JOURNAL OF CRUSTACEAN BIOLOGY, 27(1): 10–17, 2007

A NEW REMIPEDE, *CRYPTOCORYNETES LONGULUS*, N. SP., FROM CAT ISLAND, BAHAMAS

Ute Wollermann, Stefan Koenemann, and Thomas M. Iliffe

(SK, correspondence; UW) Institute for Animal Ecology and Cell Biology,
University of Veterinary Medicine Hannover, Buenteweg 17d, 30559 Hannover, Germany;
(TMI) Department of Marine Biology, Texas A&M University at Galveston, Galveston, Texas 77553-1675, U.S.A.
(UW: ute.wollermann@tiho-hannover.de; SK: stefan.koenemann@tiho-hannover.de; TMI: iliffet@tamug.edu)

A B S T R A C T

We describe *Cryptocorynetes longulus* n. sp. as the second species assigned to the genus. *Cryptocorynetes longulus* is a relatively large species (up to 34.5 mm long with 38-39 trunk segments) that occurs in sympatry with species of the two other remipede genera *Speleonectes* and *Godzilliognomus*. It was collected from Big Fountain, an anchialine cave on Cat Island, Bahamas. The new species is distinguished from *Cryptocorynetes haptodiscus* in particular by its larger size and more robust habitus, higher number of trunk segments, shape of the head shield, and number of antennular articles; moreover, the prehensile cephalic limbs differ remarkably in shape and size from those described for *Cryptocorynetes haptodiscus*.

Introduction

Six years after the discovery of the crustacean class Remipedia, Yager, 1981, *Cryptocorynetes*, Yager, 1987, was erected as the third genus of the family Speleonectidae. At that time, Remipedia was composed of two families: Speleonectidae, and Godzilliidae erected to accommodate *Godzillius* (Schram, Yager and Emerson, 1986). Two years later, two new genera were assigned to the Godzilliidae: *Pleomothra* Yager, 1989 and *Godzilliognomus* Yager, 1989. These four genera, *Godzillius*, *Pleomothra*, *Godzilliognomus*, and *Cryptocorynetes*, have remained monotypic until the present day.

For almost 20 years, *Cryptocorynetes haptodiscus* Yager, 1987 has been known from two anchialine cave systems on the islands of Grand Bahama and Abaco, both situated on the Little Bahama Bank. During diving expeditions in 2002, 2004, and 2005, we were able to collect specimens of *Cryptocorynetes* from several cave systems that represent not only new locality records for the genus, but also a considerable expansion of its distribution range to the Great Bahama Bank, including Cat Island and the Exuma Cays (Fig. 1). The specimens of the new species described herein, *Cryptocorynetes longulus*, were collected from Big Fountain, an anchialine cave system on Cat Island, in August, 2004. The description is based on eight specimens collected between 30 and 45 m depth.

Definitions of Morphological Terms

In remipede systematics, the terms 'spine' and 'seta' have been used traditionally to distinguish between slender and more robust setal structures. However, according to Watling (1989), there is a distinct difference between a spine and a seta. Watling defined a spine as a non-articulated cuticular extension that has no socket, regardless of its size or shape. A seta, on the other hand, is "an articulated cuticular extension of virtually any shape or size". Based on numerous SEM photos of various species we assume that all remipedes are equipped with a relatively large diversity of multi-functional setae, while in some species, spines sensus Watling are only present as an apical outgrowth of the first maxillular endite. Therefore, we will adopt the terminology proposed by Watling in this paper and refer to 'spines' as stout (or spiniform) setae.

The terms 'brachium' and 'lacertus' were introduced by Koenemann et al. (in press). For convenience, we repeat the definitions for both terms.

brachium: (Lat. bracchium, -i, n.; "lower arm to wrist") This term defines all segments distal to the elbow including the claw.

lacertus: (Lat. lacertus, -i, m.; "upper arm") Refers to the typically expanded segment immediately proximal to the elbow in maxillule, maxilla and maxilliped.

elbow: The main point of flexure in maxillules, maxillae and maxillipeds, typically dividing a robust proximal part from a more slender distal unit.

Systematics

Genus *Cryptocorynetes* Yager, 1987

Type Genus.—*Cryptocorynetes* Yager, 1987.

Diagnosis.—Antennular dorsal flagellum with 14-18 segments. Lacertus of maxillule weakly expanded. Brachial armature of maxilla and maxilliped with discoid organs; terminal claws with 12-14 small denticles and larger, separate outer denticles. Trunk with up to 39 segments; sternal bars heteromorphic, sublinear with parallel or concave margins anterior to somite 14, as enlarged triangular flap on trunk segment 14.

Remarks.—The most distinctive diagnostic feature of the genus *Cryptocorynetes* is the presence of numerous discoid organs on maxillae and maxillipeds. Since there are no species with comparable transitional structures known, *Cryptocorynetes* is easily distinguished from all other remipedes. Although we do not know whether discoid organs have been derived from setae or represent a different type of cuticular outgrowth, we consider these unique structures a conspicuous autapomorphy. Accordingly, the assignment of *C. longulus* n. sp. to this genus is well-supported, since maxillae and maxillipeds of this new species are also equipped with discoid organs (see also Discussion).

Cryptocorynetes longulus, new species
Figs. 2-5

Type Locality.—Big Fountain (Orange Creek), Cat Island, Bahamas (24°39′08″N, 75°42′00″W).

