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ORIGINAL PAPER

Cryptocorynetes elmorei, a new species of Remipedia (Crustacea) from an anchialine cave on Eleuthera, Bahamas

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Abstract We describe a new species of the crustacean class Remipedia based on three specimens collected from an anchialine cave on Eleuthera, an island of the Bahamian archipelago. *Cryptocorynetes elmorei* n. sp. is distinguished from the other two currently known species of the genus particularly by its extremely long maxillipeds bearing a relatively small terminal claw, the absence of discoid organs on the 4th segment of the maxilla, and the shape of its sternal bars. In addition, *Cryptocorynetes elmorei* is equipped with spiniform processes on the bases of the trunk limbs, and discoid organs that have a different shape than those of *Cryptocorynetes haptodiscus*.

Keywords Blue hole · Great Bahama Bank · Discoid organs

Introduction

During a diving expedition to investigate anchialine cave systems on the Bahamian island of Eleuthera in 2007, one of us (T.M.I.) collected three specimens of Remipedia that could be clearly assigned to the genus *Cryptocorynetes*. The prehensile cephalic appendages of these specimens possess so-called discoid organs, suctorial discs that are unique, diagnostic characters of *Cryptocorynetes*. However, the specimens also exhibited a number of morphological features that justify the status of a valid new species. Here, we present the taxonomic description of *Cryptocorynetes elmorei* n. sp., including detailed drawings of all relevant body parts, in addition to microscopic and SEM photography.

The type species of the then new genus *Cryptocorynetes*, *C. haptodiscus* Yager 1987, was first discovered on Abaco (type locality) and Grand Bahama, two islands at the northern end of the Bahamian archipelago (Fig. 1). In 2004, the second species of the genus, *Cryptocorynetes longulus* Wollermann et al. 2007, was found to inhabit a submerged cave on Cat Island, another island of the Bahamian archipelago southeast of Eleuthera. This species was larger than *C. haptodiscus* and could be easily distinguished by the shape and size of its prehensile cephalic limbs.

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Systematics

Cryptocorynetes elmorei, new species

Type locality Anchialine cave system (Bung Hole) in Wyms Bight, Eleuthera, Bahamas.

Material examined Holotype (SMF-36021; Senckenberg Research Institute and Natural History Museum, Frankfurt, Germany) about 11 mm long, with 26 trunk somites; collected August 15, 2007. Paratype 1 with 21 trunk somites, 11 mm long; collected August 15, 2007. Paratype 2: body length 12.3 mm; collected August 16, 2007. All three specimens were collected by T.M. Iliffe. The holotype is preserved in 70% EtOH. Both paratypes were dissected for the description and are stored in glycerin; body parts of the 11 mm paratype were used for DNA studies and SEM photos.

