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STYGIOMYSIS COKEI, NEW SPECIES, A TROGLOBITIC MYSID FROM QUINTANA ROO, MEXICO (MYSIDACEA: STYGIOMYSIDAE)

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ABSTRACT

Stygiomysis cokei, the seventh species of Stygiomysidae described worldwide and fifth from the Caribbean, was discovered in coastal underwater caves near Tulum, Quintana Roo, Mexico. Comparisons are made with other stygiomysid species. Distinguishing characteristics include telson length 1.7–2.0 × width, spinules absent on uropodal protopods, and pointed membranous pleopodal lamellae. Observations are made on habitats and behavior.

In addition to several species already known to be in caves in the area of Tulum, Mexico, we collected, in March 1992, some unfamiliar species, including a member of the family Stygiomysidae. The Tulum stygiomysids appeared slightly different from others described in the family. Later, additional specimens were collected, including some very large stygiomysids that were obviously distinct from our original ones. This is the first time two species of stygiomysids have been identified from the same cave system. The more distinctive, larger species is described herein, while the smaller species is still being analyzed to determine its taxonomic status.

In the family Stygiomysidae, only six species have been described. Four of these are from the Caribbean (see map, Fig. 1): *S. holthuisi* (Gordon, 1958), redescribed by Gordon (1960), from St. Martin, Lesser Antilles, a species that has also been identified from Puerto Rico (Bowman, 1976), Anguilla (Botosaneanu, 1980), and Grand Bahama Island (Bowman *et al.*, 1984); *S. major* Bowman, 1976, from Jamaica; *S. clarkei* Bowman, Iliffe, and Yager, 1984, from Middle Caicos Island and Providenciales; and *S. aemete* Wagner, 1992, from the Dominican Republic, Hispaniola.

The other two stygiomysid species, from the Salentine Peninsula of southern Italy, are poorly described. Caroli (1937) created the family Stygiomysidae for his *S. hydruntina*; he briefly described one male and one female in a "nota preliminare." Pesce (1975) briefly described, but did not name, his single specimen of a "*Stygiomysis* which shows remarkable differences compared to" the other known species, *S. hydruntina* and *S. holthuisi.*

TAXONOMY

Stygiomysis cokei, new species
Figs. 2–5

Material Examined.—All material collected by James Coke IV, from depth of 10–20 m in the fresh-water layer of caves near Tulum, Quintana Roo, Mexico. Holotype ♀ 22.0 mm with developing oostegites, Temple of Doom Cave, 100 m in from entrance to cave, spring 1992 (National Museum of Natural History, USNM 274169); paratype ♂ 15.3 mm, Mayan Blue Cave, 40 m in, 5 September 1992 (USNM 274170); paratype ♀ 16.8 mm with developing oostegites, Carwash Cave, 100 m in, spring 1992 (USNM 274171); paratype ♀ 9.0 mm, Naharon Cave, 450 m in, spring 1992 (USNM 274172); paratype ♀♀ 15.4 mm and 12.0 mm, Naharon Cave, 450 m in, 31 August 1992 (USNM 274173); paratype ♀♀ 18.2 mm with developing oostegites and 9.3 mm, Carwash Cave, 31 December 1994 (USNM 274174); paratype ♀♀ 21.3 mm with well-developed oostegites and 19.3 mm with developing oostegites, Naharon Cave, 9 January 1995 (USNM 274175).

Description.—Unpigmented, vermiform, body length 7.0–7.2 × width (Fig. 2B). Carapace length one-fifth body length. Ventrally, carapace housing mouthparts, anterior 3 pairs of pereiopods, and 1 pair of oostegites (if present) on pereiopod 3. Dorsally, pleonite segments smooth and rounded. Telson (Fig. 2A–C) length 1.7–2.0 × width, length one-sixth body length; posterior margin with 15 spines in 5 groups of 3 each: central spine of medial group 2 × longer than other 2 of medial group; spines of adjacent groups shortest, one-fourth length of medial central spine.

Antenna 1 (Fig. 3A) about one-half body length (measuring from base to tip of longer flagellum), with 3 peduncular articles and 2

