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Kaloketos pilosus, a new genus and species of Remipedia (Crustacea) from the Turks and Caicos Islands

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Abstract

We describe a new genus and species of remipede crustacean from an anchialine cave on the Turks and Caicos Islands in the Caribbean region. *Kaloketos pilosus* is a medium-sized species of robust build that occurs in sympatry with other remipedes, and is recognized as a new genus of the family Speleonectidae. *Kaloketos* is distinguished from other genera of Remipedia by several unique characters that include dense fields of short, feathered setae on most maxillary and maxillipedal segments, and distinctly expanded rami of the larger trunk limbs.

Key words: Crustacea, Remipedia, Speleonectidae, *Kaloketos*, anchialine caves, sympatry, biogeography

Introduction

Remipedes are hermaphroditic crustaceans that are exclusively known from anchialine, coastal cave systems, i.e., caves connected with sea water via cracks, tunnels or tubes. All currently recognized taxa occur in tropical or subtropical environments in the Caribbean region (13 species), Western Australian (1 species) and the Canary Islands (1 species). The greater Caribbean region, including the Yucatan Peninsula, is characterized by a high and relatively dense taxonomic diversity of Remipedia. For example, several cave systems on the Bahamas Islands are inhabited by sympatric remipedes, with up to six species and three genera (Koenemann et al., 2003; unpublished data).

The first remipede was discovered in a cave on the Bahamas Islands (Yager, 1981). Between 1981 and 2003, 14 new remipedes were discovered, all of which inhabit anchia-

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line caves. At present, there are two families, the Godzilliidae Schram, Yager & Emerson, 1986, with three monotypic genera, and the Speleonectidae Yager, 1981, composed of nine species in three genera.

The new genus and species described herein, *Kaloketos pilosus*, was collected during two cave diving expeditions to the Turks and Caicos Islands in 1983 and 2003. It occurs in sympatry with two other species of remipedes, *Godzillius robustus* Schram et al., 1986, and *Lasionectes entrichoma* Yager & Schram, 1986. The description of *Kaloketos pilosus* is based on two specimens collected from Cottage Pond Cave between 25 and 46 m depth.

Systematics

Please note that the following synonymies are not complete; they refer exclusively to papers that deal with systematics of Remipedia.

Class Remipedia Yager, 1981

Remipedia Yager, 1981: 328. Schram, Yager & Emerson, 1986: 6; Emerson & Schram, 1991: 5; Koenemann, Iliffe & van der Ham, 2003: 228.

Order Nectiopoda Schram, 1986

Nectiopoda Schram, 1986: 36. Schram, Yager & Emerson, 1986: 6; Emerson & Schram, 1991: 6; Koenemann, Iliffe & van der Ham, 2003: 228.

Family Godzilliidae Schram, Yager & Emerson, 1986

Godzilliidae Schram, Yager & Emerson, 1986: 6.

Type genus: *Godzillius* Schram, Yager & Emerson, 1986.

Additional genera: *Pleomothra* Yager, 1989; *Godzilliognomus* Yager, 1989.

Family Speleonectidae Yager, 1981

Speleonectidae Yager, 1981: 328. Schram, Yager & Emerson, 1986: 6; Koenemann, Iliffe & van der Ham, 2003: 228.
Morlockiidae Garcia-Valdecasas, 1984: 329.

Type genus: *Speleonectes* Yager, 1981.

Additional genera: *Lasionectes* Yager & Schram, 1986; *Cryptocorynetes* Yager, 1987; *Kaloketos* new genus.

***Kaloketos* new genus (Figs. 1–5)**

Type species. *Kaloketos pilosus* n. sp.

Etymology. *Kaloketos* means 'beautiful sea monster' and is composed of the Greek words *kalos* (beautiful) and *ketos* (sea monster). The gender is masculine.

Diagnosis. First trunk segment small, lateral pleurites greatly reduced (Fig. 2A); all remaining pleural tergites well developed. Trunk sternites with pointed posterolateral corners (Fig. 2A). Frontal filaments with short medial processes (Fig. 3C). Dorsal flagella of antennules very long (Figs. 1; 3A). Maxillipeds distinctly larger than maxillae, both limbs covered with dense fields of short, feathered setae on medial margins of most segments; horseshoe-type distal claws on maxillae and maxillipeds subequal, with about 18 small denticles (Figs. 4; 5B). Larger trunk limbs (of mid-trunk region) sturdy, with expanded endo- and exopods; second segment of endopod with expanded medial lobe bearing up to 32 short spines (Fig. 2B). Anal somite slightly wider than long; caudal rami about 20% longer than anal somite Fig. 2F).

***Kaloketos pilosus* new species (Figs. 1–5)**

Type locality. Cottage Pond, North Caicos Island, Turks and Caicos Islands (21º 56’ N, 72º 00’ W).

Material examined. Holotype, deposited in Zoological Museum Amsterdam (ZMA.Rem.204641; partly mounted on SEM stub), 29 mm, 41 trunk segments, collected by T. Iliffe, 10 June 2003, in 25–46 m depth of anchialine cave below halocline; 1 paratype, retained in research collection of Jill Yager, 26.5 mm, 40 trunk segments, collected by Dennis Williams, 20 October 1983.

