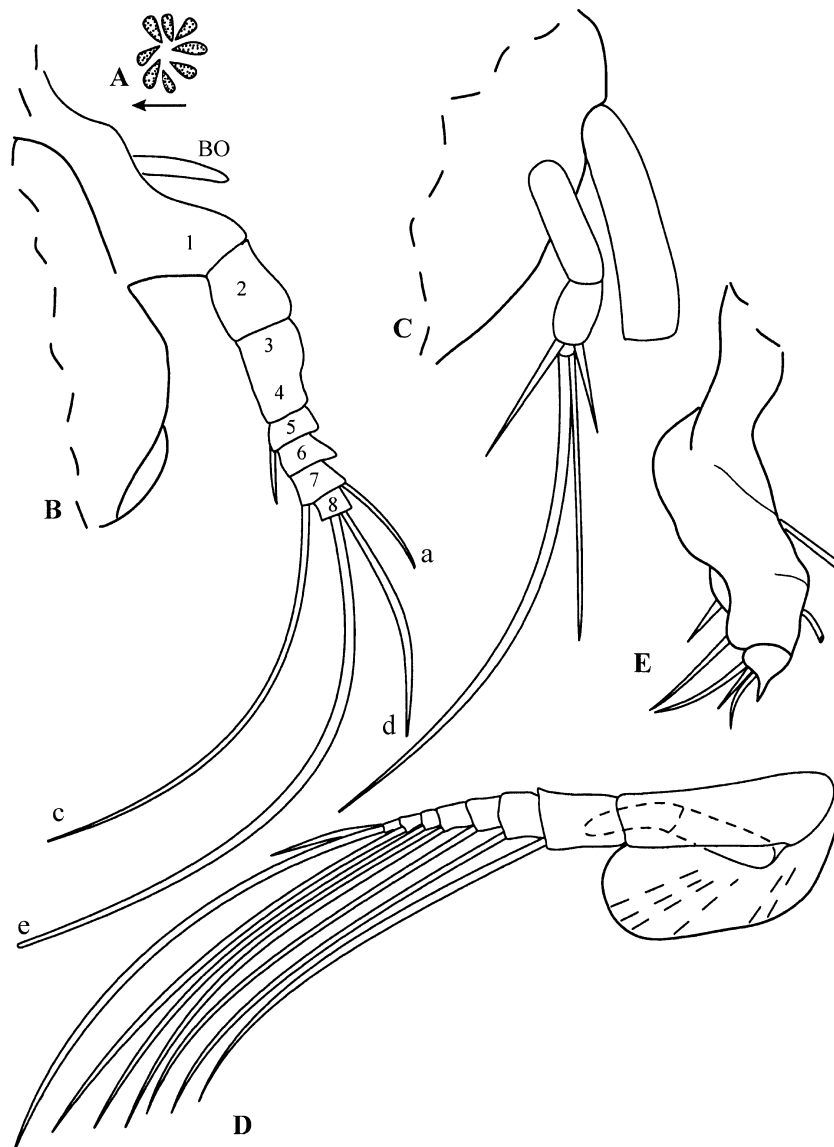


Fig. 3. *Danielopolina* sp. cf. *D. kornickeri*. A, central adductor muscle scars on left valve, outside view; B, right first antenna, Bellonci Organ (BO), and anterior of body, lateral view; C, left second antenna, distal part of protopod, endopod, and article 1 of exopod, medial view; D, right 2nd antenna, protopod, endopod (outline dashed and bristles not shown), and exopod, medial view; E, right maxilla (endite bristles not shown), lateral view.