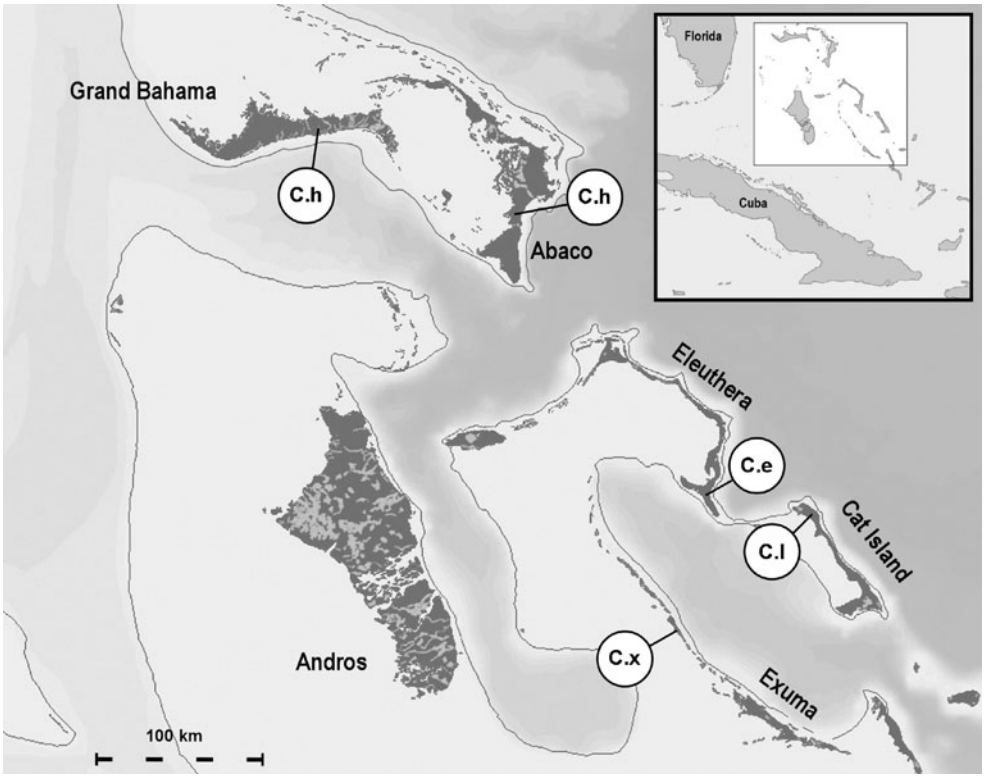

Fig. 1 The northern Bahamas (corresponding with *highlighted square in insert*), showing collection sites of *Cryptocorynetes*. *C.e Cryptocorynetes elmorei* n. sp.; *C.h Cryptocorynetes haptodiscus*; *C.l Cryptocorynetes longulus*; *C.x* presumed new (undescribed) species of *Cryptocorynetes*. Water depths are indicated by different *shadings*; the *thin gray contour line* shows the outlines of the Little Bahama Bank (*above*; surrounding the islands of Grand Bahama and Abaco) and the Great Bahama Bank (*below*). Base map with kind permission of Demis (www.demis.nl)

The remaining body parts of the paratypes are retained in the research collection of the second author (S.K.).

Etymology We dedicate the name of this species to the memory of cave diver Chris Elmore, who generously provided considerable information to us on cave locations in Eleuthera, including Bung Hole. Elmore died in 2008 at the age of 54.

Diagnosis A species of robust build, with a body length up to 12.3 mm. Sternal bars with acuminate distolateral corners; on trunk somite 14 with convex distal margin between both corners. Maxilla without discoid organs on segment 4. Maxilliped very long (nearly twice as long as maxilla), terminal claw smaller than that of maxilla. Bases of trunk limbs with proximal and distal spiniform processes. Anal somite longer than wide.

Description (Figs. 2, 3, 4, 5, and 6) Based on holotype and 2 paratypes. Body robust (Fig. 2), length up to 12.3 mm, with a maximum of 26 trunk somites. Pleurotergites well developed, with broadly rounded distolateral corners in anterior trunk region, becoming more acuminate in posterior part of trunk. Head shield subrectangular, longer than wide, anteriorly with concave lateral excavations (Fig. 3). First trunk somite very narrow, partly covered by head shield (Fig. 3). Sternal plates with distinct, acuminate processes on posterolateral margins (Fig. 6A). Sternal bars heteromorphic, with tapered distolateral corners that become more prominent in posterior trunk; sternal bar of trunk somite 14 enlarged, with convex distal margin between pointed corners; distolateral corners becoming gradually smaller towards posterior trunk (Fig. 6A). Medial processes of frontal filaments shorter than main filaments (Fig. 4C). Female gonopore small, on medioproximal corner (on basis of 7th trunk limb), situated behind spiniform process. Male gonopore (on basis of 14th trunk limb) opening on relatively large cylindrical process.

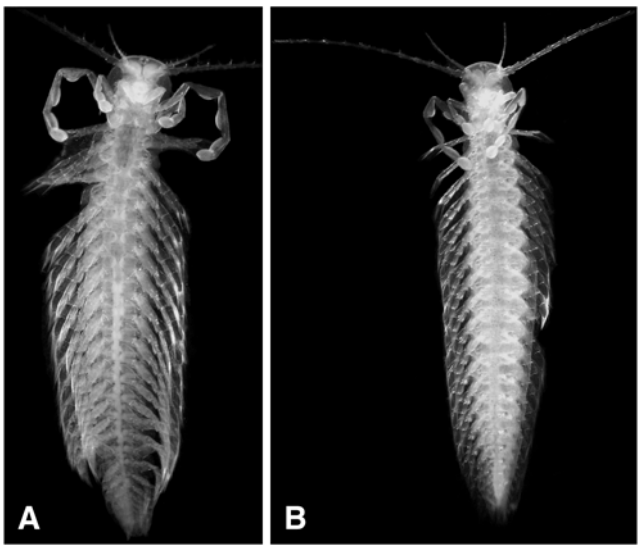

Fig. 2 *Cryptocorynetes elmorei* n. sp. Photographs of living specimens, both ventral view, by B. Gonzalez. **A** 11 mm holotype, **B** 11 mm paratype 1

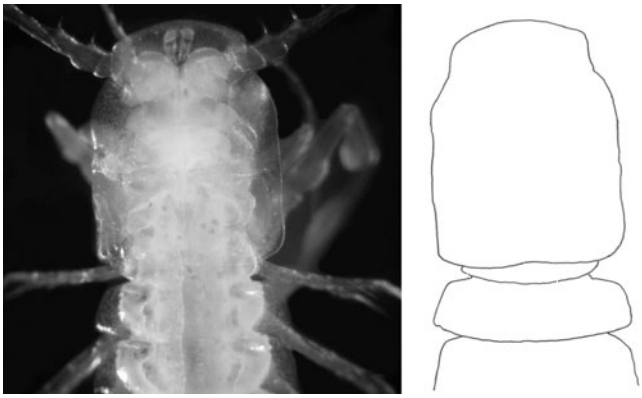

Fig. 3 *Cryptocorynetes elmorei* n. sp. Photograph of 11 mm paratype 1, dorsal view (*left*), and outline drawing of head shield (*right*). Photograph by B. Gonzalez

Antennule (Fig. 4A): peduncle with relatively few peduncular aesthetascs. Dorsal flagellum very long, reaching nearly 50% of body length, composed of 14 segments. Ventral flagellum composed of 8–9 segments, reaching about 1/3 of length of dorsal flagellum. Each segment of both flagella with 1–2 compound aesthetascs and small simple setae.