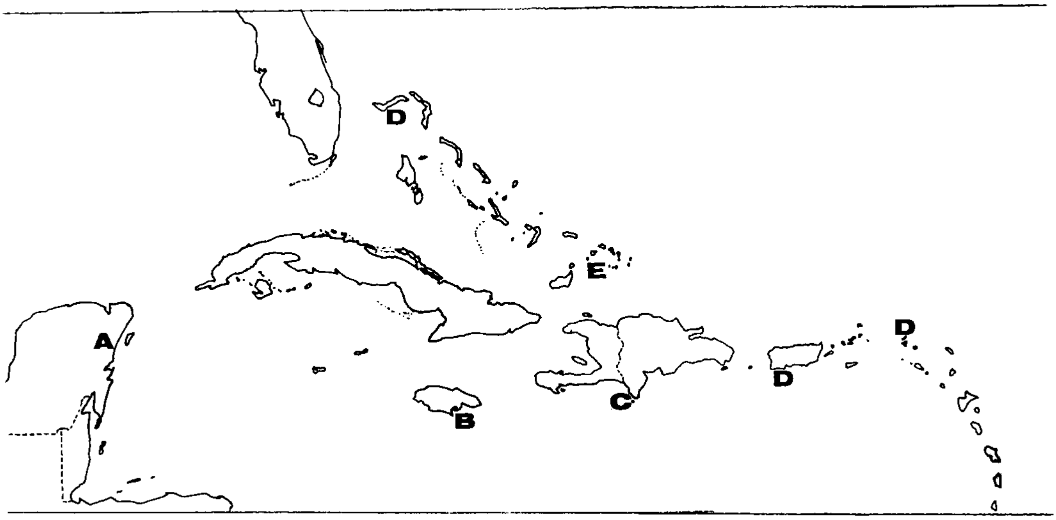

Fig. 1. Distribution of Caribbean stygiomysid species. A, *Stygiomysis cokei*, new species, from Yucatan Peninsula, Mexico; B, *Stygiomysis major* from Jamaica; C, *Stygiomysis aemete* from the Dominican Republic; D, *Stygiomysis holthuisi* from Grand Bahama, Puerto Rico, Anguilla, and St. Martin; E, *Stygiomysis clarkei* from Providenciales and Middle Caicos Islands.

flagella. Peduncular article 1 with 3 pairs of setae. Peduncular article 2 flatter than 1, with 2 plumose setae and 1 setule near proximal end, 2 distal plumose setae, and 9–12 setules along medial margin. Peduncular article 3 shortest, proximal end narrower than distal end; apical process with 2 plumose setae and 1 or 2 setules. Endoflagellum with 28–56 articles; proximal few articles each with 2 or 3 distal setae; subsequent distal articles alternating between having 1 distal seta and 3 or 4 distal setae; terminal article with 1 aesthetasc and 3–5 setae. Exoflagellum with 21–36 articles; proximal articles naked; middle articles each with 2 aesthetascs (1 distal, 1 near center) and 2 setules; distal articles with 1 distal aesthetasc and 1 or 2 setules; terminal article with 1 plumose and 3 or 4 nonplumose setae.

Antenna 2 (Fig. 3B) with 4 peduncular articles and 1 flagellum. Peduncular article 1 naked. Peduncular article 2 longer on medial margin; lateral margin with antennal scale bearing 4 spines. Peduncular article 3 length 4.5 × width with 9 setae on medial margin, 3 or 4 distal nonplumose setae, and 1 distal plumose seta. Peduncular article 4 longest (1.2 × length of article 3), length 5.8 × width with 6–8 setae along medial margin, and 5 or 6 plumose setae and 3 setules crowning distal end. Flagellum with 20–40 articles, each with 1–3 distomedial setae; penultimate article with 1 aesthetasc; terminal article with 5 nonplumose setae.

Mandibular palp (Fig. 3G) with 3 articles; article 1 naked, length one-half that of article 2; article 2 longest with 1–4 spines; article 3 length one-half that of article 2, with 6–10 spines. Left mandibular incisor process (Fig. 3G) 3-cuspidate (1 large, 2 small); lacinia 3-cuspidate (plus 1 small cusp at base by incisor, not illustrated), 3–6 lateral spines between lacinia and molar; molar with 2 or 3 spinules. Right mandibular incisor process (Fig. 3H) 5-cuspidate plus 1 cusp (fixed lacinia) and molar; 4–7 lateral spines and 2–5 spinules between molar and fixed lacinia. Maxilla 1 (Fig. 3C) proximal endite with 2 plumose and 2 serrate setae; distal endite with 9 terminal spines (8 thin, 1 thick), and 1 long subterminal plumose seta. Maxilla 2 (Fig. 3F) with all setae plumose (plumes not illustrated), exopodite with 9–22 setae; endopodite terminal article with 3–5 setae, penultimate article with 1–5 setae; distal endite bilobed with 2–4 and 8–10 marginal setae; proximal endite with 9–18 setae. Maxilliped (Fig. 3D, E) densely setose (less on immature specimens); basis with 3 inner plumose setae (plumes not illustrated on max-