Composition and distribution. — *D. (H.) bahamensis* Kornicker & Iliffe, 1989, Bahamas; *D. (H.) elizabethae* Kornicker & Iliffe, 1992, Jamaica; *D. (H.) exuma* Kornicker & Iliffe, 1998, Bahamas; *D. (H.) kakuki* Kornicker & Iliffe, 2000,

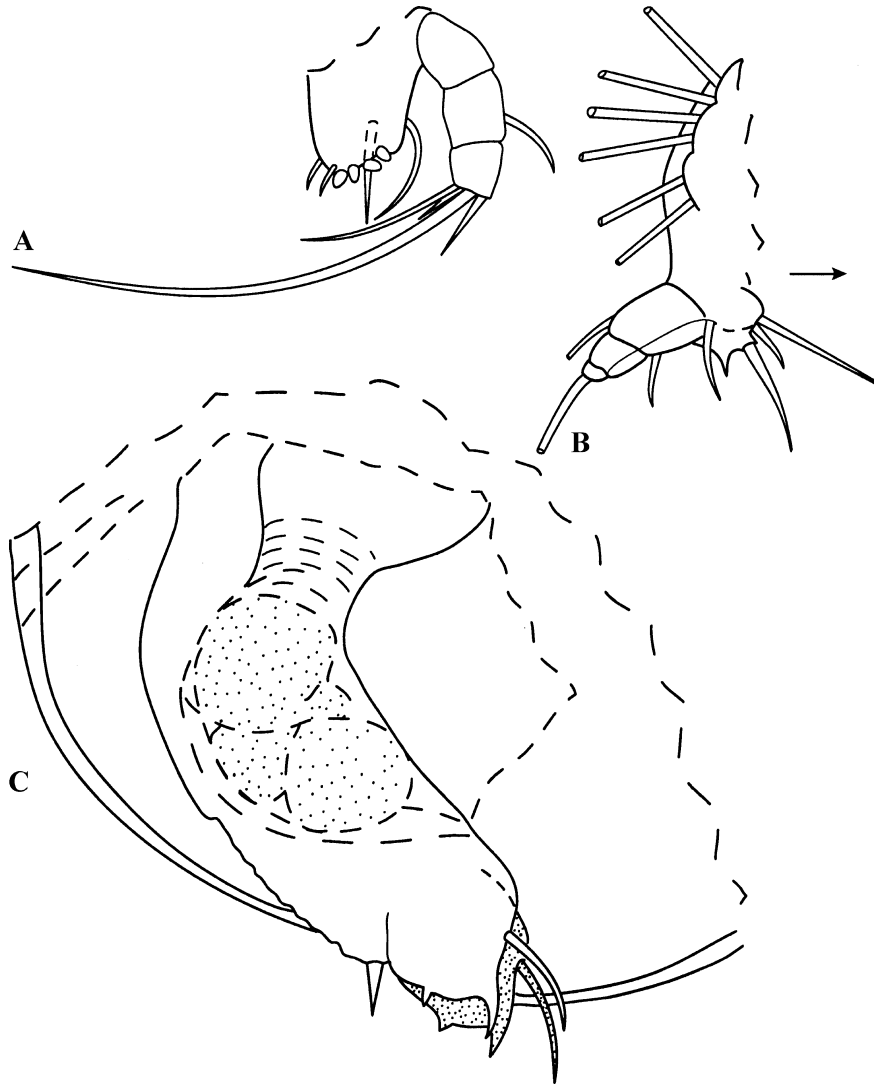


Fig. 4. *Danielopolina* sp. cf. *D. kornickeri*. A, left mandible, endopod and ventral end of basis; B, right fifth limb (not all epipodial bristles shown), lateral view; C, posterior of body shown inside left valve (left lamella of furca stippled), medial view.

Bahamas; *D. (H.) orghidani* Danielopol, 1972, Cuba; *D. (H.) styx* Kornicker & Iliffe, 1989, Bahamas; *D. (H.) wilkensi* Hartmann, 1985, Canary Islands.

***Danielopolina* Kornicker & Sohn, 1976, new subgenus**

Type species. — *Danielopolina carolinae* Kornicker & Sohn, 1976.

Diagnosis. — Protopod of second antenna with posterior bristle.

Composition and distribution. — *D. (D.) carolinae* Kornicker & Sohn, 1976, South Atlantic deep sea; *D. (D.) kornickeri* Danielopol, Baltanás & Humphreys, 2000, Australia; *D. (D.) mexicana* Kornicker & Iliffe, 1989, Yucatán Peninsula; *D. (D.) phalanx* Kornicker & Iliffe, 1995, Canary Islands; *Danielopolina* sp. cf. *D. (D.) kornickeri* (cf. Humphreys & Danielopol, 2006), Christmas Island.