Antenna (Fig. 4B): proximal segment of protopod with 7 setae, distal segment with about 10 setae. Exopod nearly twice as long as adjacent distal segment of protopod, bearing more than 30 setae. Endopod slightly bent, proximal segment with about 7 setae; following segment with 8 setae on the anterior margin; distal segment with a double row of 21 long setae altogether. All setae plumose.

Labrum (Fig. 4D): posterior lobes bearing several fields of fine setules; medial funnel-shaped excavation with a single row of denticles (Fig. 4E).

Mandible (Fig. 4F–H): left incisor process with 4 strong denticles; lacinia mobilis more or less crescent-shaped,

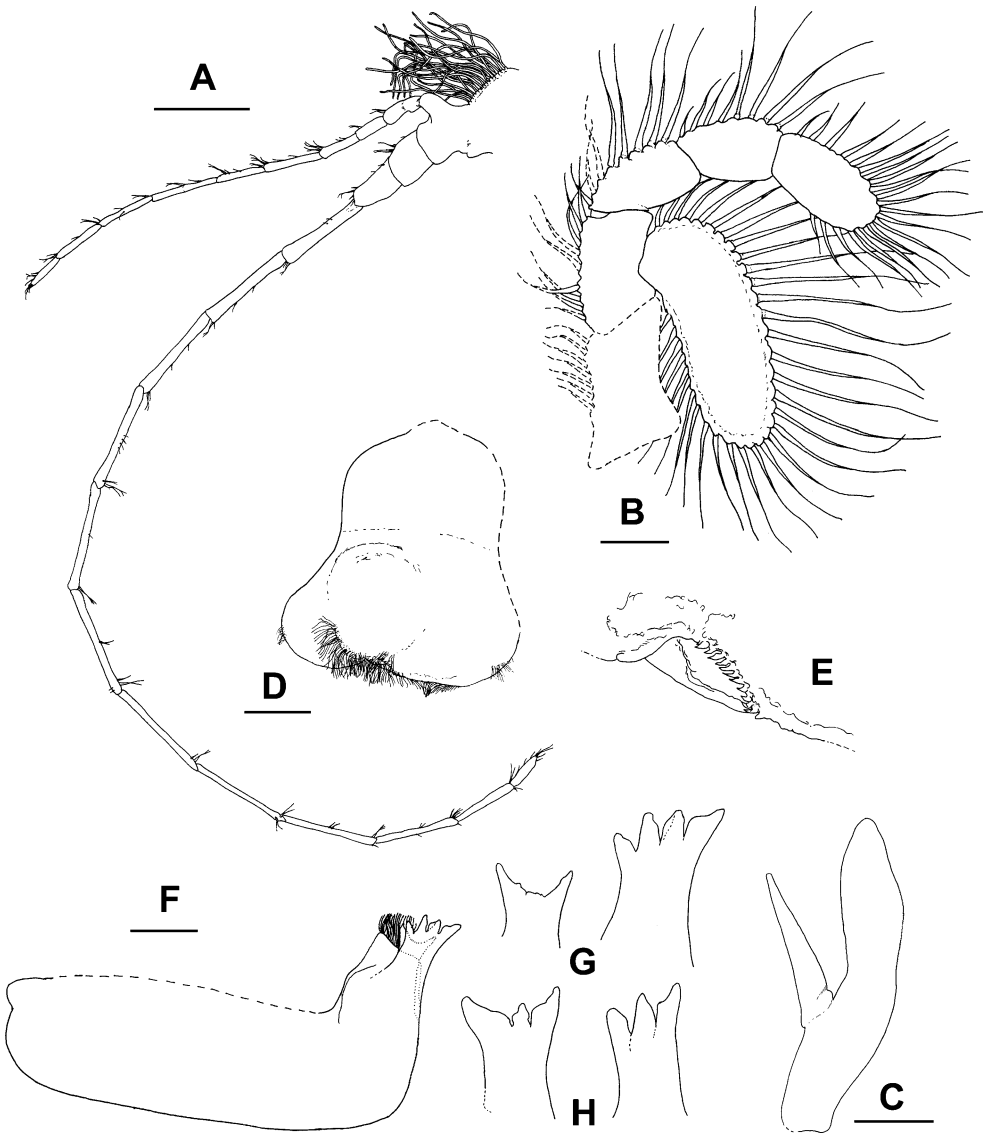

Fig. 4 *Cryptocorynetes elmorei* n. sp. 12.3 mm paratype 2. **A** Antennule; *scale bar* 0.5 mm. **B** Antenna (note that segment 1 of protopod is reconstructed after that of 11 mm paratype 1); *scale bar* 0.1 mm. **C** Frontal filament; *scale bar* 0.1 mm. **D** Labrum; *scale bar* 0.1 mm. **E** Denticle row of labrum enlarged (note that setules are deleted in this drawing). **F** Left mandible; *scale bar* 0.1 mm. **G** Enlarged lacinia mobilis (*left*) and incisor process (*right*) of left mandible. **H** Enlarged lacinia mobilis (*left*) and incisor process (*right*) of right mandible

bearing some irregularly formed small denticles (Fig. 4G). Right incisor process and lacinia mobilis each with 3 strong denticles (Fig. 4H). Molar process well defined, bearing dense field of setulose setae on apical surface.

