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BAHALANA GERACEI N. GEN., N. SP., A TROGLOBITIC MARINE CIROLANID ISOPOD FROM LIGHTHOUSE CAVE, SAN SALVADOR ISLAND, BAHAMAS

by

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ABSTRACT

Bahalana geracei is described from Lighthouse Cave on San Salvador Island, Bahamas. It is the first subterranean cirolanid from the Bahamas, and the first to be found in waters of full marine salinity. Its most distinguishing characteristic is that its first three pairs of pereiopods are prehensile and extremely long. Natural history observations are also reported.

RÉSUMÉ

On décrit *Bahalana geracei* de la Lighthouse Cave, grotte creusée dans l'île San Salvador, Bahamas. Il s'agit du premier Cirolanide souterrain des Bahamas, et en même temps du premier Cirolanide troglobionte à être trouvé dans des eaux à salinité marine. Son caractère le plus particulier est le fait que ses péréiopodes des trois premières paires sont préhensiles et extrêmement longs. Un compte-rendu est aussi fait sur des observations d'histoire naturelle.

INTRODUCTION

In the western hemisphere troglobitic (cave adapted) cirolanid isopods have been described from Mexico, Cuba, Aruba, Texas (USA) and Virginia (USA). All species except *Arubolana imula* Botosaneanu & Stock, 1979, from Aruba are from freshwater caves, but it is theorized that they are descendants of marine ancestors from the Gulf of Mexico (Bolivar y Pieltain, 1950; Bowman, 1964). The discoveries of *Arubolana imula* in a brackish groundwater tunnel and *B. geracei* in a cave containing seawater add credence to this theory.

Lighthouse Cave is situated about ½ km from the San Salvador lighthouse (northeastern side of the island) and about 1 km from the ocean. In 1977 the cave was explored and mapped by a geology class studying at the College Center of the Finger Lakes (CCFL) Bahamian Campus. On 18 June 1978 Dr. Donald Gerace and his wife Kathy led my marine biology class of 10 students and myself to Lighthouse Cave. The cave consists mainly of one room about 40 m in diameter with a large pile of breakdown rocks in the middle mostly surrounded by quiet water up to 1 m deep. Close to the entrance, which is a narrow hole near the roof, is a small room about 10 m in diameter where the isopods were found. Five specimens were collected by hand, and a few others were seen but escaped capture by swimming erratically and diving to the silt-covered bottom of the pool. Additional specimens were collected in 1979, 1980, and 1981.

Other aquatic life consists of several species of sponges (cf. Van Soest & Sass, 1981), several tube worm species including *Spirorbis*, several copepod and ostracod species, the red shrimp *Barbouria cubensis* (Von Martens), a species of asellote isopod, an occasional kilifish *Rivulus marmoratus* Poey, and rather prolific growths of the green alga *Cladophora* (this is particularly puzzling because this section of the cave is totally devoid of light). Terrestrial life is also rather diverse with numerous bats, cockroaches, four species of isopods, one snail species, and one pseudoscorpion species. The food webs in Lighthouse Cave have been described previously (Carpenter, 1981).

TAXONOMIC PART

Bahalana n. gen.

D i a g n o s i s. — Cirolanidae. Eyes absent. Body without pigment except for brown mandibular masticatory blades, spines on exopod of maxilla 1, and microscopic crystals surrounding some internal pereional organs. All 5 pleonal segments clearly visible; pleonite 1 not covered by pereional segment 7; lateral margin of pleonite 5 not covered by pleonite 4 (type *a* of Bowman, 1975). Peduncles of antennae 1 and 2, 4-segmented and 5-seg-

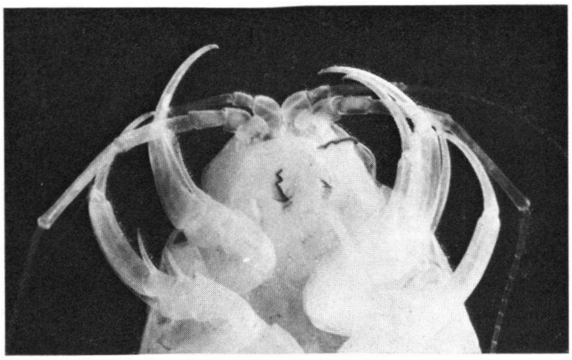


Fig. 1. *Bahalana geracei* n. gen., n. sp.: head, with left mandible pulled anteriad, ventral.