DESCRIPTION

Danielopolina* sp. cf. *D. (D.) kornickeri

Carapace shape (fig. 2). — An elongate oval in lateral view with upper and lower spinous anterior processes. Dorsal margin straight; ventral and posterior margins convex; anterior margin between upper and lower processes straight.

Carapace ornamentation (fig. 2). — Valves of specimen preserved in alcohol without reticulations, but reticulate on fresh specimen (Humphreys & Danielopol, in press, fig. 1A, C).

Carapace size. — Disarticulated right valve: length including upper anterior process 0.32 mm; length excluding upper anterior process 0.28 mm; height 0.20 mm.

Central adductor muscle attachments (fig. 3A). — Consisting of about 8 wedge-shaped scars radially arranged.

First antenna (fig. 3B). — Articles 1-4 and 6 without bristles; 3rd and 4th articles fused; 5th article with small ventral bristle; 7th article with a- and c-bristles; 8th article with slender d-bristle and longer, stouter e-bristle.

Second antenna (fig. 3C, D). — Protopod bare. Endopod with 3 articles: article 1 bare, article 2 with 2 bristle (1 ventral, 1 dorsal); article 3 small, with 2 terminal bristles (1 long, 1 short) (dorsal bristle on 2nd article could actually be on 3rd article). Exopod article 1 undivided and without bristle; articles 2-7 each with long bristle; article 8 with 2 bristles; natatory hairs not visible on bristles. (Bristles of obscured endopod not shown on illustrated right limb; illustrated right limb with protopod oriented in unnatural position.)

Mandible (fig. 4A). — Coxal endite obscured. Basis with 4 triangular terminal teeth, 1 long distal lateral bristle, a long anterior bristle near midlength, and 2 short distal posterior bristles (distal of these stouter); dorsal margin of basis of left mandible obscured; dorsal bristles not observed on basis of right mandible. Endopod (note: endopod of right mandible not present): article 1 without bristles; article 2 with 1 dorsal bristle; article 3 with 4 bristles (1 very long, 1 medium length, 2 short).

Maxilla (fig. 3E). — Endite bristles not counted, obscured. Coxa with stout dorsal bristle. Basis with 1 ventral bristle. Endopod: article 1 with 2 bristles (1 dorsal, 1 ventral); article 2 with short, stout, pointed claw-like bristle and 3 slender bristles.

Fifth limb (fig. 4B). — Epipod with 3 sets of bristles (number uncertain, not all shown on illustration). Coxa endites obscured; proximal endite of basis with 2 bristles; distal endite with 1 lateral bristle, 1 claw-like ventral bristle, and 1 triangular bristle without suture at base. Endopod: article 1 with 2 bristles (1 ventral, 1 dorsal); article 2 without bristles; article 3 with long terminal bristle.

Sixth and seventh limbs. — Absent.

Bellonci organ (fig. 3B). — Elongate with rounded tip.

Furca (fig. 4C). — Each lamella with 1 articulated anterior claw, 1 short non-articulated claw on anteroventral corner, followed by 1 small non-articulated ventral claw. Unpaired process on posterior of body following lamellae.

Posterior of body (fig. 4C). — With scalloped edge appearing as 8 or 9 minute segments.

Gut content. — Brown, unidentified particles.

Ontogeny of carapace shape (table I). — The first instar described herein was referred to *D. cf. D. (D.) kornickeri* because the carapace is unusually elongate, a character peculiar to the adult of *D. kornickeri*. In order to ascertain whether or not the shape of the first instar reflected the shape of the adult, a rough measure of shape (height of carapace as a percentage of length) was calculated for stages of known species of *Danielopolina*. The data show that the shape of the carapace remains fairly constant during ontogeny, and that the carapaces of both the first instar identified as *D. cf. D. (D.) kornickeri* and the adult female of *D. kornickeri* are more elongate than known stages of any other species of *Danielopolina*.