Maxillule (Fig. 5A) with long, narrow endite on first (basal) segment, bearing 10 robust apical setae, one of which with setulose margin (Fig. 5D). Second segment with spatulate endite, with 1 stout serrate apical seta, followed by about 7 stout naked setae and several long slender setae on anterior margin. Segment 3 with cone-shaped endite, bearing 2–3 stout setulose setae (Fig. 5E). Segment 4 (lacertus) with expanded, oblique inner margin, bearing 1–2 stout setulose setae on corner followed by a double row of 9–10 slender setulose setae. Segment 5 well developed, with a field of few simple setae on distomedial margin. Segment 6 short, with 2 distal fields of simple setae. Terminal claw long, with proximal field of simple setae.

Maxilla much longer than maxillule, with club-like appearance (Fig. 5B). Proximal (basal) segment with 3 prominent endites, each bearing 1 stout naked apical seta

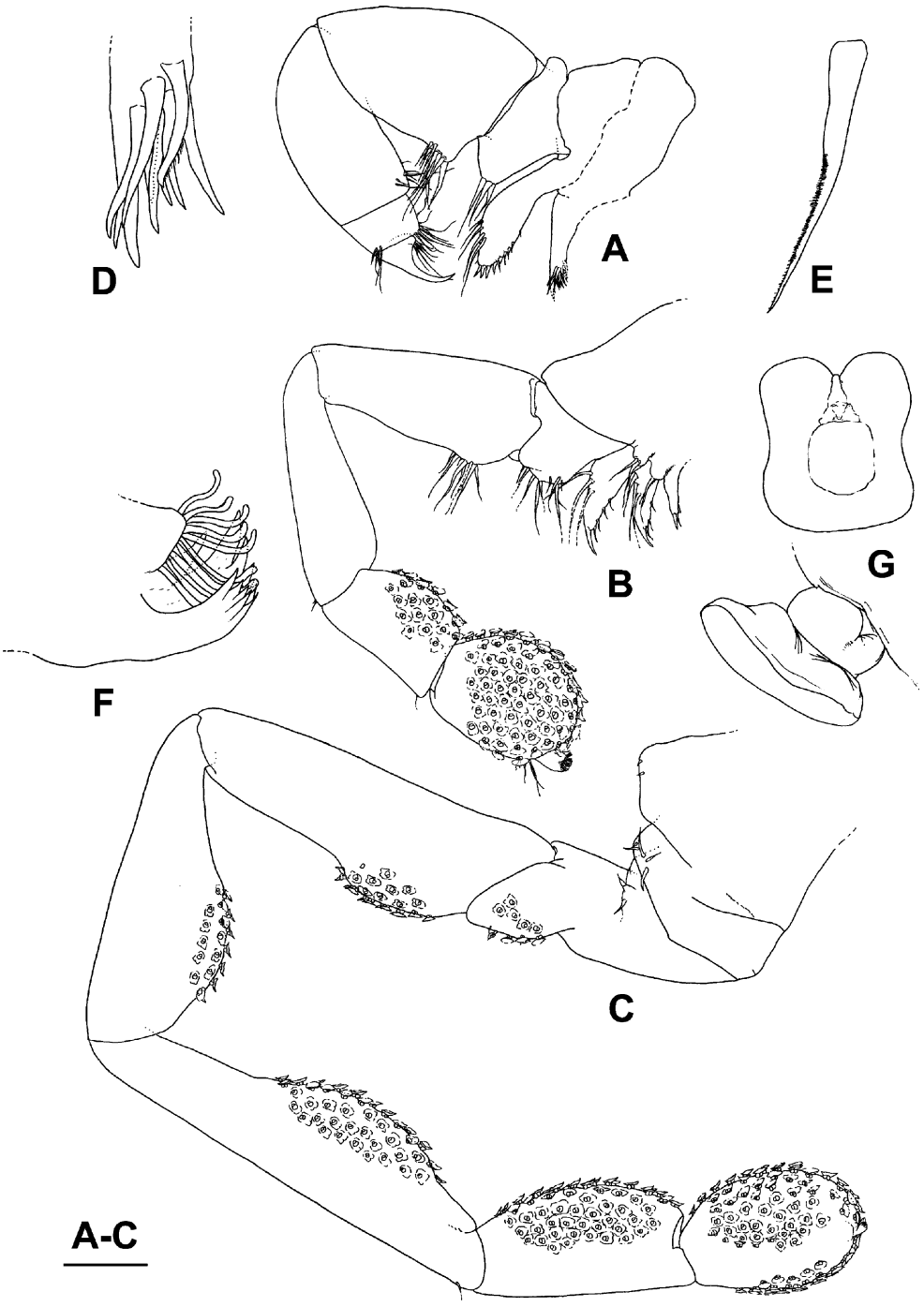

Fig. 5 *Cryptocorynetes elmorei* n. sp. **A**–**E**,**G** 11 mm paratype 1, **F** 12.3 mm paratype 2. **A** Maxillule. **B** Maxilla. **C** Maxilliped. **D** Enlarged maxillulary endite of segment 1. **E** Enlarged stout setulose seta of maxillule. **F** Claw of maxillae and maxillipeds. **G** Discoid organ (freehand drawings; *above*: top view; *below*: lateral view). *Scale bars* **A**–**C** 0.2 mm