mented, respectively. Pereiopods 1-3 prehensile; dactylus, propodus, and projections of merus all extremely long. Pereiopods 4-7 slender, ambulatory. Rami of pleopods 1-2 and endopods of pleopods 3-5 undivided, but with partial transverse sutures in exopods of pleopods 3-4 and complete suture in exopod of pleopod 5; endopods 1-2 and all exopods with numerous marginal setae; endopods 3-5 with a few marginal setae.

Type-species. — *Bahalana geracei* n. sp.

Etymology. — The generic name is a combination of *Baha*(ma) + (*Ciro*)*lana*; the specific name *geracei* is for Dr. Donald T. Gerace, director of the Bahamian Campus, who was of great help in this discovery.

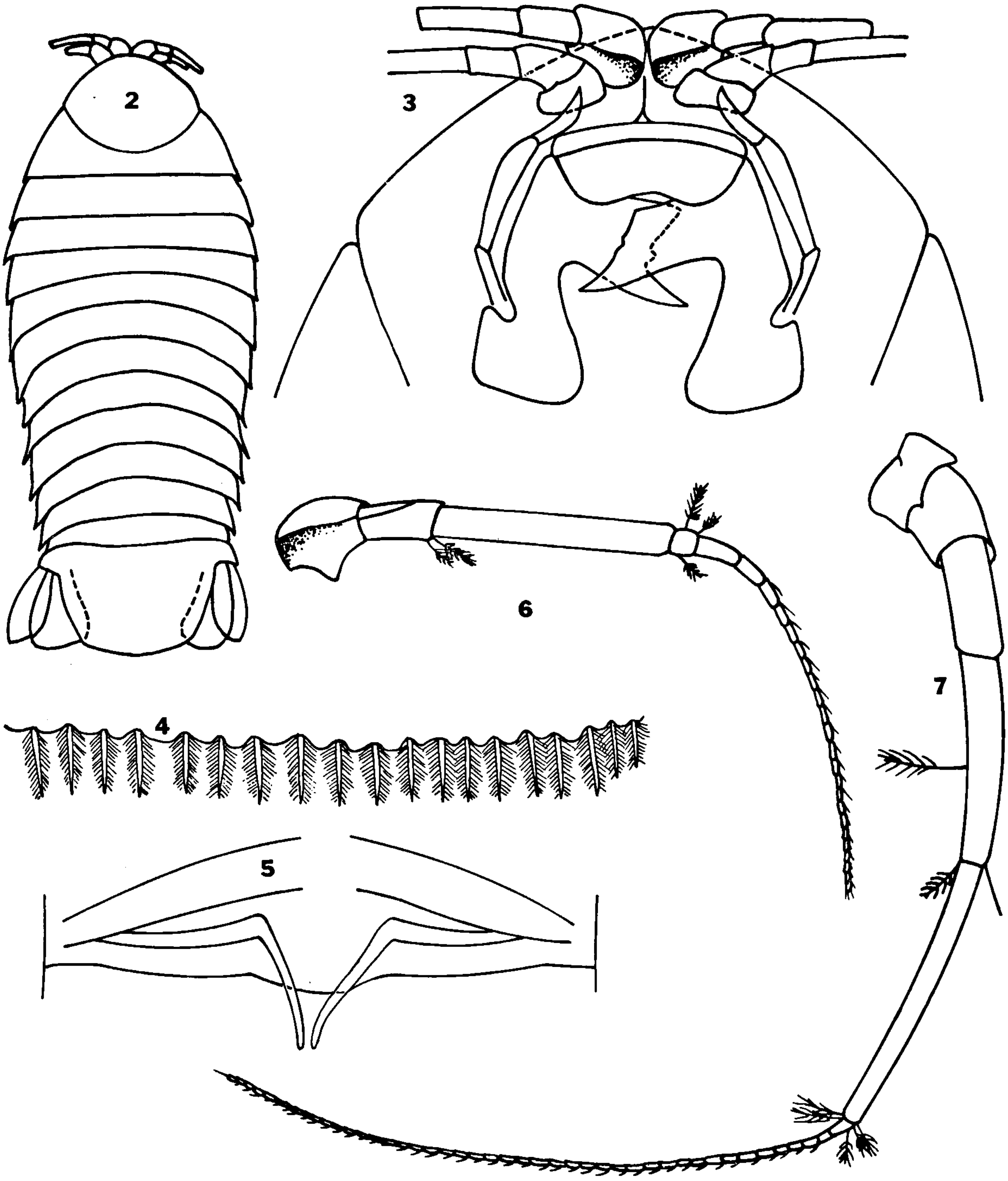
Bahalana geracei n. sp.