Etymology. The epithet *pilosus* (Latin for hairy, covered with hair) refers to the dense fields of short spines and setae on the limbs of this species.

Diagnosis. A medium-sized species of robust build, up to 29 mm long, composed of 40–41 trunk segments (Fig. 1). First trunk segment small, completely covered by head shield; sternal bars heteromorphic (as enlarged convex flap on trunk segment 14, all remaining bars with concave distal margins; Fig. 2A). Dorsal flagella of antennules very long, reaching over 50% of body length, composed of 18 segments; ventral flagellum with up to 18 segments (Figs. 1; 3A). All remaining diagnostic characters as described for the genus.

Description. Based on holotype and paratype. Body robust and long, length ca. 29 mm, with 41 trunk segments (see Fig. 1). Pleurotergites well developed, with broadly rounded distolateral corners on trunk segments 2–11, becoming more acuminate posteriorly (Fig. 2A). Trunk sternites with pointed posterolateral corners; sternal bars heteromorphic, as convex flap on segment 14, and with concave distal margins on remaining segments anterior and posterior to segment 14 (Fig. 2A). Female gonopores (on trunk segment 7) small; male gonopores (on trunk segment 14) large, cylindrical.

Head shield subquadrangular; first trunk segment small and narrow, completely covered by head shield (Figs. 1; 2A). Frontal filaments with short mid-medial processes (Fig. 3C).

Antennules (Figs. 1; 3A): Peduncle slightly dilated ventrally, bearing dense rows of very fine aesthetascs. Dorsal flagellum long, reaching 55–60% of length of body, composed of 18 segments. Ventral flagellum with 17–18 segments, slightly longer than head shield, 40–45% of length of dorsal flagellum, articulation of proximal segments weak. Both flagella with small, short setae.

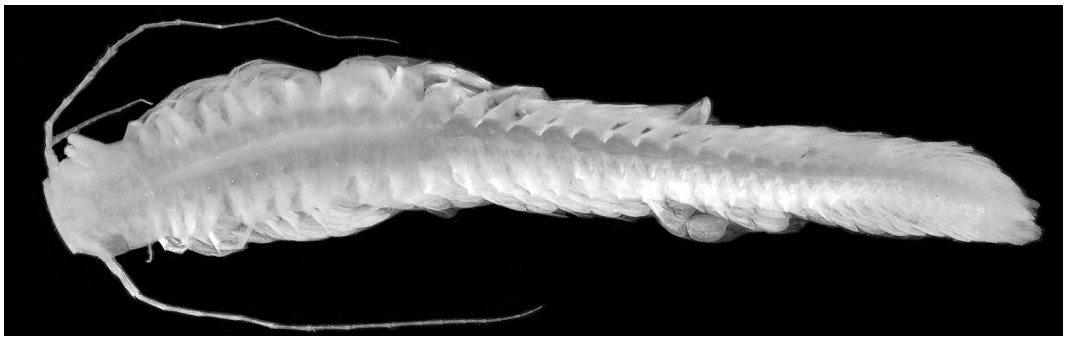

FIGURE 1. *Kaloketos pilosus* n. gen., n. sp. Photo of 29 mm holotype.

Antennae (Fig. 3B): Protopod 2-segmented; proximal segment with ca. 13 setae, distal segment with 13–18 setae (in two rows). Exopod wider and more than twice as long as adjacent distal segment of protopod, equipped with more than 60 long setae. Endopod bent in a semicircular way; first (proximal) segment with 14–16 setae; second segment with double row of setae; distal segment with double row of setae on lateral (anterior) and distal margins, and single row of setae on medial margin. All setae plumose (or 'faintly feathered'; cf. Fig. 2E).

Labrum fleshy, with posterolateral margins bearing three disjunct clusters of fine setules (Fig. 3D).

Mandibles: Both right incisor process and lacinia mobilis equipped with three large denticles each (Fig. 3E). Left incisor process with four large denticles; left lacinia mobilis crescent-shaped, bearing several large and small denticles (Fig. 3F). Molar processes prominent; distal surface long and narrow, bearing dense rows of fine, plumose setae on outer margins.

Maxillules (Fig. 4A, E): Segment 1 with long and narrow endite, bearing 1 prominent, apical spine and 9–10 smaller subapical spines (all spines naked). Segment 2 with broad, spatulate endite; medial (proximal) margin with regular row of 7 short, naked spines; lateral (distal) margin with row of long setae; apical margin bearing 1–2 finely serrate spines (between row of long setae and row of short spines; Fig. 4E); anterior surface with several long, finely serrate setae and short, feathered setae (Fig. 5C). Segment 3 short; endite with rounded apical margin, bearing about 10 long setae, and 2 long, slender, finely serrate api-

cal spines (cf. Fig. 4E). Segment 4 with expanded, oblique enditic margin, bearing 2 long, slender, finely serrate spines on apical margin, and two rows of long and short, finely serrate subapical setae (cf. Fig. 4E). Segment 5 slightly shorter and narrower than fourth segment, with rows of few naked setae on distal margins. Segment 6 short, with separate rows of naked setae on distal margins. Claw long and well developed.