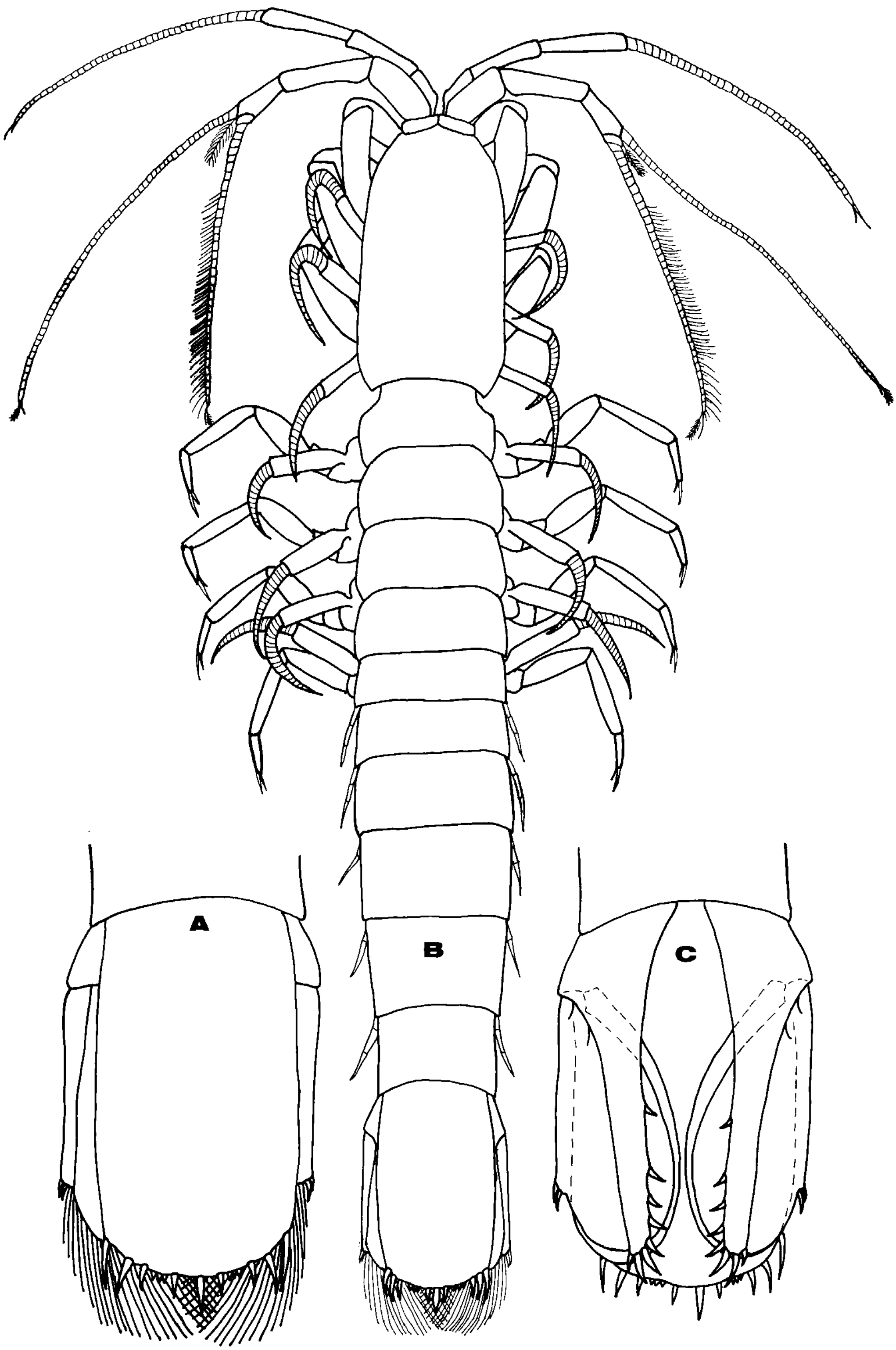

Fig. 2. *Stygiomysis cokei,* new species, all from holotype. A, telson, dorsal; B, habitus, dorsal; C, telson and uropods (setae removed), ventral.