Material examined. — Female 14.0 mm (holotype, National Museum of Natural History, Washington, D.C. (USNM), cat. no. 172191), male 8.0 mm (paratype, USNM 172192), female 15.0 mm (paratype, USNM 172193). Over 30 other specimens maintained in author's collection.

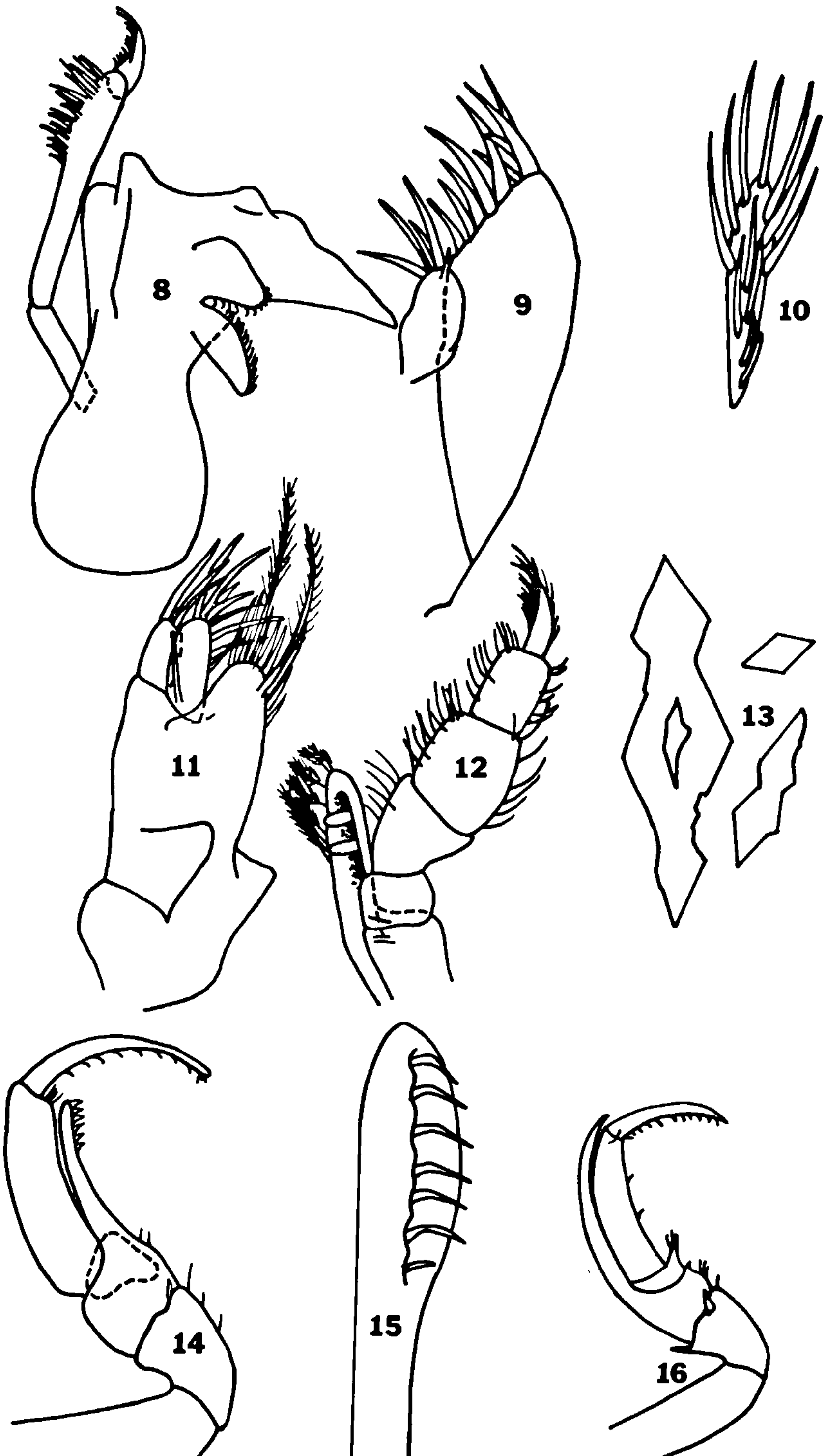
Description. — Body (fig. 2) rather broad; length about 3 times width. Unable to roll into a ball (when live specimens were placed on their backs in shallow water, they could not turn over). Head (figs. 1, 3) about as long as broad; rounded and smooth on anterior surface; no rostrum. Frontal lamina a poorly developed narrow carina on a moderately small posterior base. Base of frontal lamina partly covered by clypeus. Clypeus and labrum together form oval structure with slight rounded concavity on mandibular margin. Pereionite 1 slightly longer than other pereionites which are approximately equal in length. Posterior corners of coxal plates 2-3 rounded, that of pereionite 4 squared, those of pereionites 5-7 pointed. Posterior lateral margins of pleonites 1-5 angularly produced, of pleonite 5 only slightly. Telson linguiform, length nearly equal to width, margins rounded; posterior margin crenulate with about 50 crenulations and with a seta inserted between each of the crenulations (fig. 4); lateral margins without setae or spines.