accompanied by several short and longer setae; basal region with 2 short rounded endites, each equipped with a few long setae. Segment 2 with broadly rounded endite, bearing several short and long setae. Medioproximal margin of segment 3 (lacertus) weakly expanded, with several long setae. Segment 4 naked, with weakly expanded mediodistal margin. Segment 5 short, expanded, bearing transverse rows of discoid organs on medial margins (Fig. 5G, 7A–C). Segment 6 as long as segment 5, but more expanded and broadly rounded, with regular rows of discoid organs on medial and lateral margins. Terminal claw relatively small, with horseshoe-like arc of 10 deeply incised denticles (Fig. 5F). All setae simple (non-setulose).

Maxilliped (Fig. 5C) about twice as long as maxilla. Proximal segments 1–3 with a few short setae. Segment 3 with few discoid organs on medial margin. Segment 4 very long, with expanded medioproximal endite, covered with discoid organs. Segment 5 shorter than segment 4, with expanded mediodistal margin. Segment 6 distinctly longer than segment 5, with mediodistal expansion. Segment 7 nearly half as long as segment 6; segments 7–8 expanded, similar to segments 5 and 6 of maxilla. Expanded margins of segments 5–8 covered with transverse rows of discoid organs. Terminal claw much smaller than that of maxilla, but horseshoe-like arc similar to that of maxilla (Fig. 5F, 7A, B).

Trunk limb of trunk somite 1 comparatively slender (Fig. 6B), with four-segmented endopod and three-segmented exopod. Segments 1–3 of endopod with long setae on lateral margins; segments 1 and 2 each with 1 short, stout, plumose seta (Fig. 6E) on distolateral margins; segment 4 with long setae on lateral and subapical margins. Segment 1 of exopod with 2, segment 2 with 3 short, stout setae on distolateral margins; one of them plumose (Fig. 6E), the other ones serrate (Fig. 6F); all segments with long setae on lateral margins, segments 2 and 3 also with