DISCUSSION

As documented above, the first instar was tentatively identified as *Danielopolina* sp. cf. *kornickeri*, because of the similarities in the carapaces of the specimens from Christmas Island and north-western Australia. It is assumed that the adult of the former bears a posterior bristle on the protopod of the 2nd antenna, too. Its absence on the 1st instar from Christmas Island would not be unusual, because appendages of juveniles generally bear fewer bristles than those of adults (cf. Kornicker & Iliffe, 1989). The nine other known members of the genus inhabiting epicontinental anchialine ecosystems and one deep-sea species, have more circular carapaces (table I). Additional collections from the locality on Christmas Island should permit a more definitive identification of the species.

TABLE I

Relative shape (height as percentage of length) of instars and adults of species of the genus *Danielopolina*. A perfect circle would be 100%, and the percentage will decrease with an increase in elongation. (Length and height measurements are for complete specimens and exclude projecting processes on valves. A few dimensions are based on measurements of illustrated carapaces. The number of stages is unknown for some species; five stages for each species is used in the table because the number of stages is not particularly relevant for comparison of carapace shape for the present purpose.)

Stage	I	II	III	IV	Adult	
					Female	Male
Species						
<i>D. cf. D. kornickeri</i>	71	–	–	–	–	–
<i>D. kornickeri</i>	–	–	–	–	67	–
<i>D. bahamensis</i>	83	84	77-85	–	86-92	83-88
<i>D. styx</i>	–	87	79-84	86	–	–
<i>D. mexicana</i>	85-86	86-88	–	79	75	–
<i>D. wilkensi</i>	75-92	81-100	89	–	83-89	85
<i>D. exuma</i>	78-90	79-90	89-92	86	87-93	88
<i>D. orghidani</i>	–	–	–	–	76-84	–
<i>D. kakuki</i>	–	–	79	–	–	–
<i>D. elizabethae</i>	–	85	–	–	–	91
<i>D. phalanx</i>	–	–	–	–	72-78	–
<i>D. carolinae</i>	–	–	–	–	93	–

Carapace size is quite variable among different species of Halocyprida (cf. Kornicker & Iliffe, 1989), but it may be more than coincidental that adults of species in the subgenus *Danielopolina* are larger than species in the subgenus *Humphreysella* (tables II, III). The division of *Danielopolina* into subgenera is based, as mentioned above, on the presence or absence of a long posterior seta on the protopod of the 2nd antenna. This peculiar seta is a novel feature for the Ostracoda. Apparently, except for the Mystacocarida (cf. Boxshall & Defaye, 1996), it is also absent from other crustacean taxa that could be potential outgroups for the Ostracoda. Obviously, novel structures must arise sometimes, and if they are lacking in potential outgroups, such structures are the best evidence available indicating a synapomorphy, in our case showing a relationship of the species belonging to the subgenus *Danielopolina*. Considering the geographical distribution of the four species of this subgenus (cf. map in Humphreys & Danielopol, 2006) it is improbable that the presence of this seta is a homeomorphic structure with this ostracode group.

It is worth noting that the description of the first Thaumatoocyprididae representative happened 100 years ago (Müller, 1906). It was a deep-sea ostracode, *Thaumatoocypris echinata* Müller, 1906, caught in the Indian Ocean. The second living thaumatoocypridid species, *Danielopolina orghidani* Danielopol, 1972 was

TABLE II

Tabular key to the species of *Danielopolina* new subgenus. All species except *D. carolinae* (deep sea) were collected in anchialine caves. Because appendages are not fully developed, the 1st instar of the specimen described herein from Christmas Island is not included in the key. Abbreviations: art, article; end., endopod; post., posterior; vent., ventral; F, female; M, male; P, present; A, absent. The a-bristle is a dorsal bristle on the 7th article of the 1st antenna

Species	Sex	Carapace length, height (mm)	Post. dorsal process	1 st ant. 7 th art. a-bristle	2 nd ant. end. art. 1, vent. brist.	Furca, articulate/unarticulate claws
<i>D. (D.) kornickeri</i>	F	0.85*, 0.56	A	1	2	1/7
<i>D. (D.) phalanx</i>	F	0.93*, 0.68	A	1	0	3/4
	M	0.86*, 0.57	A	1	0	4/3-4
<i>D. (D.) mexicana</i>	F	0.95*, 0.71	P	1	0	2/5
<i>D. (D.) carolinae</i>	F	1.85*, 0.72	P	0	0	2/6

* Measurement of length does not include processes on valve. Measurements from one specimen.