Material Examined.—Eight specimens (see Table 1 for body sizes and number of trunk segments); holotype (31.1 mm

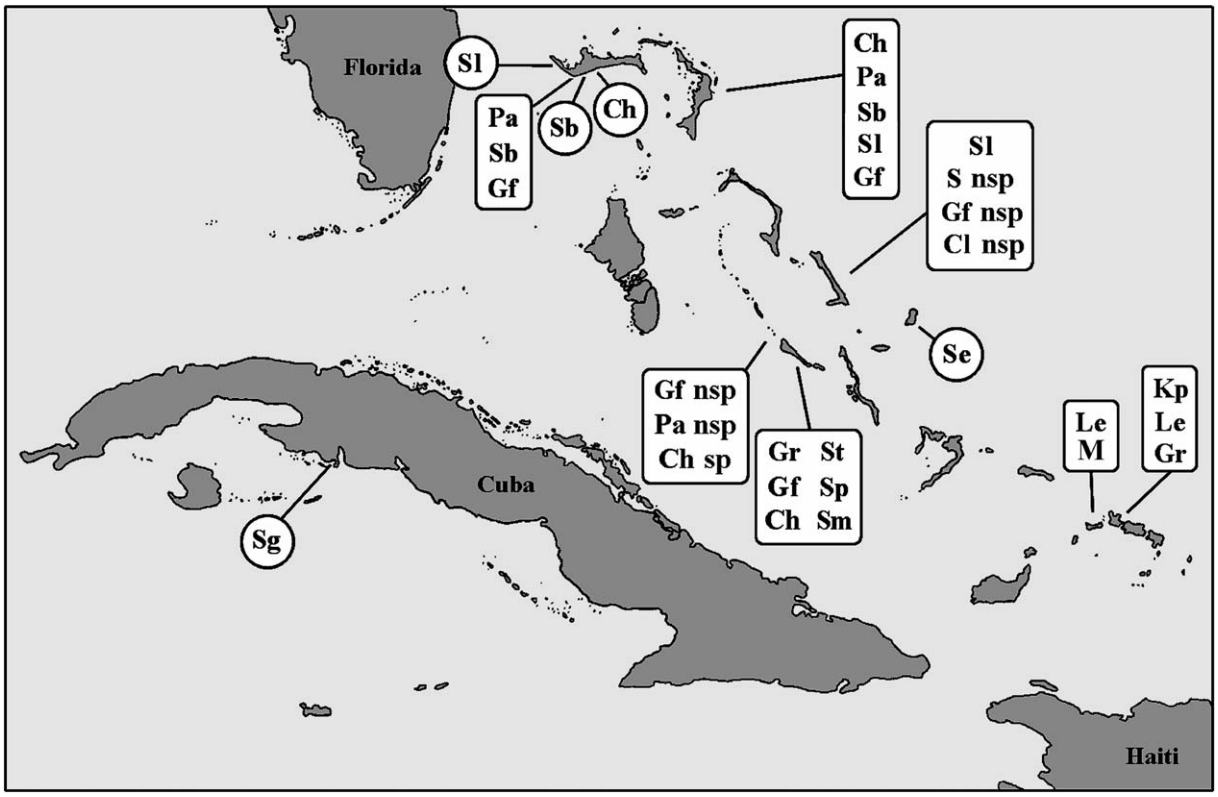

Fig. 1. Map of the northeastern Caribbean region showing collection localities for several species of Remipedia (Ch = *Cryptocorynetes haptodiscus*, Ch sp = undetermined species of *Cryptocorynetes*, Cl nsp = *Cryptocorynetes longulus* n. sp., Gf = *Godzilliognomus frondosus*, Gf nsp = new species near *Godzilliognomus frondosus*, Gr = *Godzillius robustus*, Kp = *Kaloketos pilosus*, Le = *Lasionectes entrichoma*, M = new family of Remipedia (Koenemann et al., in press), Pa = *Pleomothra aplectocheles*, Pa nsp = new species near *Pleomothra aplectocheles*, Sb = *Speleonectes benjamini*, Sg = *Speleonectes gironensis*, Sl = *Speleonectes lucayensis*, Sm = *Speleonectes minnsi*, S nsp = undetermined species of *Speleonectes*, Sp = *Speleonectes parabenjamini*, St = *Speleonectes tanumekes*).

long, 38 trunk segments); 4 paratypes dissected for descriptions and DNA isolation; all specimens were collected from the type locality by Thomas M. Iliffe on 18 August 2004.

Holotype.—Deposited at Zoological Museum Amsterdam (ZMA Crust. Rem. 204750).

Paratypes.—Retained in the SK research collection.

Etymology.—The epithet *longulus* (Latin; rather long) refers to the relatively long trunk and appendages of the new species.

Diagnosis.—Relatively long species of robust build, up to 34.5 mm long, largest specimens composed of 38-39 trunk segments; first trunk segment very narrow, not covered by head shield; cuticular bars on sternal plates 1-13 with parallel margins, those on trunk segment 14 and more posterior segments as triangular flaps. Frontal filaments each with medium-sized medial process. Dorsal flagella of antennules long, reaching nearly 50% of body length; dorsal and ventral flagella each composed of 14 segments.

Description.—Body robust and long (Fig. 2, Table 1), length from 11.5 up to 34.5 mm, with 27-39 trunk segments. Pleural tergites well developed, with broadly rounded distolateral corners, becoming more acuminate on posterior part of trunk (Fig. 3A). Head shield subrectangular, tapered anteriorly. First trunk segment very narrow, not covered by head shield (Fig. 3A).

Sternal plates with small, triangular projections at posterolateral corners (Fig. 3B). Sternal bars on trunk segments 1-13 narrow, with parallel margins; trunk segment 14 with large, triangular sternal flap, such flaps on more posterior trunk segments also bear medium triangular flaps but smaller than that of trunk segment 14. Frontal filaments each with relatively short medial process (reaching half the length of the main filament) (Fig. 4D).