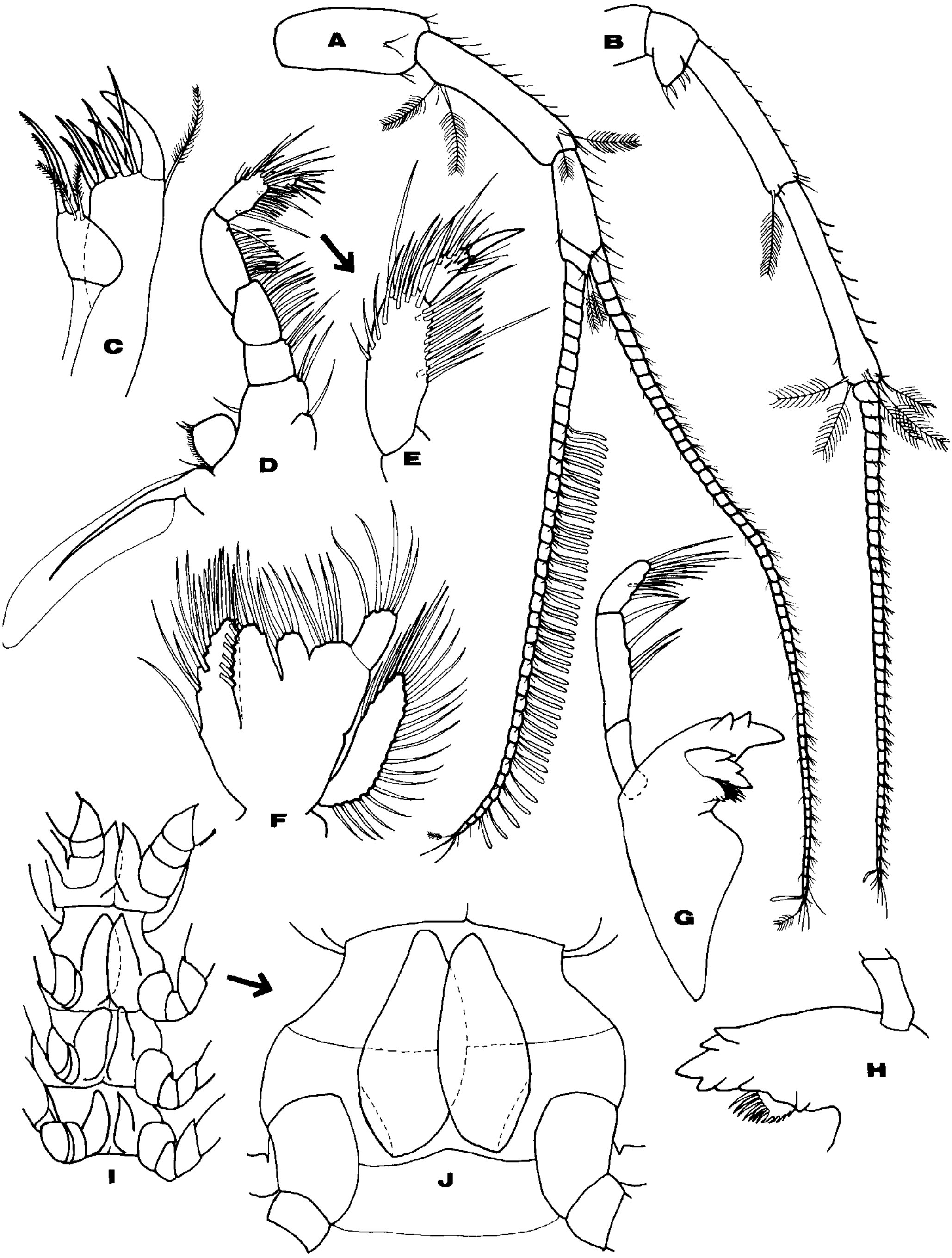

Fig. 3. *Stygiomysis cokei,* new species, all from holotype except I and J from 21.3-mm female with well-developed oostegites. A, left antenna 1; B, right antenna 2; C, left maxilla 1; D, left maxilliped, plumose setae with plumes removed; E, left maxilliped, enlargement of propodus and dactylus; F, left maxilla 2, all setae plumose (plumes removed); G, left mandible, dorsal; H, right mandible, dorsal; I, oostegites between pereiopods 3–6, ventral; J, oostegite pair between pereiopods 3, enlarged and flattened to show shape.