Antenna 1 (fig. 6) relatively long, reaching posterior margin of pereionite 2 and past end of fifth peduncular segment of antenna 2. Antenna 1 with 4 peduncular segments; segment 1 about as broad as long and having a depression into which fits segment 1 of antenna 2; segment 2 joins 1 at lateral anterior corner; segment 2 slightly shorter than segment 1 and having a depression into which fits segment 2 of antenna 2; segment 3 slightly longer than segments 1 and 2 combined; segment 4 very short, nearly as broad as long and bearing a few sensory setae; flagellum composed of 23 short segments. Antenna 2 (fig. 7) long, nearly extending to end of body. Antenna 2 with 5 peduncular segments; segment 1 with a knob on anterior medial margin; segments 1, 2, and 3 about equally short; segments 4 and 5 each about as long as segments 1-3 combined; distal end of segment 5 surrounded by about 6 sensory setae; flagellum with about 40 to 45 segments.

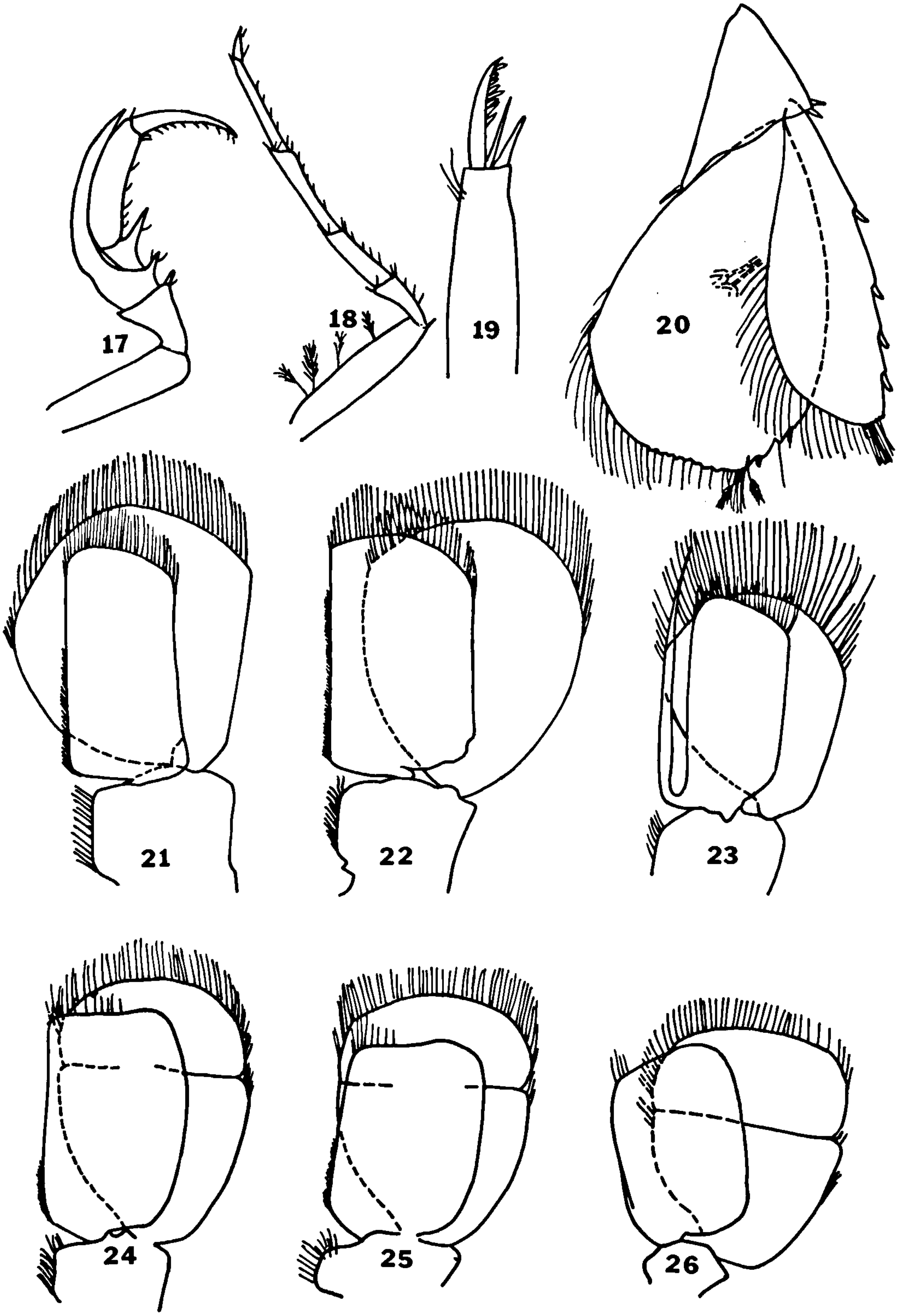
Mandibles asymmetrical, left masticatory blade overlapping right; posterior tooth of left longer than right; teeth more deeply divided on right; lacinia mobilis (fig. 8) present on both mandibles, bearing about 12 marginal spines; molar bearing about 13 marginal teeth. Segment 2 of palp about 2 times as long as segment 1 with row of about 18 spines on distal half; segment 3 slightly less than half as long as segment 2, with about 20 pectinate setae. Exopod of maxilla 1 (figs. 9-10) with 12 spines (11 marginal and 1 central): marginal spines generally larger toward distal end except for one short terminal spine. Endopod with 4 non-plumose spines and 1 short seta near base of distal spine. Maxilla 2 (fig. 11) with 4 and 8 setae on palp and exopod, respectively; endopod with about 14 setae. Endite of left maxilliped (fig. 12) with 2 retinacula, right with 1 to 3 retinacula.



Figs. 2-7. *Bahalana geracei* n. gen., n. sp.: 2, dorsal view; 3, head, ventral; 4, posterior margin of telson, dorsal; 5, seventh pereional segment with penis, ventral; 6, left first antenna, ventral; 7, left second antenna, ventral.