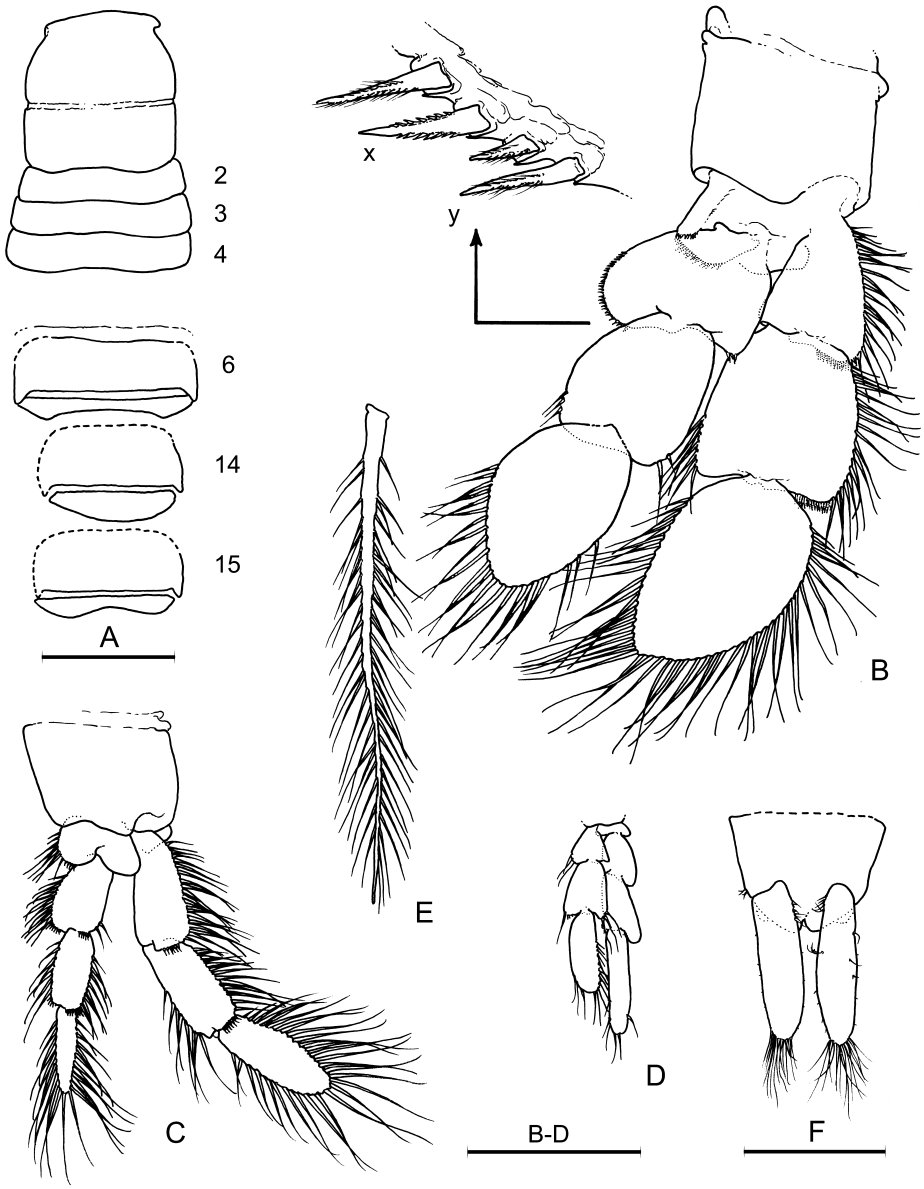

FIGURE 2. *Kaloketos pilosus* n. sp., 29 mm holotype. A, above: dorsal view of head shield with anterior trunk segments 2–4; below: ventral view of three trunk segments, with sternites and sternal bars of segments 6, 14 and 15, respectively (scale bar for sternites 6, 14 and 15 = 1 mm). B, 14th thoracopod, with enlarged detail of spine row on expanded margin of endopod (x, serrate spine; y, setulose spine). C, second thoracopod. D, thoracopod from posterior trunk near abdominal somite. E, plumose seta. F, anal segment and caudal rami (scale bar = 0.5 mm). Scale bar B–D = 1 mm.