Antennules (Fig. 4A) with peduncle bearing dense rows of long aesthetascs. Dorsal flagellum very long, reaching nearly 50% of body length, composed of 14 segments. Ventral flagellum also with 14 segments, reaching 40-50% of length of dorsal flagellum, articulations of proximal segments weakly developed. Each segment of both flagella with small short setae and 2-4 compound aesthetascs (Fig. 4B).

Antennae (Fig. 4C) with proximal segment of protopod bearing 4 setae, distal segment with 15 setae. Exopod wider and more than twice as long as adjacent distal segment of protopod, equipped with more than 60 long setae. Endopod slightly bent; proximal segment with 12 setae; following segment with double row of 21 long setae (altogether) on anterior margin; distal segment with double row of 28-30 setae (altogether) on lateral and distal margins, and single row of 11 setae on medial margin. All setae feathered (Fig. 3D).

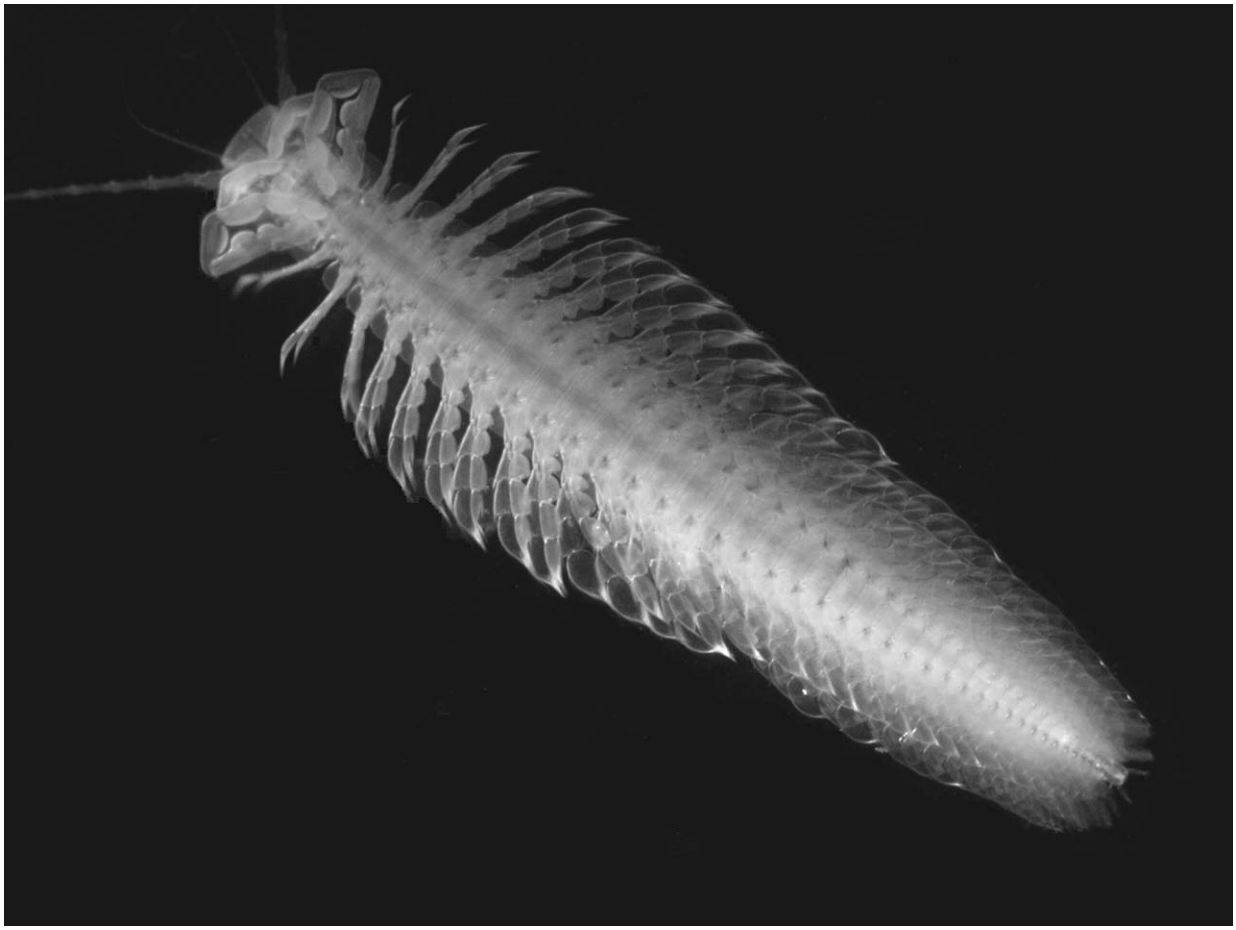

Fig. 2. *Cryptocorynetes longulus* n. sp. Photograph of a refrigerated living specimen (ventral view).

Labrum (Fig. 4E) bearing three disjunct clusters (one median, two lateral) of very fine setules on apical margin.

Mandible left incisor process equipped with 4 strong denticles; left lacinia mobilis more or less crescent-shaped, bearing several small and larger denticles (Fig. 4G). Right incisor process and lacinia mobilis each with 3 strong denticles (Fig. 4H). Molar processes well developed; distal surface long and narrow, bearing dense transverse rows of setae on apical surface.

Maxillule (Fig. 5A) segment 1 (basal segment) with long and narrow endite, bearing 1 large spine and 8 smaller, stout (spiniform) setae apically. Segment 2 with broad, prominent, irregularly formed endite, bearing apically 1 rasplike stout seta followed by 17 naked stout setae and several long setae on anterior margin; slightly excavated posterior margin with row of setae; lateral surface with 2 setae. Segment 3 with cone-shaped endite, bearing 2 prominent rasplike stout setae (Fig. 5D) and 3 slender setae. Segment 4 (lacertus) robust, with expanded, oblique enditic margin, bearing 1 prominent rasplike stout seta (Fig. 5D) and double row of 17 long, naked setae (altogether). Segment 5 stout, bearing distal cluster of 7 long setae, and row of short setae along inner margin. Segment 6 short, with disjunct clusters of long setae on distal margins. Claw long and well developed.