Figs. 8-16. *Bahalana geracei* n. gen., n. sp.: 8, left mandible; 9, left first maxilla; 10, left first maxilla, chewing surface; 11, left second maxilla; 12, left maxilliped; 13, crystals from internal organs; 14, left first pereiopod, dorsal; 15, projection of merus of left first pereiopod, dorsal; 16, left second pereiopod, dorsal.



Figs. 17-25. *Bahalana geracei* n. gen., n. sp.: 17, left third pereiopod, dorsal; 18, left fourth pereiopod, dorsal; 19, dactylus of left fourth pereiopod with pectinate claw, dorsal; 20, left uropod, ventral; 21, left first pleopod, ventral; 22, left second pleopod, female, ventral; 23, left second pleopod, male, ventral; 24, left third pleopod, ventral; 25, left fourth pleopod, ventral; 26, left fifth pleopod, ventral.

Pereiopods 1-3 (figs. 3, 14-17) prehensile, dactylus and propodus both extremely long. Pereiopod 1 with carpus reduced to small plate, distal posterior margin of merus with long spatulate projection reaching to distal end of propodus, anterior margin of basis grooved to accept ischium and merus. Pereiopod 2 with distal posterior margin of carpus bearing projection which extends about 1/4 length of propodus, distal anterior margin of ischium with short projection, distal anterior margin of merus with long projection extending to proximal end of dactylus, anterior margin of basis grooved to accept ischium and merus. Pereiopod 3 with distal posterior margin of carpus with projection which extends to about 1/3 length of propodus, distal anterior margin of merus with long projection extending to proximal end of dactylus, distal posterior margin of merus with projection slightly shorter than projection on carpus, distal anterior margin of ischium with slight projection, distal posterior margin of ischium with spine of about same length as projection on merus, anterior margin of basis grooved to accept ischium and merus.

Pereiopods 4-7 (figs. 18, 19) similar, ambulatory, and slightly longer than pereiopods 1-3. Dactyli short, about 1/4 length of propodus, terminated by 2 claws and 1 spine; longer claw about 1/3 length of dactylus and bearing 6-8 teeth of varying size and arrangement along medial edge (fig. 19); spine and shorter claw about 1/6 length of dactylus. About 10-14 short spines on posterior surfaces of propodus, carpus, and merus; about 4 on posterior surface of ischium; a ring of about 8 short spines around distal ends of propodus, carpus, merus, and ischium; 1 sensory seta on anterior side of distal end of each carpus. Anterior margin of each basis grooved to accept ischium and merus.

Endopod of pleopod 1 (fig. 21) about 1/2 as wide as exopod, medial margin straight, bearing close-set row of setules; distal margins of exopod and endopod bearing row of setae; protopod with row of about 13 spines on medial margin. Pleopod 2 (fig. 22) similar to 1 except endopod is wider. Stylet of male pleopod 2 (fig. 23) inserted near base of endopod, about 1/3 longer than endopod, gently curved, gradually tapering to slender tip. Endopod of pleopods 3 and 4 (figs. 24, 25) similar to those of 1 and 2 except wider and having row of about 9-13 setae on medial half of distal margin; exopod and protopod similar to those of pleopods 1 and 2 except for partial transverse suture on exopod. Exopod of pleopod 5 (fig. 26) similar to 3 and 4 except transverse suture is complete; endopod with about 4 setae on medial 1/3 of distal margin; protopod naked.

Ejaculatory duct visible from proximal end of basis of seventh pereiopod and extends medially to penis (fig. 5), which is unusually long (about 1/2 length of basis).

Uropod (fig. 20) reaching slightly posterior to telson. Exopod about 1/2 as wide as endopod; endopod slightly longer than broad. Medial and distal margins of exopod and endopod lined with setae and with a tuft of apical setae. Lateral margin of exopod with 4 step-like indentations, each bearing a short spine. Dorsal surface of endopod bearing about 4 sensory setae. Protopod strongly produced medially, bearing 1 apical seta; lateral apex bears 3 spines.