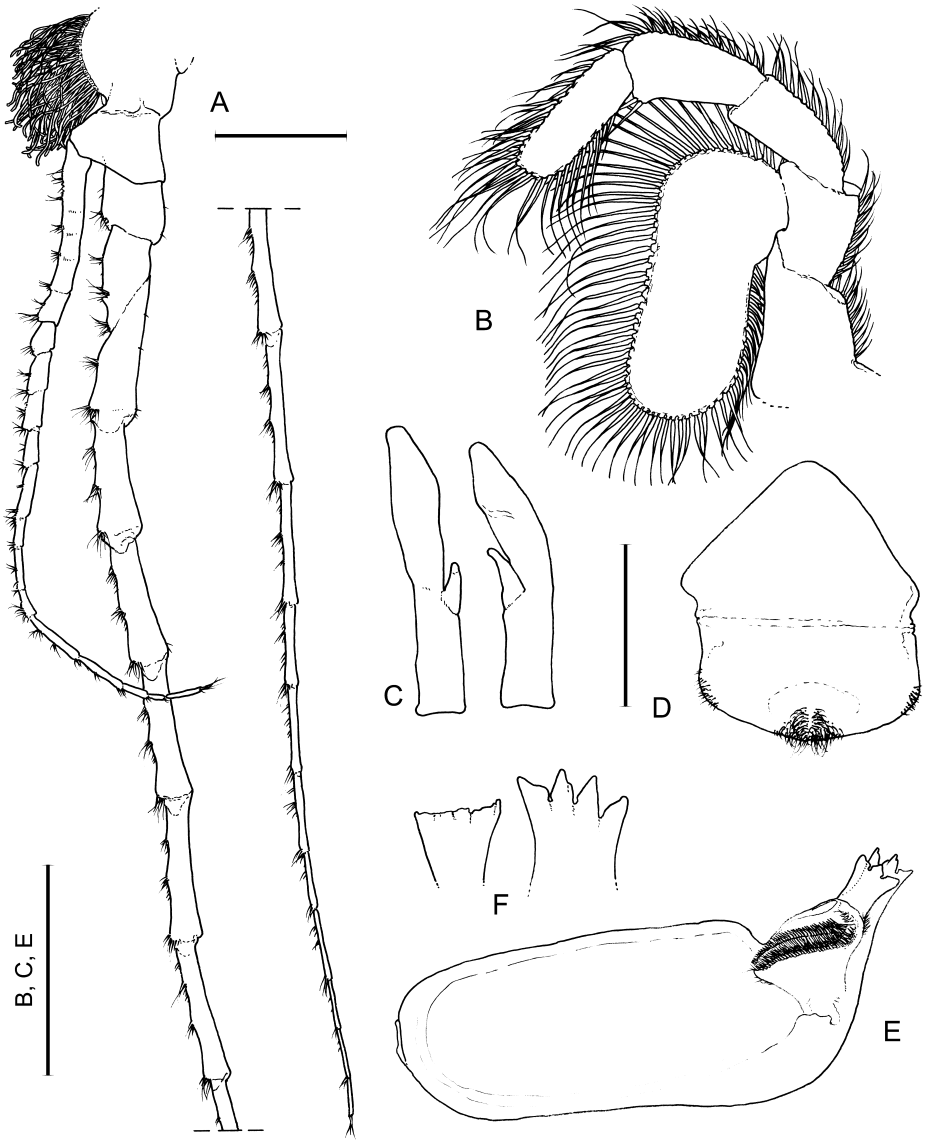

FIGURE 3. *Kaloketos pilosus* n. sp., 29 mm holotype. A, antennule (scale bar = 1 mm). B, antenna. C, frontal filaments. D, labrum (scale bar = 0.5 mm). E, right mandible. F, enlarged lacinia mobilis and incisor process of left mandible. Scale bar B, C, E = 0.5 mm.

Maxillae (Figs. 4B; 5): Endites of segment 1 bearing 1 prominent, apical spine accompanied by several short spines and rows of long and short, finely serrate setae on both margins. Segment 2 with broadly rounded endite, bearing a row of short spines on proximal margin, and a double row of finely serrate setae on distal margin. Segment 3 pear-shaped, distinctly expanded, with 2 rows of short, feathered setae and a few finely serrate setae on medial margin. Segments 4–6 weakly expanded, growing gradually shorter in length from proximal to distal, medial margins densely covered with short feathered setae (Fig. 5A, C), and a few distal setae; segment 4 slightly shorter than third segment. Arc of horseshoe-

type claw finely serrate, composed of 17–19 fine denticles flanked by stouter, more separate denticles on each side (Figs. 4D; 5B).