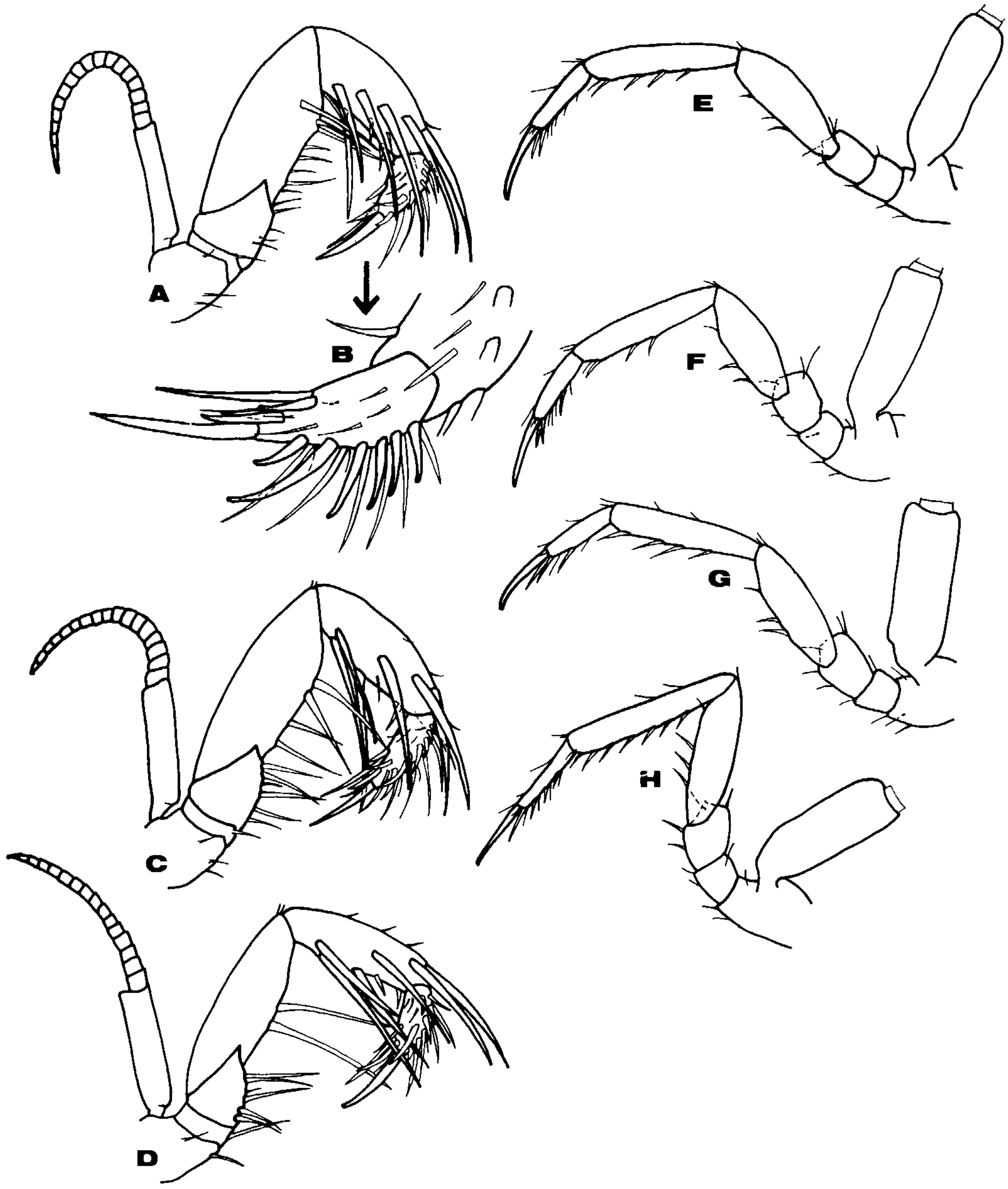

Fig. 4. *Stygiomysis cokei,* new species, all from holotype. A, left pereiopod 1; B, left pereiopod 1, dactylus enlarged, palmar; C, left pereiopod 2; D, left pereiopod 3; E, left pereiopod 4; F, left pereiopod 5; G, left pereiopod 6; H, left pereiopod 7.

illiped) and 1 outer plumose seta; exopodite on basis with 1 plumose basal seta, dense setules along margin, and 2 nonplumose apical setae; ischium with 2 or 3 plumose setae; merus with 4–9 plumose setae; carpus with 5–11 plumose setae; propodus with 9–20 plumose setae on palmar surface and 3 longer plumose setae on opposite surface; dactylus with 8–10 setae; dactylus and unguis lengths subequal.

Pereiopod 1 (Fig. 4A) basis with exopod and 3 setae. Ischium smallest article with 1 seta. Merus triangular with 1 side cupping carpus, and with 4 or 5 spines. Carpus longest article, length 2.6–3.2 × width, with 8 spines. Propodus length 2.7–3.2 × width, with 6 long spines subequal to propodus length, 1 short distal spine, 4 palmar setae, and 2 distal setae. Dactylus (Fig. 4B) length 2.0–2.4 × width, with 13–15 spines and about 10 setae. Unguis and dactylus lengths subequal.

Pereiopod 2 (Fig. 4C) basis with exopod and 3 setae. Ischium with 1 seta. Merus with 5 or 6 spines. Carpus length 3.0–3.4 × width, with 4 or 5 palmar spines and 2 distal setae. Propodus length 2.8–3.1 × width, with 4 or 5 setae and 6 long spines subequal to propodus length, plus 1 short distal spine. Dactylus length 2.4–3.0 × width, with 12–15 spines and 6–8 setae. Unguis and dactylus lengths subequal.

Pereiopod 3 (Fig. 4D) basis with exopod and 1 or 2 setae. Ischium with 1 or 2 setae. Merus with 4 or 5 spines and 1 seta. Carpus length 3.3–3.6 × width, with 2 or 3 spines at least one-half carpus length, and 2 distal setae. Propodus length 3.3–3.5 × width, with 6 spines at least one-half propodus length, 1 short distal spine, and 5 or 6 setae. Dactylus length 2.3–3.0 × width, with 13–16 spines and 6–10 setae. Unguis and dactylus lengths subequal.