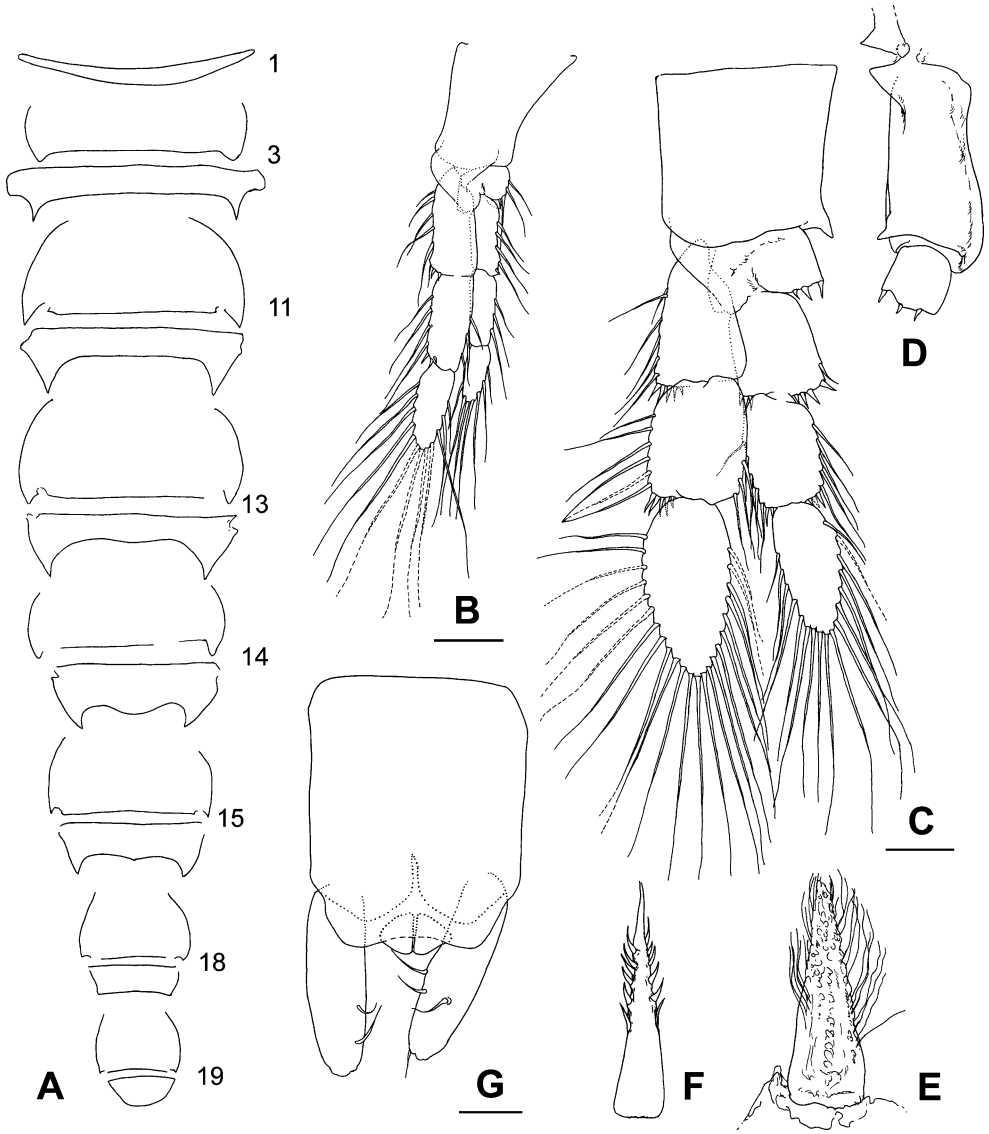

Fig. 6 *Cryptocorynetes elmorei* n. sp. **A**,**G** 11 mm paratype 1, **B**–**F** 12.3 mm paratype 2. **A** Freehand drawing of sternites and sternal bars; *numbers* indicate individual trunk somites. **B** Appendage of first trunk somite, *scale bar* 0.2 mm. **C** Limb of seventh trunk somite, *scale bar* 0.2 mm. **D** Lateral view of protopod of trunk limb (freehand drawing). **E** Short, stout serrate seta. **F** Short, stout plumose seta. **G** Anal somite (note that terminal setae on caudal rami are lost), *scale bar* 0.1 mm

long setae on medial margins. Endopods of larger trunk limbs (Fig. 6C) with 3 short, stout setae on distolateral margin of segment 1, 4 short, stout setae on distolateral margin of segment 2 and 3 on distolateral margin of segment 3; thereof the inner seta of segment 1 serrate, of segment 2 the two inner ones and on segment 3 all 3 setae serrate (Fig. 6F), the other ones plumose (Fig. 6E); distomedial margins of segment 2 with 3, of segment 3 with 2 stout, serrate setae; segments 2–4 with long setae on lateral margins, and on segments 3 and 4 also on medial margins. Distolateral margins of exopodal segment 1 with 5–6, of segment 2 with 5 short, stout, serrate setae; all segments with long setae on lateral margins; on segments 2 and 3 also on medial margins. All long setae of trunk limbs faintly plumose. Medial margins of protopod of larger trunk limbs with proximal and distal spiniform processes (Fig. 6C, D).

Anal somite (Fig. 6G) longer than wide, caudal rami relatively short, reaching about 2/3 of length of anal somite.

Discussion

Ecological profile of the collection site

Bung Hole (24°44.0′N, 76°12.5′W) is located at the southern end of Eleuthera, south of the settlement of Wyms Bight. This 60-m-diameter, circular, inland blue hole is situated about 40 m east of the main road and on the opposite side of the road from White Lake. The shallow edges of the hole slowly descend down a mud slope to a depth of 9 m where a 60-cm-high crack begins at the base of a rock ledge. The crack continues down a talus slope, through two low restrictions with limited visibility to a depth of 45 m where a larger room was encountered and the water clarity increased substantially. Abundant animals were observed in this section of the cave including the cave fish *Lucifuga*, shrimp, isopods, ostracodes, copepods, thermosbaenaceans, and polychaetes. Remipedes were collected in individual vials with ambient cave water from depths of 45–48 m.

Morphological comparisons with closely related species

The new species could be assigned unambiguously to the genus *Cryptocorynetes* because of the occurrence of discoid organs on maxilla and maxilliped; these organs are autapomorphic structures that only occur in this genus. Although the basic prehensile function of maxilla and maxilliped seems obvious, the particular function of the discoid organs is still unknown. It seems likely that they serve to secure large, vigorous and/or slippery prey. Compared with the other species in the genus, the maxillipeds of *Cryptocorynetes elmorei* are enormous, suggesting a specialization on rather large prey organisms. Possible prey of *C. elmorei* could include larval or juvenile cave fish or other cave-inhabiting crustaceans, for example shrimp, thermosbaenaceans and even other remipedes.

Although we assume that filtering small particles out of the water column is an important mode of feeding in at least some remipedes (Koeneman et al. 2007), the interspecific morphologic variability of the three pairs of prehensile cephalic limbs indicates a distinct degree of specialization on different prey organisms. Facultative, specialized carnivory may also explain the occurrence of up to six sympatric species of Remipedia within the same cave system (Koeneman et al. 2003; 2004).