Maxilla (Figs. 2, 5B) three endites of segment 1 each bearing 1 prominent, naked, apical seta, accompanied by several short setae; few long setae on lateral margins. Segment 2 with short, broadly rounded endite, bearing double row of long and short setae. Medioproximal margin of segment 3 (lacertus) distinctly expanded, with long setae on enditic margin. Segments 4 to 6 (brachium) weakly expanded, decreasing gradually in length, bearing each dense fields of discoid organs on medial margins. Terminal claw small, with horseshoe-like arc of 12-14 fine denticles and larger, separate outer denticles (Fig. 5E).

Maxillipeds distinctly longer than maxillae (Figs. 2, 5C). Proximal segments 1 to 3 with oblique articulation; segment 3 broadly rounded, bearing 2 setae and dense field of discoid organs on medial margin. Segment 4 elongate, with expanded medioproximal margin covered with discoid organs. Segment 5 shorter than segment 4, distal margin expanded. Segment 6 distinctly longer than segment 5, segments 6 to 8 gradually decreasing in length. Segments 5 to 8 densely covered with discoid organs on medial margins. Claw similar to that of maxilla (Fig. 5E).

Trunk appendages (Figs. 2, 3C) with limbs of region anterior to mid-trunk level stout; limbs of anterior-most and posterior trunk regions smaller and narrower, gradually decreasing in length and width. Segments 1 to 3 of four-segmented endopod with dense rows of short spiniform setae on distolateral and -medial margins (Fig. 3E, F); segments 3 and 4 with long setae on lateral and medial margins.

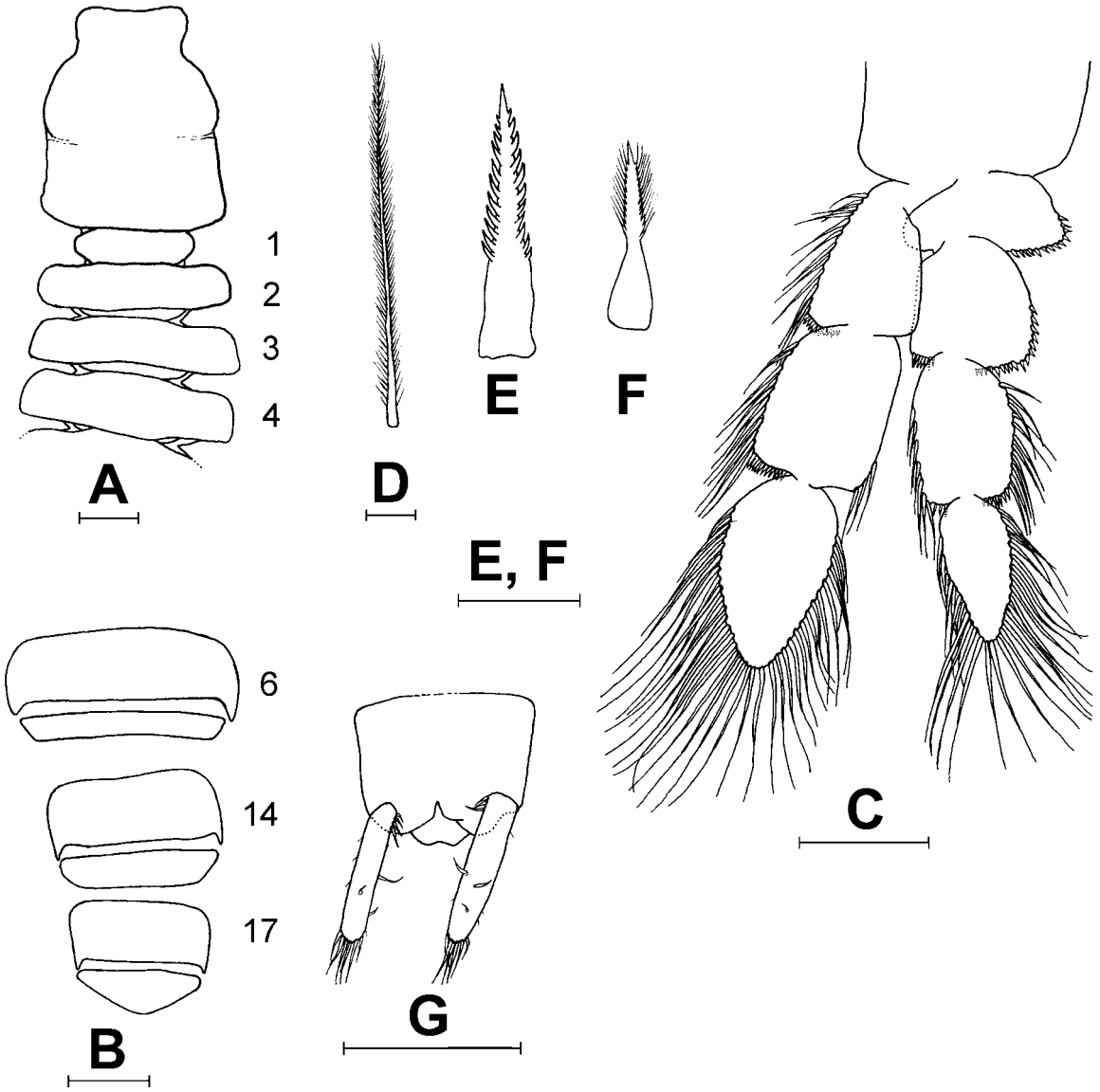

Fig. 3. *Cryptocorynetes longulus* n. sp.; A, B, 31.1 mm holotype; C-G, 34.5 mm paratype. A, head shield and following trunk segments, dorsal view (scale bar = 1 mm); B, sternites and sternal bars of segments 6, 14, and 17 (scale bar = 1 mm); C, 4th thoracopod (scale bar = 1 mm), bearing structures D-F; D, feathered seta (scale bar = 0.1 mm); E, serrate spiniform seta; F, feathered spiniform seta (scale bar E, F = 0.05 mm); G, anal segment and caudal rami (scale bar = 1 mm).