Pereiopods 4–7 (Fig. 4E–H) similar; bases with exopod and 2–4 setae, ischia with 1 or 2 setae, meri with 3–5 setae. Pereiopods 4–6 carpus length 2.7–3.3 × width with 2 or 3 setae; propodus length 4.9–5.8 × width with 3–5 spines and 2–5 setae; dactylus length 4.0–4.6 × width with 2 or 3 spines and 2–8 setae; unguis and dactylus lengths subequal, unguis accompanied by 2 spines and 1–4 setae at base. Pereiopod 7 longer and generally more setose and spiny than pereiopods 4–6; carpus length 3.3–4.0 × width with 2–4 spines; propodus length 5.8–6.8 × width with 5–8 spines and 1–4 setae; dactylus length 4.6–5.2 × width with 2–4 spines and 2–8 setae; unguis and dactylus lengths subequal, unguis accompanied by 1 spine and 2 setae at base.

Paired ventral oostegites (Fig. 3I, J) extending medially and anteriorly from coxal plates between pereiopods 3–6. Each oostegite single flexible membranous flap, rounded and elongated anteriorly.

Pleopods as illustrated (Fig. 5A–G). Pleopod 1 located most lateral, others more ventral. No lamellae on pleopods 1 or 2; bases of pleopods 3–5 fused with paired lamellae (Fig. 5G, H). Each lamella single membranous flap, narrow medially, wide toward pleopod base, pointed posteriorly, with 6 setae on mediolateral margin.

Length of uropodal protopod (excluding apical spines) slightly shorter than telson (Fig. 2C); protopod with 7 or 8 spines along medial and apical margins, no spinules; base of protopod with 2 lateral setae. Distal margin of uropodal exopod (Fig. 2C) extending slightly beyond endopod; exopod (Fig. 5I) length 2.4 × width; dense plumose setae on entire medial and apical margins and on distal one-third of lateral margin; proximal two-thirds of lateral margin naked, bearing 2 spines at junction of setose margin. Uropodal endopod (Fig. 5J) length 2.6 × width; distal one-half of medial margin and distal one-third of lateral margin with dense plumose setae; proximal one-half with sparse nonplumose setae.

Size.—9.0–22.0 mm.

Distribution.—Coastal inland caves, Quintana Roo, Mexico.

Etymology.—The specific epithet *cokei* is for James Coke IV, a former cave SCUBA instructor in Akumal, Quintana Roo, Mexico, who discovered and sent the specimens to us.

Discussion

Comparisons

Descriptions of four of the seven stygiomysid species are based on only 1–3 specimens. Therefore, little is known about variability. Nevertheless, the entire family appears to be remarkably uniform in many features. As one example, the posterior margin of the telson almost always has 15 spines in five groups of three each, regardless of species or size. This general uniformity often requires that subtle differences be examined to distinguish species. Table 1 compares the characteristics that we find most important in distinguishing the seven species, including *S. cokei*.

The easiest way to separate *S. cokei* from other species is by the length of the telson, which is proportionally much longer. The telson length-to-width ratio is 1.7–2.0 compared to 0.9–1.2 in other species.

Other distinguishing characteristics of *S. cokei* include: spinules are absent on the uropodal protopod; the membranous lamel-