Cryptocorynetes elmorei can easily be distinguished from the other two species of the genus, *C. haptodiscus* and *C. longulus*, by several noticeable morphological features, in particular the exceptionally long maxilliped (see also Table 1). In *C. longulus*, the maxilla only reaches about 2/3 of the maxilliped in length, while in *C. haptodiscus*, it is even shorter. In addition, the terminal claw of the maxilliped in *C. elmorei* is distinctly smaller than that of the maxilla, while there is no distinct size difference between both claws in *C. haptodiscus* and *C. longulus*. Another convenient feature to distinguish the new species from the other two species of *Cryptocorynetes* is the absence of discoid organs on the 4th segment of the maxilla; in both *C. haptodiscus* and *C. longulus*, the 4th maxillary segments bear discoid organs.

Cryptocorynetes elmorei can also be identified by a number of less obvious autapomorphic structures.

- The dorsal flagellum of its antennule is composed of 14 segments (as in *C. longulus*), whereas it possesses 16–18 segments in *C. haptodiscus*.
- The ventral antennular flagellum in *C. elmorei* is composed of 8–9 segments (14 segments in *C. longulus* and 10–12 segments in *C. haptodiscus*); it reaches, as in *C. haptodiscus*, about 1/3 of the length of the dorsal flagellum (in *C. longulus* nearly half the length of the dorsal flagellum).
- The setal patterns of the maxillules differ among the three species. In *C. elmorei*, the endite of segment 1 bears 9 smaller stout setae and 1 large stout seta (Fig. 5A, D), compared to 8 smaller stout setae in *C. longulus*, and at least 7 stout setae in *C. haptodiscus* (based on examination of one individual at hand; in the description of *C. haptodiscus*, the number of stout setae is not mentioned). The 3rd maxillular endite bears 2–3 comparatively long, stout setae in *C. elmorei*, whereas the 3rd endites in both *C. longulus* and *C. haptodiscus* are each equipped with 2 setae (Yager 1987; Wollermann et al. 2007).

Table 1 Comparison of main diagnostic characters in three species of *Cryptocorynetes*

	Cryptocorynetes haptodiscus	*Cryptocorynetes longulus*	*Cryptocorynetes elmorei* n. sp.
Body length	Up to 18 mm	Up to 34.5 mm	Up to 12.3 mm
Trunk somites	Up to 32 somites	Up to 39 somites	Up to 26 somites
A1, dorsal flagellum	16–18 segments	14 segments	14 segments
A1, ventral flagellum	10–12 segments	14 segments	8–9 segments
Mxl, endite of 1st segment	With ca. 7 small stout setae	With 8 small stout setae	With 9 small stout setae
Mxl, endite of 3rd segment	With 2 setae	With 2 setae	With 2–3 setae
Max, length	Max <2/3 length of Mxp	Max=2/3 length of Mxp	Max half as long as Mxp
Max, 4th segment	Discoid organs present	Discoid organs present	Discoid organs absent
Max, Mxp, size of terminal claws	Equal size	Equal size	Claw Mxp < claw Max
Max, Mxp, horseshoe-like arc of claw	With 8–9 fused denticles	With 12–14 fused denticles	With 10 fused denticles
Trunk limbs	Protopod simple	Protopod simple	Protopod with pointed corners
Sternal bars, TS 2–13, distolateral margins	With broadly rounded corners	Without distinct corners	With pointed corners
Sternal bar, TS 14	Pointed triangular flap	Rounded triangular flap	Pointed corners, medial bulge

A1 Antennule (first antenna), *Mxl* maxillule (first maxilla), *Max* maxilla (second maxilla), *Mxp* maxilliped, *TS* trunk somite. See "Discussion" for further explanations