Segments 1 and 2 of exopod with rows of short spiniform setae on distolateral margins; all segments with long setae on lateral margins, segments 3 and 4 also on distomedial margins. All long and slender setae feathered (Fig. 3D).

Female gonopores on bases of 7th trunk limbs very small, knob-like; male gonopores on 14th trunk limbs as cylindrical processes.

Anal segment (Fig. 3G) slightly wider than long; caudal rami as long as anal somite.

Discussion

Morphological Affinities

Cryptocorynetes longulus is easily distinguished from *Cryptocorynetes haptodiscus* by a number of morphologic characters. In general, the new species appears more robust and is larger than *C. haptodiscus*. The relatively larger body size of *C. longulus* is, in part, the result of a considerably higher number of trunk segments in adult specimens (see Table 1 for a comparison). The dorsal flagellum of the antennule consists of fewer segments (14 in *C. longulus* vs. 16-18 in *C. haptodiscus*). The ventral flagellum also is composed of 14 segments (10-12 segments in *C. haptodiscus*), and it reaches nearly 50% of the length of the dorsal flagellum (less than 1/3 of the length of dorsal flagellum in *C. haptodiscus*).

Further morphological differences between the two species can be found in the three pairs of prehensile cephalic limbs. The general shape of the maxillule in *C. longulus* is quite different from that described for *C. haptodiscus*. For

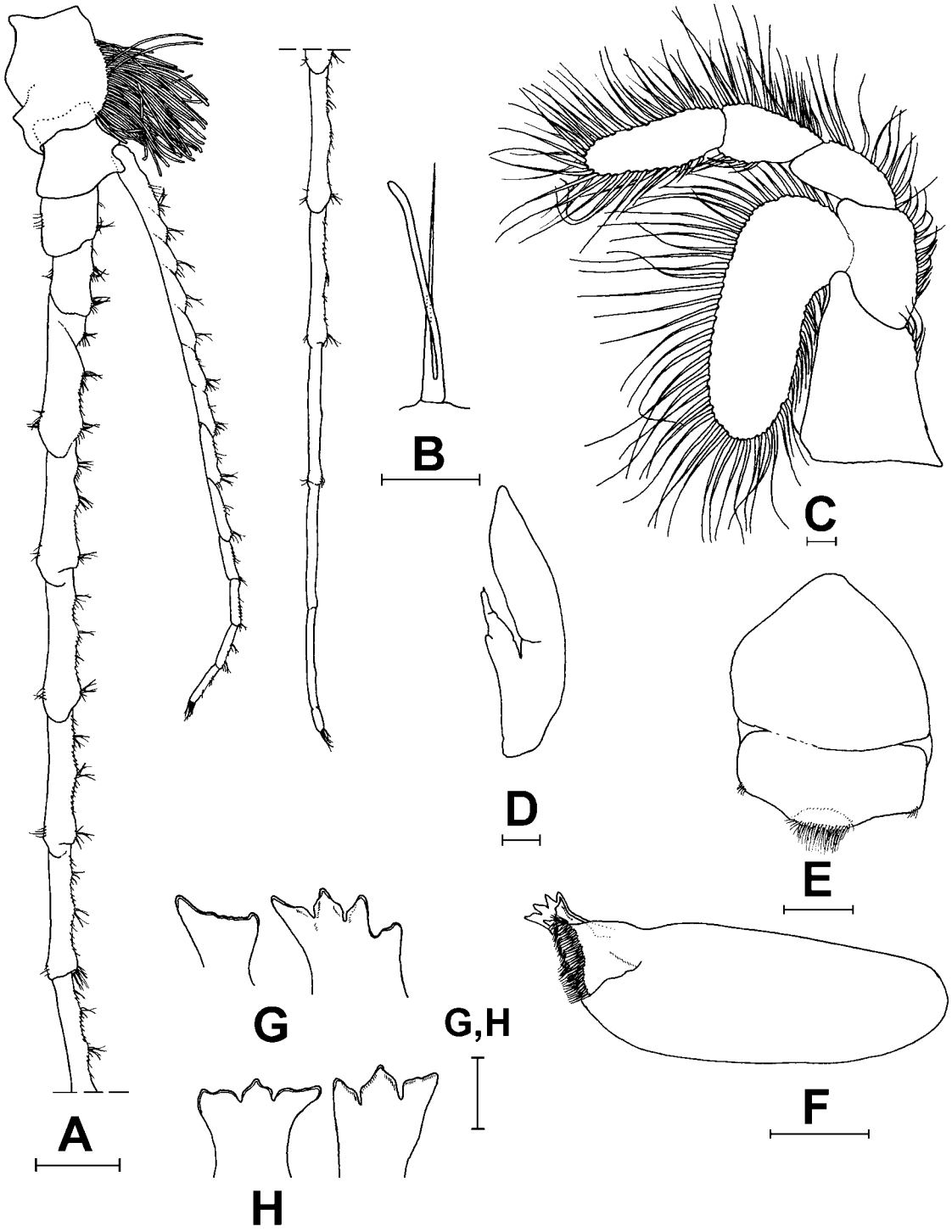

Fig. 4. *Cryptocorynetes longulus* n. sp., 34.5 mm paratype. A, antennule (scale bar = 1 mm); B, compound aesthetasc (scale bar = 0.05 mm); C, antenna (scale bar = 0.1 mm); D, frontal filament (scale bar = 0.1 mm); E, labrum (scale bar = 0.1 mm); F, left mandible (scale bar = 0.1 mm); G, enlarged lacinia mobilis (left) and incisor process (right) of left mandible; H, enlarged lacinia mobilis (left) and incisor process (right) of right mandible (scale bar G, H = 0.05 mm).