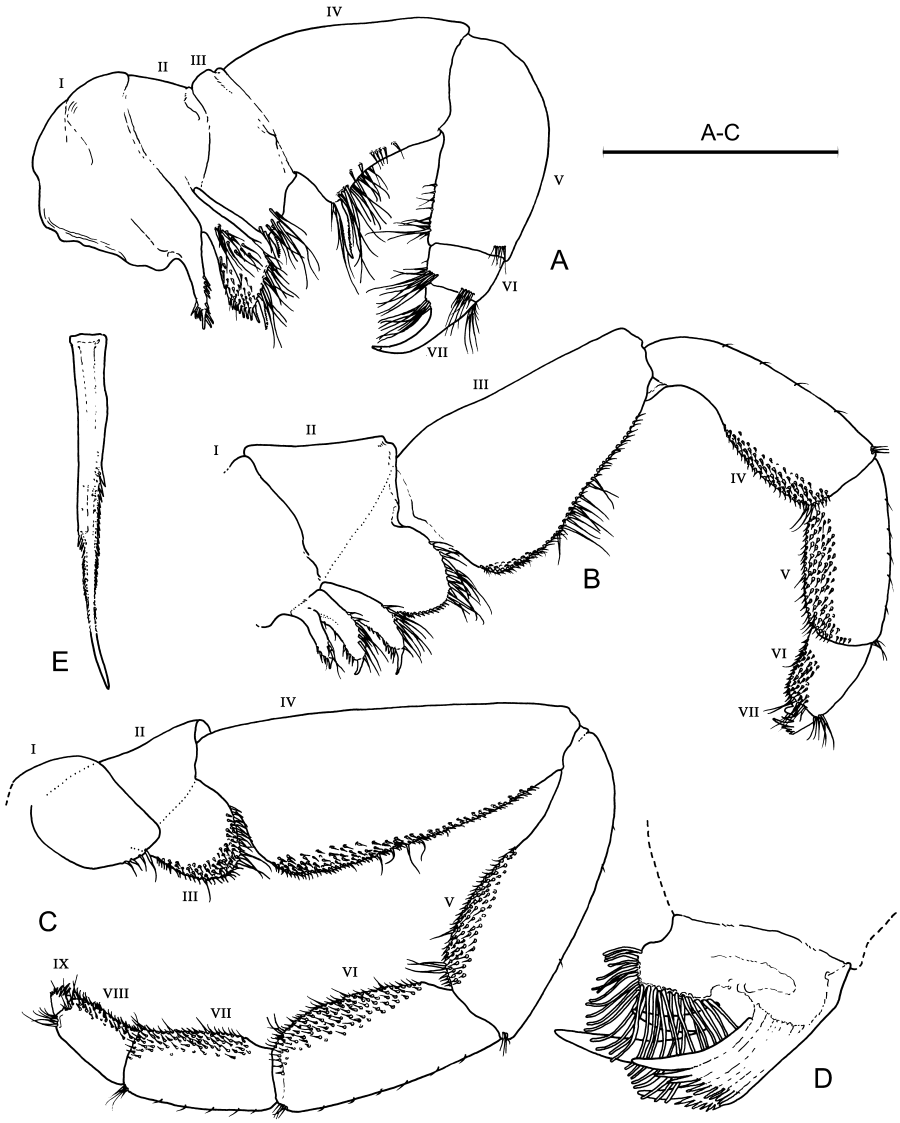

FIGURE 4. *Kaloketos pilosus* n. sp., 29 mm holotype. A, maxillule. B, maxilla. C, maxilliped. D, claw of maxilla. E, finely serrate spine of segment 2, and segments 3–4 of maxillule. Roman numerals indicate individual limb segments; scale bar = 1 mm.

Maxillipeds distinctly larger than maxillae, slender, 9-segmented (Fig. 4C); elbow between segments 4 and 5. Proximal segments 1–3 with oblique, interconnected articulation; segments 1 and 2 bearing a few short medial setae; segment 3 broadly rounded, bearing a few naked setae and a dense cover of short, feathered setae on distal and proximal margins. Fourth segment elongate, with expanded, oblique medial margin densely covered with short, feathered setae and a few naked setae. Segment 5 shorter than segment 4, distal

margin weakly expanded. Segments 5–8 gradually decreasing in length; medial margins densely covered with short, feathered setae and a few naked setae (cf. Fig. 5A, C). Claw similar to that of maxillae (Figs. 4D; 5B).

Trunk appendages (Fig. 2B–E): Larger limbs of anterior to mid-trunk region stout, with expanded endo- and exopods; limbs of anterior-most and posterior trunk smaller and narrower (Fig. 2C, D). Basal segment of four-segmented endopod with row of short setulose spines on distal margin; segment 2 distinctly expanded, much wider than long, bearing up to 14 short serrate spines on distolateral margin and up to 32 short, mostly setulose spines on distomedial margin (intermingled with a few serrate spines at distal end of row; Fig. 2B-x+y); segment 3 bearing up to 17 setae and up to 12–14 serrate spines on lateral and medial margins, respectively; segment 4 ovate, with long, plumose setae. First segment of 3-segmented exopod bearing long setae on lateral margin, and a row of up to ca. 21 short serrate spines on distolateral corner; segment 2 subquadrangular, with setae on both lateral and medial margins, and up to 19 serrate spines distolateral corner; segment 3 ovate, with long, marginal setae. All setae plumose (Fig. 2E).

Anal segment slightly wider than long (Fig 2F); caudal rami about 20% longer than anal somite, with a few short setae on proximomedial margins and about 18 longer setae on apical margins.

Discussion

Kaloketos pilosus does not share any of the apomorphies that define the Godzilliidae, including the advanced subdivision of maxillae and maxillipeds in a robust proximal segment and narrow, partly fused distal segments; the reduction or modification of maxillules; and the variably shaped head shields. Therefore, the new genus is assigned to the Speleonectidae based on its rectangular head shield, long ventral antennular flagella, asymmetrical mandibles, and the shape of the three prehensile limbs.