TABLE III

Tabular key to the species of *Humphreysella* new subgenus. Abbreviations: art, article; brist., bristle; dors., dorsal; end., endopod; post., posterior; vent., ventral; Roman numerals, instar; F, female; M, male; P, present; A, absent. The a-bristle is a dorsal bristle on the 7th article of the 1st antenna

Species	Sex	Carapace length, height (mm)	Post. dors. process	1 st ant. vent./dors. brist.	2nd art. 7th art. a-brist.	Furca, articulate/nonarticulate claws
<i>D. (H.) orghidani</i>	F	0.56*, 0.47	P	1/1	0	2/3
<i>D. (H.) elizabethae</i>	M	0.70*, 0.61	P	0/0	0	1/3
<i>D. (H.) styx</i>	III-IV? F	0.68*, 0.51	A	0/1	1	1/4
<i>D. (H.) exuma</i>	F	0.62*, 0.45	P	0/1	0	2/3
	M	0.51*, 0.45	P	0/1	0	2/3
<i>D. (H.) wilkensi</i>	F	0.63*, 0.50	P	0/1	1	2/6
	M	0.58*, 0.45	P	0/1	1	2/6
<i>D. (H.) bahamensis</i>	F	0.41, 0.37	A	0/0	1	2/3
	M	0.43*, 0.35	A	0/0	1	2/3
<i>D. (H.) kakuki</i>	IV? M	0.63*, 0.44	P	0/1	1	2/2

* Measurement of length does not include processes on valve. Measurements from one specimen.

sampled by Tr. Orghidan in an anchialine cave in Cuba during a 1970 expedition (Danielopol, 1972). As in the present case, only one sub-adult individual was at the time found in Cuba and it represented a real surprise because of the great geographical separation of the new species from locations for *T. echinata* in the Indian Ocean (Danielopol, 1972). The present capture of *Danielopolina* sp. cf. *D. (D.)*

kornickeri offers a new biogeographic puzzle, particularly the question of its origin on Christmas Island, an isolated seamount (Humphreys & Danielopol, 2006). In order to better approach the biogeography and the history of the *Danielopolina* group we need, in the future, to explore better the benthic marine environment, including micro- and macroporous habitats outside and inside anchialine caves. For instance, it may be significant that, whereas most species in the subgenus *Humphreysella* live in caves in the Bahama Islands (refer to the systematic section, above), no species of the subgenus *Danielopolina* have been collected there. The closest location to the Bahamas for a species in the latter subgenus is *D. mexicana*, which lives in caves on the Yucatán Peninsula facing the Gulf of Mexico (Kornicker & Iliffe, 1989).

Finally, to facilitate the potential identification of new species of *Danielopolina*, we offer herein a tabular summary of the main morphological traits distinguishing the known species belonging to the two new subgenera (tables II and III).

ACKNOWLEDGMENTS

Darren Brooks collected the unique *Danielopolina* specimen at Christmas Island. Angel Baltanás kindly provided the photograph of this specimen from which the artistic view is here presented. Tadeusz Namiotko helped with discussion on the origin of this thaumatocypridid at Christmas Island. Molly K. Ryan has drawn figs. 1 and 2 and inked the camera lucida drawings of figs. 3 and 4. The senior author thanks Geoff A. Boxshall, London, for correspondence concerning the protopod of the 2nd antenna of crustaceans. Parks Australia North funded the field collection.