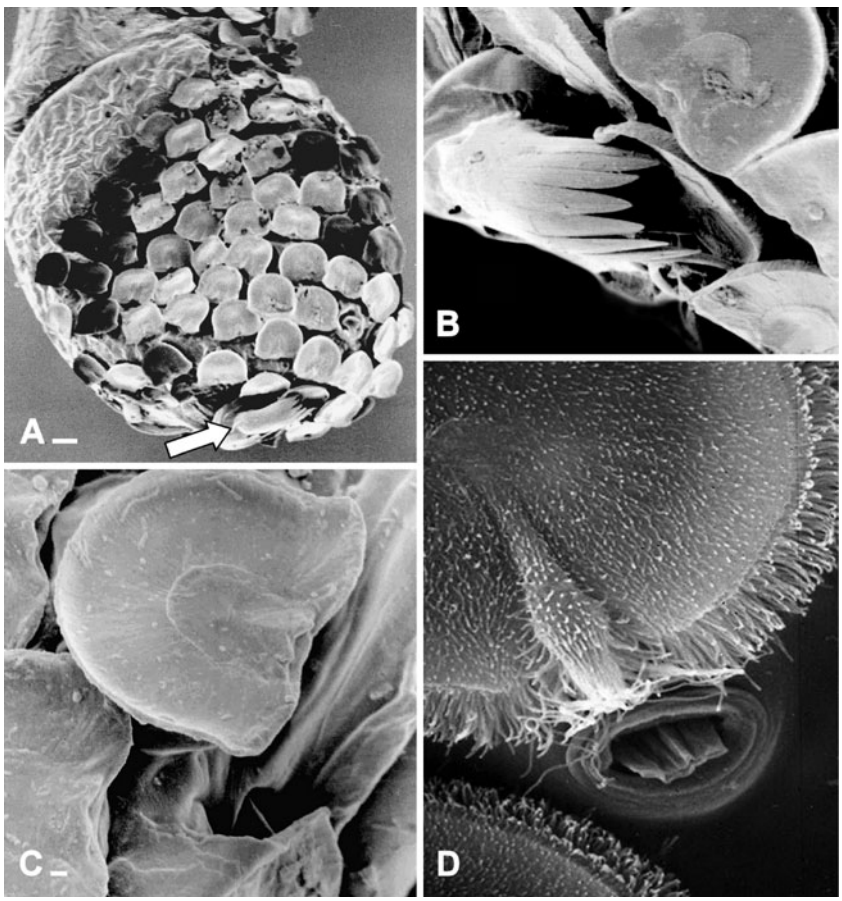

Fig. 7 **A**, **B** *Cryptocorynetes elmorei* n. sp., SEM photos of 11 mm paratype 1; **D** SEM photo of *Cryptocorynetes haptodiscus*. **A** Distal end of maxilliped, with *arrow* pointing at claw, *scale bar* 10 µm. **B** Terminal claw and discoid organs of maxilliped. **C** Upper surface of discoid organ on maxilla, *scale bar* 1 µm. **D** Discoid organ of *Cryptocorynetes haptodiscus* (with kind permission of Jill Yager)

- In *C. elmorei*, the protopods of the trunk limbs have pointed medial corners (Fig. 6C, D); *C. longulus* and *C. haptodiscus* lack these structures.
- Finally, the sternal bars of *C. elmorei* are also equipped with pointed corners (Fig. 6A), which are absent in the other two species (Yager 1987; Wollermann et al. 2007).

We found another remarkable difference between discoid organs in *C. elmorei* and *C. haptodiscus*. The discoid organs in *C. haptodiscus* are circular; the outer surfaces are covered and fringed with fine hairs (Fig. 7D). In *C. elmorei*, one side of each disc is angled, and the surface lacks hairs. A re-examination of discoid organs on dissected prehensile limbs of *C. longulus* appeared similar to those of *C. elmorei* under the light microscope; however, the outer margins of the disk surfaces, although not as clearly visible as in *C. elmorei*, seemed to reveal slight differences in shape and size.

In paratype 1, we found two small endites on segment 1 in both maxillae (Fig. 5B). These structures appeared in addition to the three prominent, typically elongated proximal endites. To date, comparable features have not yet been described in any species of Remipedia. We also detected these knob-like endites in a specimen of *C. haptodiscus*, although less developed than in *C. elmorei*, whereas specimens of *C. longulus* seem to lack these structures.

Remarks on the biogeography of *Cryptocorynetes*

The discovery of the new species *Cryptocorynetes elmorei* constitutes the first record of Remipedia for Eleuthera. In the Bung Hole cave system, the type locality of *C. elmorei*, one of us (T.M.I.) found other remipedes that most likely represent as yet undescribed species of the genera *Godzilliognomus* Yager 1989, *Pleomothra* Yager 1989 and *Speleonectes* Yager 1981. The island of Eleuthera is situated along the eastern margin of a major shallow-water carbonate platform, the Great Bahama Bank (Fig. 1). *Cryptocorynetes longulus* occurs on Cat Island, also on the Great Bahama Bank and directly southeast of Eleuthera. We have a single specimen of a presumably new species of *Cryptocorynetes* from the Exuma Cays, another group of isles on the Great Bahama Bank (Wollermann et al. 2007). The type species of the genus, *C. haptodiscus*, has been reported from the islands of Grand Bahama and Abaco, both located on the Little Bahama Bank, which is separated from the Great Bahama Bank by deeper water (Yager 1987).

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References

Koeneman S, Iliffe TM, van der Ham J (2003) Three new sympatric species of remipede crustaceans (Speleonectidae) from Great Exuma, Bahamas Islands. Contrib Zool 72(4):227–252

Koeneman S, Iliffe TM, Yager J (2004) *Kaloketos pilosus*, a new genus and species of Remipedia (Crustacea) from the Turks and Caicos Islands. Zootaxa 618:1–12

Koeneman S, Schram FR, Iliffe TM, Hinderstein LM, Bloechl A (2007) The behavior of Remipedia (Crustacea), with supporting field observations. J Crustac Biol 27(4):534–542

Wollermann U, Koenemann S, Iliffe TM (2007) A new remipede, *Cryptocorynetes longulus*, n. sp., from Cat Island, Bahamas. J Crustac Biol 27(1):10–17

Yager J (1981) A new class of Crustacea from a marine cave in the Bahamas. J Crustac Biol 1:328–333

Yager J (1987) *Cryptocorynetes haptodiscus*, new genus, new species, and *Speleonectes benjamini*, new species, of remipede crustaceans from anchialine caves in the Bahamas, with remarks on distribution and ecology. Proc Biol Soc Wash 100:302–320

Yager J (1989) *Pleomothra apletocheles* and *Godzilliognomus frondosus*, two new genera and species of remipede crustaceans (Godzilliidae) from anchialine caves of the Bahamas. Bull Mar Sci 44(3):1195–1206