example, segment 5 of the maxillule is nearly as broad and stout as segment 4 (lacertus) in *C. longulus* (vs. rather narrow brachium in *C. haptodiscus*). Segment 3 bears two prominent stout setae, whereas there is only one stout seta on segment 3 of *C. haptodiscus*. Finally, in *C. longulus*, the maxillule is much more robust than the maxilla, while the maxilliped is much longer than the maxilla (vs. rather small maxillule and relatively shorter maxilliped in *C. haptodiscus*).

Minor morphological differences between *C. longulus* and *C. haptodiscus* include: a head shield that is clearly tapered anteriorly and does not cover the first trunk segment

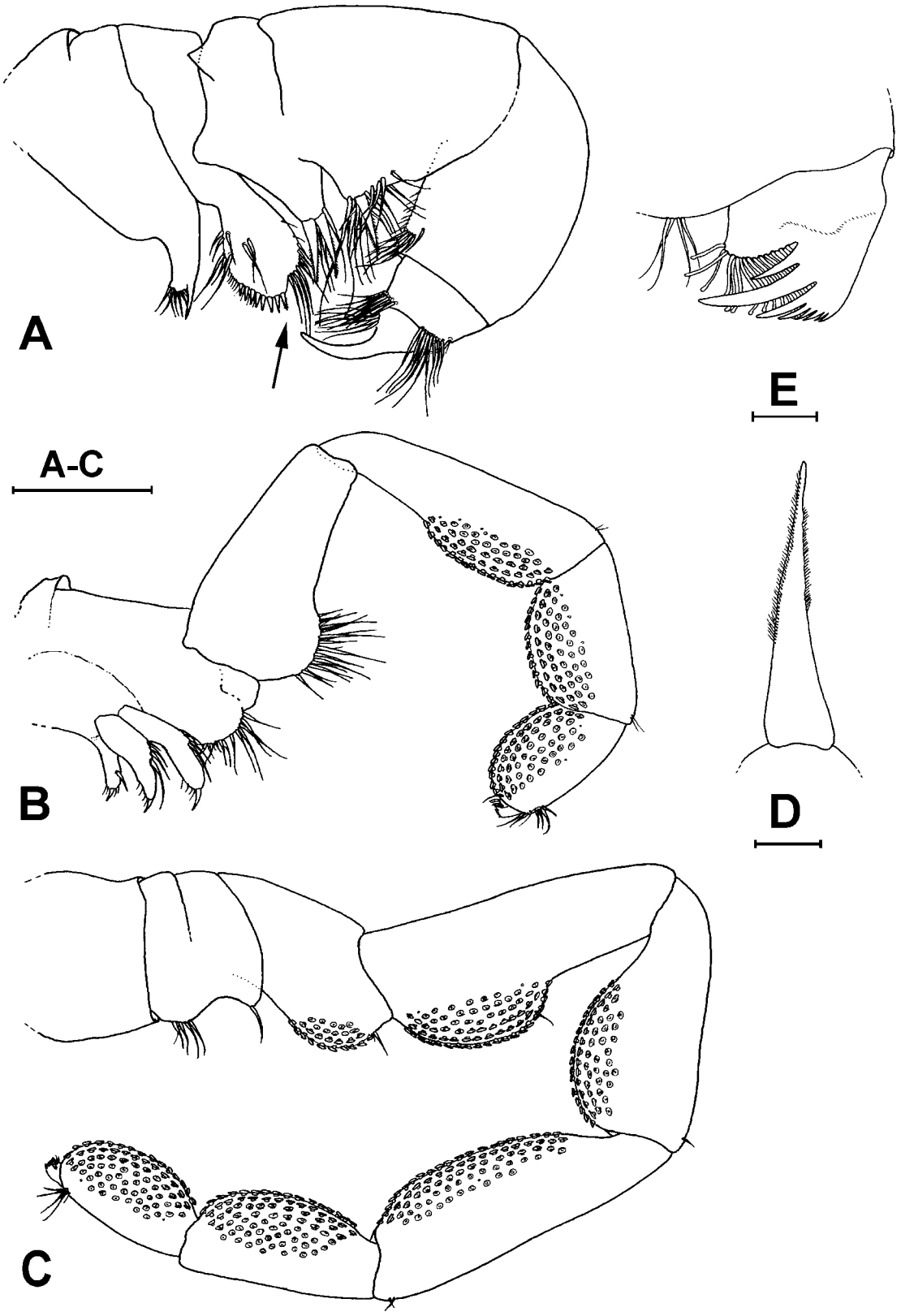

Fig. 5. *Cryptocorynetes longulus* n. sp., 34.5 mm paratype; A, maxillule (arrow pointing to single stout (spiniform) seta on endite of segment 2); B, maxilla; C, maxilliped (scale bar A-C = 1 mm); D, enlarged spiniform seta of maxillule (scale bar = 0.05 mm); E, enlarged claw of maxilla (scale bar = 0.1 mm).

Table 1. Recorded body lengths (mm) and numbers of trunk segments for different specimens of 2 species of *Cryptocorynetes*. Abbreviations: BH = collection J. Yager; SK = Stefan Koenemann; USNM = United States National Museum; Y&C = Yager & Carpenter; ZMA = Zoological Museum Amsterdam.