REFERENCES

- BOXSHALL, G. A. & D. DEFAYE, 1996. Classe des Mystacocarides (Mystacocarida Pennak & Zinn, 1943). In: J. FOREST (ed.), *Traité de Zoologie*, 7, Crustacés (2): 409-424.
- DANA, J. D., 1853. Crustacea. Tribe III: Cyproidea — Ostracoda. In: United States Exploring Expedition during the Years 1838, 1839, 1840, 1841, 1842, under the Command of Charles Wilkes, U.S.N., with Atlas of 96 plates, 13: 1277-1304, pls. 90, 91. (C. Sherman, Philadelphia).
- DANIELOPOL, D. L., 1972. Sur la présence de *Thaumatocypris orghidani* n. sp. (Ostracoda, Myodocopida) dans une grotte de Cuba. *Comp. rend. hebd. Séances Acad. Sci., Paris*, 247: 1390-1393.
- DANIELOPOL, D. L., A. BALTANÁS & W. F. HUMPHREYS, 2000. *Danielopolina kornickeri* sp. n. (Ostracoda: Thaumatocypridoidea) from a western Australian anchialine cave — morphology and evolution. *Zoologica Scripta*, 29: 1-16.
- HARTMANN, G., 1985. *Danielopolina wilkensi* n. sp. (Halocyprida, Thaumatocyprididae), ein neuer Ostracode aus einem marinen Lava-Tunnel auf Lanzarote (Kanarische Inseln). *Mitt. Hamburgischen zool. Mus. Inst.*, 82: 255-261.

- HUMPHREYS, W. F. & D. L. DANIELOPOL, 2006. *Danielopolina* (Ostracoda, Thaumatoocyprididae) on Christmas Island, Indian Ocean, a seamount island. *Crustaceana*, **78** (11): 1339-1352.
- HUMPHREYS, W. F. & S. M. EBERHARD, 1998. Assessment of the ecological values and management options for cave use on Christmas Island, Project **97/002**: 1-134. (Western Australian Museum, Unpubl. Report prepared for Parks Australia North).
- KORNICKER, L. S. & T. M. ILIFFE, 1989. New Ostracoda (Halocyprida: Thaumatoocyprididae and Halocyprididae) from anchialine caves in the Bahamas, Palau, and Mexico. *Smithson. Contr. Zool.*, **470**: 1-47.
- — & — —, 1992. Ostracoda (Halocypridina, Cladocopina) from anchialine caves in Jamaica, West Indies. *Smithson. Contr. Zool.*, **530**: 1-22.
- — & — —, 1995. Ostracoda (Halocypridina, Cladocopina) from an anchialine lava tube in Lanzarote, Canary Islands. *Smithson. Contr. Zool.*, **568**: 1-32.
- — & — —, 1998. Myodocopid Ostracoda (Halocypridina, Cladocopina) from anchialine caves in the Bahamas, Canary Islands, and Mexico. *Smithson. Contr. Zool.*, **599**: 1-93.
- — & — —, 2000. Myodocopid Ostracoda from Exuma Sound, Bahamas, and from marine caves and Blue Holes in the Bahamas, Bermuda, and Mexico. *Smithson. Contr. Zool.*, **606**: 1-98.
- KORNICKER, L. S. & I. G. SOHN, 1976. Phylogeny, ontogeny, and morphology of living and fossil Thaumatoocypridacea (Myodocopa: Ostracoda). *Smithson. Contr. Zool.*, **219**: 1-124.
- MÜLLER, G. W., 1906. Ostracoda. In: *Wissenschaftliche Ergebnisse der Deutsche Tiefsee-Expedition 1898-1899*, **8**: 1-154.
- NAMIOTKO, T., K. WOUTERS, D. L. DANIELOPOL & W. F. HUMPHREYS, 2004. On the origin and evolution of a new anchialine stygobitic *Microceratina* species (Crustacea, Ostracoda) from Christmas Island (Indian Ocean). *Journ. Micropalaentol.*, **23**: 49-60.
- SARS, G. O., 1866. Oversigt af Norges marine Ostracoder. *Forhandlinger i Videnskabs-Selskabet i Christiania*, **8**: 1-130.
- VOLSCHENCK, E. S., N. A. LOCKET & M. S. HARVEY, 2001. First record of a troglobitic ischnurid scorpion from Australasia (Scorpiones: Ischnuridae): 161-170. In: V. FET & P. A. SELDON (eds.), *Scorpiones 2001. In memoriam Gary A. Polis*. (British Arachnological Society, Burnham Beeches, Buckshire).

First received 3 November 2005.

Final version accepted 15 November 2005.