The prominent diagnostic characters that distinguish and define the three speleonectid genera, *Cryptocorynetes*, *Lasionectes* and *Speleonectes*, are the shape and size ratios, and the armature of the three prehensile cephalic limbs. *Kaloketos pilosus* is well-distinguished from these three genera by its unique morphology of the prehensile appendages, most notable of which are dense fields of short, feathered setae on most maxillary and maxillipedal segments. All species of both *Lasionectes* and *Speleonectes* bear sparsely inserted rows of simple setae on their maxillae and maxillipeds, while in the monotypic genus *Cryptocorynetes*, these two pairs of limbs are equipped with discoid organs (modified cuticular outgrowths that may facilitate holding onto active prey). Apart from the armature, the shape and size ratios of the three prehensile limbs in *Kaloketos* are also distinctly different from those in both *Cryptocorynetes* and *Lasionectes*. Maxillae and maxillipeds in *Lasionectes* are much larger than the maxillules, and have conspicuously enlarged segments proximal to the elbows (not enlarged in *Cryptocorynetes*). In contrast, maxillules

and maxillae in *Kaloketos* are subequal in size, and the maxillary and maxillipedal segments proximal to the elbows are only slightly enlarged and expanded.

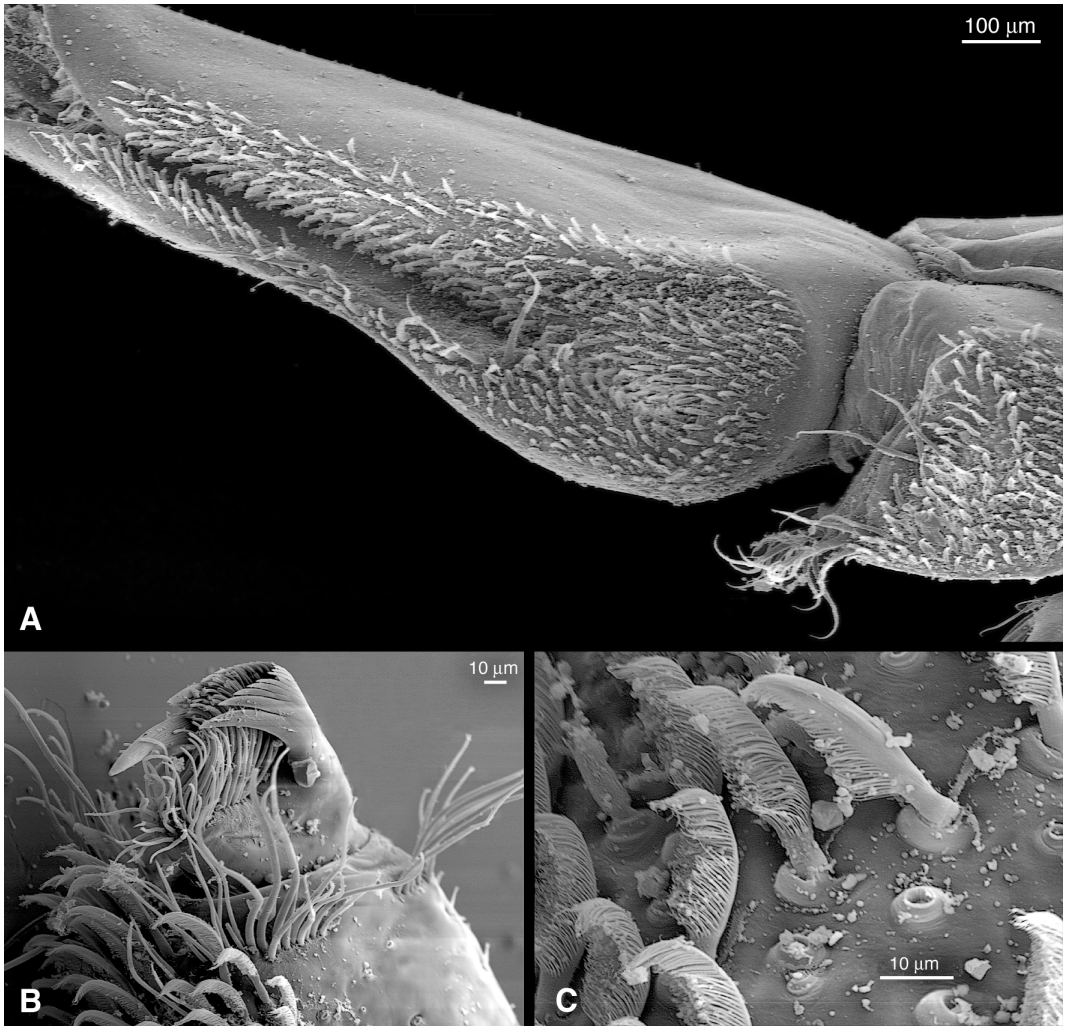

FIGURE 5. *Kaloketos pilosus* n. sp., 29 mm holotype. A, medial surface of maxilla (segments 4 and 5). B, distal claw of maxilla. C, enlarged feathered setae of maxilla.