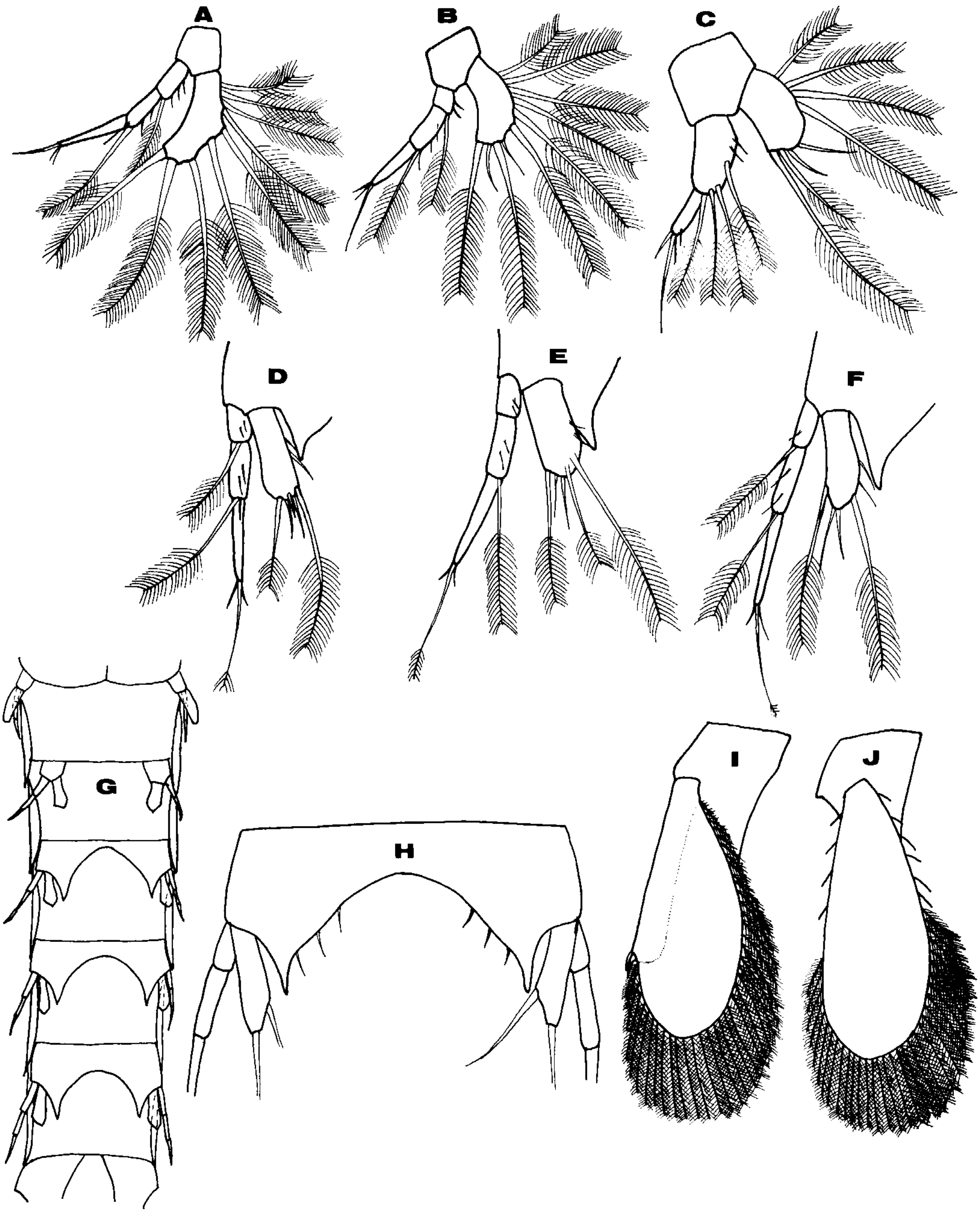

Fig. 5. *Stygiomysis cokei,* new species, all from holotype except C from 14.8-mm male, G from 21.3-mm female, and H from 16.8-mm female. A, left pleopod 1, dorsal; B, left pleopod 2, dorsal; C, left pleopod 2, male, dorsal; D, left pleopod 3, dorsal; E, left pleopod 4, dorsal; F, left pleopod 5, dorsal; G, pleonites 1–5 showing membranous lamellae between pleopods 3–5, ventral; H, membranous lamella between pleopod pair 5, enlarged; I, right uropodal exopod, ventral; J, right uropodal endopod, ventral.

lae are pointed, not rounded; and the right mandibular incisor process contains 5 + 1 cusps instead of 4 + 1 found in other species, where described.

Stygiomysis cokei, S. major, and *S. aemete* are similar in size, specimens being at least 9.0 mm. Of our 10 specimens of *S. cokei* (nine females, one male), the six larg-

Table 1. Distinguishing characteristics of species of *Stygiomysis*.

	S. cokei	*S. major*	*S. aemete*	*S. holthuisi*	*S. clarkei*	*S. hydruntina*	*S.* (Pesce)
Number in type series	10	16	1	15	3	2	1
Body length (mm)	9.0–22.0	9.0–20.8	15.5	3.5–10.0	4.8–6.2	10.1	6.5
Telson length/width	1.7–2.0	1.2	1.2	1.2	0.9	1.2	1.0
Protopod versus telson length	Shorter	Subequal	—	Longer	Subequal	—	—
Uropod protopod:							
Spines	7 or 8	10 or 11	7	7	6 or 7	7	4
Spinules	0	6	9	10	7–11	20	3
Membranous lamellae:							
Posterior margin	Pointed	Rounded	—	Rounded	—	Rounded	Rounded
Left and right halves	Fused	—	—	Fused	—	Divided	Divided
Mandibular palp:							
Segment 3 l/w	1.8–3.0	1.1	0.9	1.2	1.4	—	—
Left mandible:							
Incisor cusps	3	3	3	—	3	—	—
Lacinia cusps	3 + 1	4	3	—	3	—	—
Right mandible cusps	5 + 1	4 + 1	4 + 1	4 + 1	4 + 1	—	—

est females (15.2–22.0 mm) have oostegites in various stages of development. Descriptions of *S. major* and *S. aemete* do not mention oostegites. The other four species (*S. clarkei, S. holthuisi, S. hydruntina,* and Pesce's species) are similar to each other in size, all specimens being smaller than 10.2 mm; the only females described as having oostegites are 7.0 and 9.0 mm in *S. holthuisi* and 10.1 mm in *S. hydruntina.*

Stygiomysis major, S. holthuisi, S. hydruntina, and Pesce's species, in which pleonite lamellae are at least partially described or illustrated, apparently have rounded lamellae at the bases of pleopods 3–5; in *S. cokei* these lamellae are distinctly pointed. Descriptions of *S. hydruntina* and Pesce's species indicate that left and right halves of lamellae are divided; in *S. cokei* and *S. holthuisi* lamellae are fused.