Species	Source	Trunk segment no. 27	28	29	30	31	32	33	34	35	36	37	38	39
C. haptodiscus	BH 232					13.0								
C. haptodiscus	USNM 368231		11.0											
C. haptodiscus	Yager "1987"						16.3							
C. haptodiscus	Yager "1994"					18.0								
C. haptodiscus	Y&C "1999"		9.7											
C. haptodiscus	Y&C "1999"						17.6							
C. longulus	holotype (ZMA 204750)												31.1	
C. longulus	paratype (SK collection)													34.5
C. longulus	paratype (SK collection)			18.3										
C. longulus	paratype (SK collection)		11.5											
C. longulus	paratype (SK collection)										24.8			
C. longulus	paratype (SK collection)											22.3		
C. longulus	paratype (SK collection)											23.0		
C. longulus	paratype (SK collection)	11.8												

(vs. rather rectangular and not distinctly tapering, and almost completely covering the first trunk segment in *C. haptodiscus*); cuticular bars on segments 1-13 that have almost parallel margins (vs. distinctly concave anterior margins in *C. haptodiscus*); and caudal rami that are rather long and narrow (vs. short in *C. haptodiscus*).

At present, the genus *Cryptocorynetes* is known from four Bahamian islands (Fig. 1) located on two shallow water platforms, the Great Bahama and Little Bahama Banks, separated from one another by the Northeast (3800 to 4700 m deep) and Northwest (700 to 2800 m deep) Providence Channels. *Cryptocorynetes haptodiscus* was reported by Yager (1987) from Mermaid's Lair on Grand Bahama and Dan's Cave on Abaco, both located on the Little Bahama Bank. During a recent diving expedition in March, 2006, we collected six specimens of *C. haptodiscus* from a new locality at Sawmill Sink on Abaco.

The new species described herein, *C. longulus*, was collected on Cat Island on the Great Bahama Bank, approximately 230 km southeast of Abaco Island, in August, 2004. In addition, a single specimen of *Cryptocorynetes* was collected by us in 2002 from Oven Rock, an

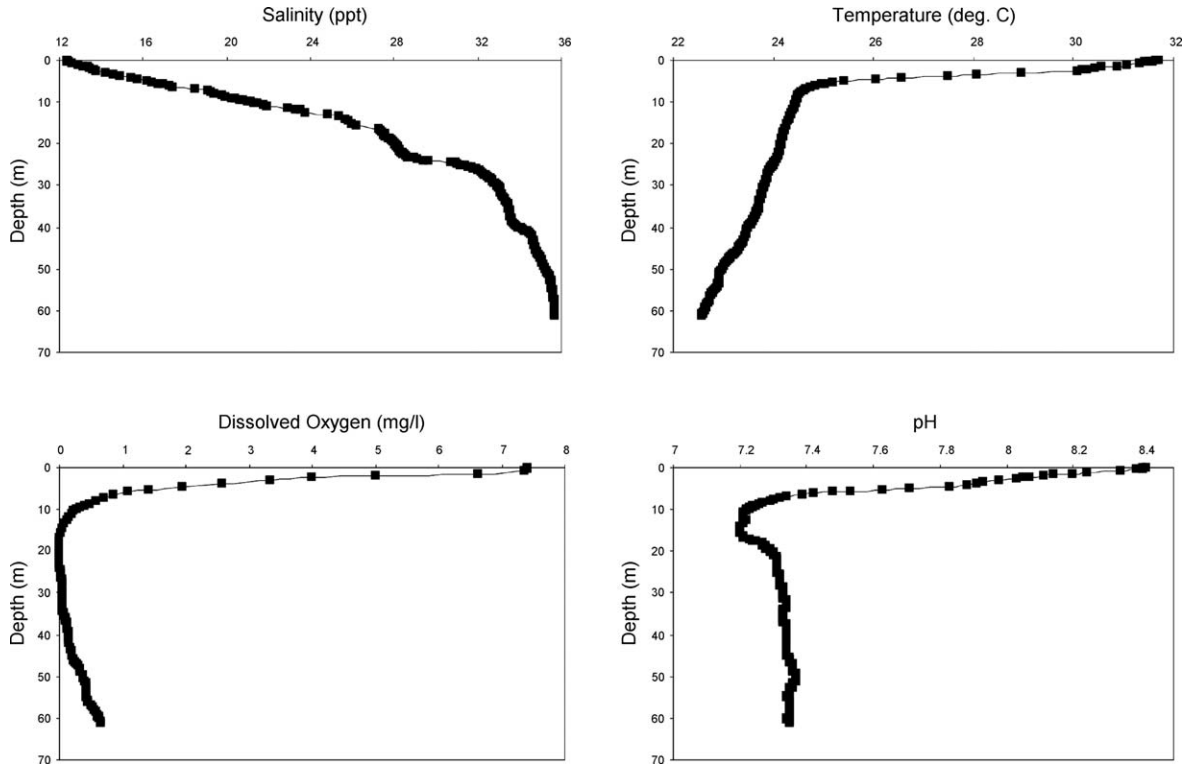

Fig. 6. Salinity, temperature, dissolved oxygen, and pH water column profiles from Big Fountain, Cat Island, Bahamas, taken on 12 August 2004 with a YSI Model 6000 multi-parameter water quality monitor. Black squares (■) represent individual data points.

anchialine cave on Great Guana Cay, Exuma Cays, also on the Great Bahama Bank. Although the specimen from the Exuma Cays showed a number of minor morphological differences both from *C. longulus* and *C. haptodiscus*, it was not possible to confidently determine whether it belonged to either one of the two species. The morphologic deviations were also too weak to justify recognition as a new (third) species. We encountered similar problems regarding the identification of specimens of *Godzilliognomus* and *Pleomothra*, also collected from the Exuma Cays during the 2002 expedition. In these cases, we will have to await the results of our ongoing analyses of several genetic markers to identify these remipedes.