The shape and size ratios of the three prehensile limbs in *Kaloketos* are similar to those in some species of *Speleonectes*. However, in addition to the dense, unique armature of maxillae and maxillipeds, there are several further characters that justify a separate generic status for *Kaloketos*. These include both rami of the larger trunk appendages, which are developed as robust, dilated paddles (more slender in *Speleonectes*). In particular, the trunk limbs have second endopodal segments with large, expanded medial margins that bear dense rows of short spines.

The following characters are known to vary within genera of Remipedia. They are, nevertheless, distinctive features that distinguish *Kaloketos pilosus* from other species of

Speleonectes, for example, dorsal and ventral antennular flagella both with up to 18 segments (dorsal 18, ventral 12 in *Cryptocorynetes*; dorsal 10–16, ventral 7–14 in *Speleonectes*; dorsal 12–13, ventral 8–12 in *Lasionectes*); a reduced 1st thoracic segment completely covered by the head shield; and a long trunk composed of up to 41 segments. In fact, this is the largest number of trunk segments recorded for remipedes to date. *Speleonectes tanumekes* Koenemann et al., 2003, has up to 40 trunk segments. However, *S. tanumekes* is a very slender species with weakly developed pleurotergites, slender trunk limbs, and morphologically different prehensile limbs as described above.

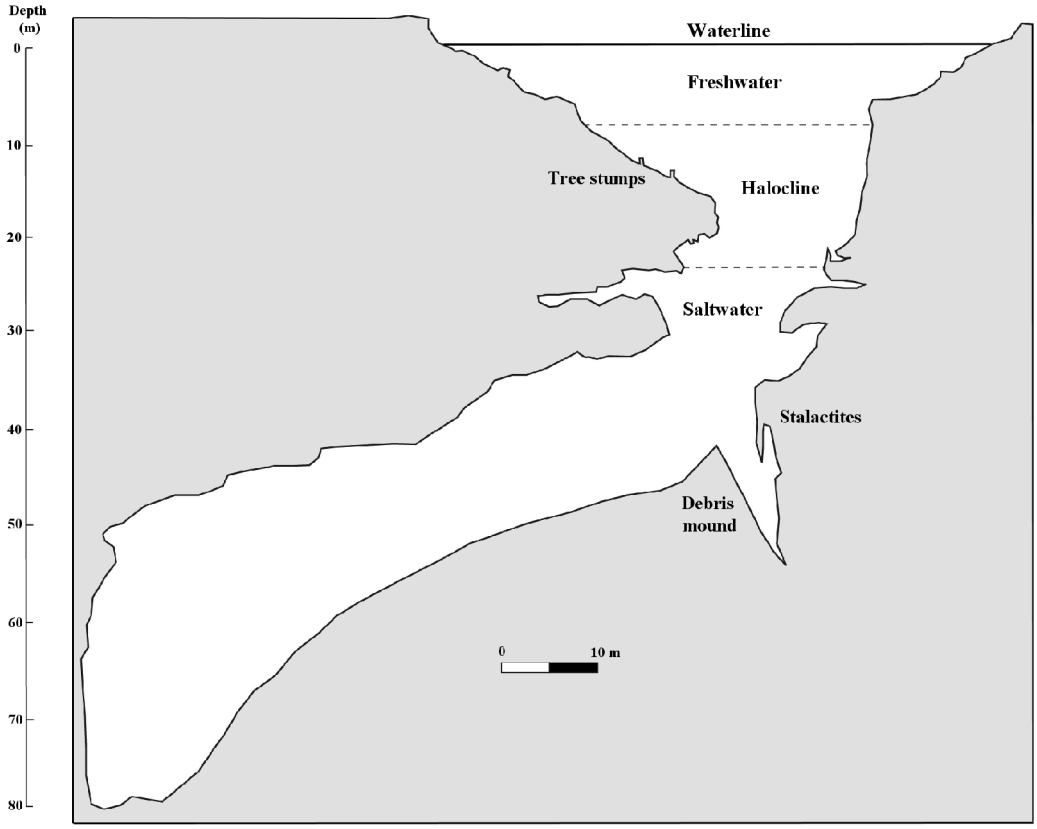

FIGURE 6. Profile view of Cottage Pond, North Caicos Island, showing salinity stratification and other features. Adapted with permission from a map by John Garvin, James Hurley and Mark Parrish.

Ecological profile of the type locality

Cottage Pond is a submerged sinkhole located 4 km inland from the coast on North Caicos Island. The pond consists of a nearly circular pool, 50 m in diameter, in a shallow, rock-rimmed depression. Tidal amplitude in the pond is approximately 50 cm. The pond water is somewhat murky, seasonally limiting underwater visibility at the surface to about 1–3 m. Near the center of the pond at about 20 m depth, a 12 m long vertical crack opens into a collapse chamber (70 m diameter) reaching water depths of 80 m (Fig. 6). At 15–20 m