On the mandibular palp, *S. cokei* has an elongate third segment, length 1.8–3.0 × width; other species have the third palp segment length 0.9–1.4 × width. On the left mandibular lacinia mobilis, *S. cokei* and *S. major* have four cusps in comparison to *S. aemete* and *S. clarkei,* described as having a 3-cuspidate lacinia.

Habitat and Behavior

This species was found in caves near Tulum, Quintana Roo, Mexico. Temple of Doom Cave, the type locality, is about 6 km northwest of Tulum Pueblo, along Mexico Rt. 180. All caves from which *S. cokei* were collected are completely under water and are entered through cenotes. The caves have an upper fresh-water layer and a deeper salt-water layer, which mix to form a halocline. While all other stygiomysid species were collected from relatively shallow areas of wells or cave pools, all specimens of *S. cokei* were collected in a depth of 10–20 m, in the fresh-water layer or occasionally in the upper part of the halocline. Conditions remain relatively constant throughout the year in these areas of the caves: temperature 24.5–25.5°C, pH 6.8–7.0, low oxygen (near 2.0 ppm), and high carbon dioxide (44–864 ppm) (Kallmeyer and Carpenter, 1994; James Coke, in correspondence). All specimens of *S. cokei* were collected from remote areas of caves, where there is little disturbance by SCUBA divers. We do not yet know to what extent *S. cokei* interacts with the other crustacean species that we have collected in these caves at similar depths: *Stygiomysis* sp., atyid shrimps, thermosbaenaceans (*Tulumella unidens* Bowman and Iliffe), amphipods (*Bahadzia tulumensis* Holsinger), harpacticoid copepods, ostracods (*Danielpolina mexicana* Kornicker and Iliffe), cirolanid isopods (*Anopsilana* sp., *Bahalana mayana* Bowman, and *Creaseriella anops* (Creaser)), anthurid isopods, and remipedes (*Speleonectes tulumensis* Yager).

The only published account of any stygiomysid behavior is that of the single specimen of *S. aemete* which "was captured while swallowing an ant that was drowned in the well" (Wagner, 1992). Thus, we include here some of our observations of live *S. cokei.* On 9 January 1995, two specimens were collected, one of which, sent to us in Kentucky, stayed alive until 29 January 1995; the other specimen, retained by the collector, remained alive for about 4 weeks. Cave water collected at the same depth as the specimens had high levels of carbon dioxide, keeping the pH relatively low (6.8–7.0). When water was brought to the surface and left in an open container, carbon dioxide escaped and the pH rose to about 8.0 within 24 h (James Coke, in correspondence). We kept our specimens in closed containers to retard carbon dioxide loss and maintain low pH. Nevertheless, since pH tended to creep upward, we made almost daily partial changes of pH-adjusted water. The mysids kept their tails almost straight up at a 90° angle to the body when pH was comfortably low; but as pH rose, their tails gradually dropped in proportion (e.g., 75, 60, 45, 30, 15°, to near horizontal in extreme situations). They also lowered their tails to near horizontal while walking. When animals were forced off their substrate in either the caves or in culture containers, they displayed frantic, ineffective swimming movements.

The specimen maintained alive in Kentucky was examined under a dissecting microscope periodically for several hours and was videotaped for about four min, providing the following observations. Antennae 1 and 2 were generally pointed almost directly out to the side (not pointed posteriorly as in Fig. 2B); both branches of antenna 1 were held horizontally above the substrate; the single branch of antenna 2 was held down on the substrate. Endopods of pereiopods 1–3 were held forward toward the mouth, while endopods of pereiopods 4–7 were used for standing and walking. Exopods of pereiopods 1–7 pointed anterolaterally when at rest; they moved posteriorly during walking; they beat periodically for respiration while the animal was standing. Each respiratory beat began with pereiopod 7 moving posteriorly, followed quickly by 6, 5, 4, 3, 2, 1, and maxilliped; pereiopod 7 started moving forward again while 6 was still moving backward, with similar sequences for other pereiopods. Left pereiopods beat forward, while right ones were beating backward, and vice versa. Beating was most pronounced on pereiopods 4–7, with relatively little movement of pereiopods 1–3 and maxilliped. When the animal appeared healthiest (with pH near 7.0), respiratory sequences usually consisted of beating for 3–9 s, followed by rest periods from 2–45 s. As carbon dioxide dropped and pH rose, rest periods increased to as much as 50 min. Apparently this is a common response to changes in carbon dioxide and pH. According to Randall (1988), most, if not all, animals respond to changes in oxygen and carbon dioxide with changes in ventilation; in mammals, if carbon dioxide is held at a low level experimentally, breathing will cease.

The heart beat mostly when pereiopods were beating, and usually about three beats/s. Pleopods were held motionless out to the side, except during walking and respiration, when they were held back against the body. During walking, the uropods spread away from the telson to make a wide tail fan.

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