Ecological Profile of the Type Locality

Big Fountain on Cat Island is an open, 40 m long by 25 m wide, water-filled sinkhole, situated about 1.5 km inland from the coast in a low, marshy area (Palmer et al., 1986). An underwater rift chamber begins at depth of 33 m in the southeast corner of the pool and extends to at least 65 m depth. The inclined rift passage continues horizontally for 75 m with numerous speleothems on both roof and floor. A YSI Model 6000 multi-parameter water quality monitor was used to determine a vertical profile starting at the surface pool (Fig. 6). Salinity rose steadily from 12 ppt at the surface to 33 ppt at 30 m depth and then more gradually to 35.7 ppt at 61 m depth. Temperature dropped steeply from 31.7°C at the surface to 24.5°C at 8 m, followed by a gradual decrease to 22.6°C at 61 m. Dissolved oxygen concentration fell from 7.4 mg/L at the surface to 0.3 mg/L at 10 m and remained at zero down to 36 m before slowly recovering to reach 0.7 mg/L at 61 m. pH declined from 8.4 at the surface to 7.2 at 11 m, and were constant below 20 m at 7.3. Clouds of sulfide precipitates was present between 10 and 17 m depth, with a gradual improvement in water clarity below that point and great improvement below 35 m depths. The remipedes were collected in individual vials at 35-50 m depths. Also collected were the cirolanid isopod *Cirolana* (*Cirolana*) *troglexuma* Botosaneanu and Iliffe, 1997, the shrimp *Agostocaris williamsi* Hart and Manning, 1986, the copepods *Bofuriella* and *Bomburiella*, the ostracode *Spelaeoecia*, the thermosbaenacean *Tulumella*, and the polychaete *Pelagomacellicephala*.

Acknowledgements

The collection of specimens from Abaco Island in 2006 was supported by a grant of the German Research Society to S. Koenemann (DFG KO 3483/1-1). The research expedition to Cat Island in August, 2004, and the expedition to Abaco in March, 2006, were funded by a grant from the Biodiversity Surveys and Inventories Program of the National Science Foundation (DEB-0315903) to T. Iliffe. Collection of biological specimens from the Bahamas was done under a marine resource collection permit from the Bahamas Department of Fisheries to T. Iliffe. Biological studies and dives in Sawmill Sink, Abaco, were carried out with permission from the Antiquities, Monuments and Museums Corporation of the Bahamas. We thank the following 2004 Abaco expedition team members: Pennsylvania State University at Worthington Scranton biologist Dr. Renee Bishop, Texas A&M graduate students Lara Hinderstein and Brett Gonzalez, University of Veterinary Medicine Hannover (Germany) graduate student Mario Hoenemann, and cave divers Brian Kakuk (Bahamas Underground, Bahamas), Gregg Stanton (Walkulla Diving Center, Florida), and Tamara Thomsen (Diversions Scuba, Wisconsin). Logistical assistance for field work in Abaco was generously provided by Nancy Albury (Friends of the Environment, Abaco). Gregg Stanton also assisted with diving and research activities during the 2004 Cat Island expedition.

References

Botosaneanu, L., and T. M. Iliffe. 1997. Four new stygobitic cirolanids (Crustacea: Isopoda) from the Caribbean—with remarks on intergeneric limits in some cirolanids. Bulletin de L'Institut Royal des Sciences Naturelles de Belgique, Biologie 67: 77-94.

Hart, C. W., and R. B. Manning. 1986. Two new shrimps (Procaridae and Agostocarididae, new family) from marine caves of the western North Atlantic. Journal of Crustacean Biology 6: 408-416.

Koenemann, S., T. M. Iliffe, and J. van der Ham. 2003. Three new species of remipede crustaceans (Speleonectidae) from Great Exuma, Bahamas Islands. Contributions to Zoology 72(4): 227-252.

———, ———, and ———. (in press.) Micropacteridae, a new family of Remipedia (Crustacea) from the Turks and Caicos Islands. Organisms Diversity & Evolution.

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

Palmer, R. J., M. McHale, and R. Hartlebury. 1986. The caves and blue holes of Cat Island, Bahamas. Cave Science 13(2): 71-78.

Schram, F. R., J. Yager, and M. J. Emerson. 1986. Remipedia. Part I. Systematics. Memoirs of the San Diego Society of Natural History 15: 1-60.

Watling, L. 1989. A classification system for crustacean setae based on the homology concept, pp. 15-26. In, B. E. Felgenhauer, L. Watling, and A. B. Thistle (eds.), Functional Morphology of Feeding and Grooming in Crustacea. Crustacean Issues 6, A. A. Balkema, Lisse.

Yager, J. 1981. A new class of Crustacea from a marine cave in the Bahamas. Journal of Crustacean Biology 1: 328-333.

———. 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. Proceedings of the Biological Society of Washington 100: 302-320.

———. 1989. *Pleomothra apletocheles* and *Godzilliognomus frondosus*, two new genera and species of remipede crustaceans (Godzilliidae) from anchialine caves of the Bahamas. Bulletin of Marine Science 44: 1195-1206.

———. 1994. *Speleonectes gironensis*, new species (Remipedia: Speleonectidae) from anchialine caves in Cuba, with remarks on biogeography and ecology. Journal of Crustacean Biology 14: 752-762.

———, and J. H. Carpenter. 1999. *Speleonectes epilimnius*, new species (Remipedia: Speleonectidae) from surface water of an anchialine cave on San Salvador Island, Bahamas. Crustaceana 72: 965-977.

Received: 30 May 2006.
Accepted: 14 July 2006.