depth, several tree stumps with roots intact indicate lower stands of sea level. Directly below the crack is a conical debris mound beginning at 40 m depth and extending to the bottom of the chamber. Several large logs and boulders are located on the lower slope of the debris mound. Submerged stalactites and flowstone, evidence of prior subaerial exposure, are present to at least 45 m depth. A Hydrolab Datasonde 3 was used to obtain a water quality profile from the cave (Fig. 7). Surface water in the pond in June 2003 was slightly brackish (2.9 ppt), relatively warm (30.7° C), saturated with dissolved oxygen (7.5 mg/l) and slightly basic (pH 7.77). A halocline began at 8 m depth and stabilized at 24 m depth (30 ppt salinity). At this point, the temperature had dropped substantially to 24.13° C, DO to 0.42 mg/l and pH to 6.59. In the deeper waters below the halocline, the salinity remained nearly constant while DO and temperature continued to decline and pH increased slightly. At the deepest depth monitored with the Hydrolab (64.4 m), salinity was 30.6 ppt, temperature 22.35° C, DO 0.18 mg/l and pH 6.63.

In October of 1983, when the first specimen of *Kaloketos pilosus* was collected, a layer of hydrogen sulfide was encountered starting at a depth of about 3 m and extending to about 6 m. At a depth of 47 m, the salinity was 28 ppt and the dissolved oxygen was less than 0.4 mg/l.

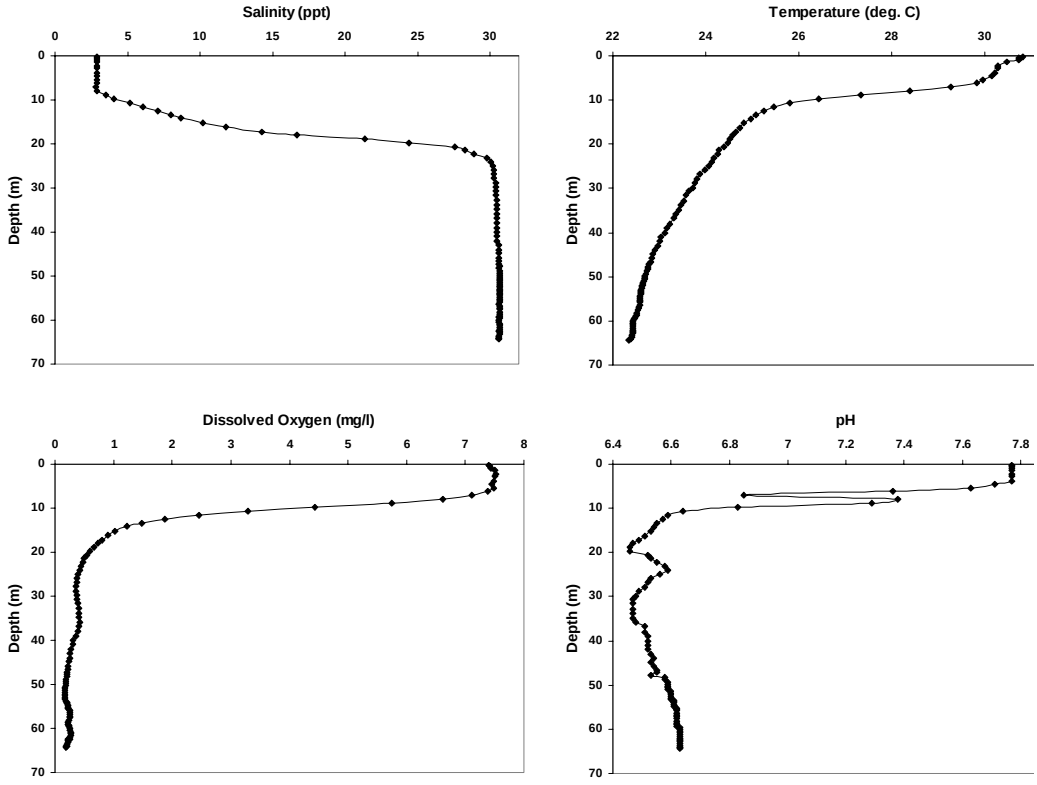

FIGURE 7. Water column profiles of salinity, temperature, dissolved oxygen and pH versus depth from Cottage Pond, North Caicos Island. Data were collected on 9 June 2003 with a Hydrolab DataSonde 3 water quality analyzer carried by a diver.

Stygobitic animals collected from salt water below the halocline in Cottage Pond include the remipedes *Godzillius robustus*, *Lasionectes entrichoma* and the new species *Kaloketos pilosus*; a leptostracan, probably *Speonebalia cannoni*; the agostocarid shrimp *Agostocaris williamsi*; the ostracod *Deeveya spiralis*; and copepods including pseudodiaptomid calanoids, oithonid cyclopoids, two new genera of epacteriscids, and a possible new genus of ridegwayiid (Audun Fosshagen, pers. comm.).

In addition, a species of the entirely subterranean-adapted, monophyletic genus *Bahalana*, restricted in its distribution to the vast archipelago of the Bahamas and Caicos Islands (supposedly also Turks Islands), is also known from anchialine caves of North and Middle Caicos Islands (Botosaneanu & Iliffe, 2003). *Bahalana caicosana* is closely related to species presently known from San Salvador, and from Mayaguana and Acklins.

Acknowledgments

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