A light brown tint of some internal organs was noted, and I expected to find food in the digestive cavity. Upon dissection no food was found, but the connective tissues surrounding several organs were impregnated with crystals. High-power magnification (450 $\times$) showed these crystals to be basically diamond-shaped (fig. 13) and about 0.03 mm long, but many crystals were imperfect with double or triple diamond shapes up to 0.1 mm long.

DISCUSSION

The family Cirolanidae, considered the most primitive of the families of the suborder Cymothoidae (= Flabellifera), has 3 subfamilies: Cirolaninae, Bathynominae, and Faucheriinae (Vandel, 1965); *B. geracei* is in the Cirolaninae.

In 1975 Bowman arranged 30 known genera of the family into 9 groups according to pleonal segmentation. He recognized 10 genera in the first group (Bowman's fig 4*a*), which has 5 well-developed pleonal segments, considered the most primitive condition; the other genera in the family have various degrees of fusion of pleonites. *Bahalana* definitely has 5 well-developed pleonal segments. Of the 10 genera in this group only 7 are presently recognized as valid (3 have been combined with other genera). Within these 7 genera there are only 3 troglobitic species, and none of these seems to be closely related to *B. geracei*. *Sphaeromides raymondi* from France and *Sphaeromides virei* from Italy are in the subfamily Bathynominae (Vandel, 1965). *Cirolanides texensis* from Texas is in the subfamily Cirolaninae but is considerably different from *B. geracei* in that it has the exopod of pleopod 2 and endopods of pleopods 3-5 with 2 segments, and only pereiopod 1 is prehensile (Bowman, 1964). The other species of this group, not troglobitic, differ from *B. geracei* in a number of distinctive ways and do not seem to be closely related to it.

The genus *Bahalana* is unique in several ways, but there are two particularly distinctive characteristics worth noting. First, the setation and segmentation of the pleopods in *Bahalana* are very distinctive and separate it from other genera. Second, the extremely long dactylus, propodus, and projections of the merus of pereiopods 1-3 are considerably different from those of other cirolanid genera. Some other species (e.g., *Cirolana borealis* and *C. concharum*) of the Atlantic coast of North America have moderately long projections of the merus and ischium on all pereiopods, but in these cases the projections are broad and flat so as to make the segments nearly triangular in shape and approximately as broad as long; the segments are obviously flattened and extremely setaceous as modifications for swimming. In addition, the bases of the projections of the merus and ischium in these species are grooved so as to make a hinge joint with the next distal segment. The long projections of the merus of *Bahalana*, on the other hand, are not flattened or grooved and function in grasping and holding prey, but not in swimming.

ZOOGEOGRAPHIC REMARKS

In 1973 Holthuis coined the term anchialine from the Greek word anchialos, meaning "near the sea") for the habitat in a "pool with no surface connection with the sea, containing salt or brackish water, which fluctuates with the tides." Most anchialine pools described by Holthuis are within 150 m of the sea and are somewhat cave-like in that they have rather limited access to the surface; they also contain a rather distinctive fauna including some endemic crustaceans, but no troglobites. Several blue holes in the southwestern part of San Salvador Island fit the description of the typical anchialine habitat quite well except that some are over 1 km from the sea; one even contains the red shrimp *Barbouria cubensis* (cf. Hobbs, 1978).

Lighthouse Cave can be considered an unusual type of anchialine habitat in that it is at a relatively great distance from the sea and the pools are in total darkness (except for the areas close to the entrance). The cave waters communicate with the ocean and have tidal fluctuations of about 60 cm. The water was analyzed with a hydrometer at 1.026 specific gravity or about 3.5% salinity.

All other troglobitic cirolanids (except *Arubolana imula*) are found in freshwater caves at great distances from seawater. Presumably they were left stranded when high seawaters receded. For some species, this was probably during the Cenozoic Era (about 55 million years ago); for others, during the Late Cretaceous Period (about 135 million years ago) (Bowman, 1964). They probably all began their break from the sea in an anchialine habitat and gradually adapted to lower salinities. Although *B. geracei* and *A. imula* also may have existed in the subterranean habitat for millions of years, they are the only known troglobitic cirolanids still found in anchialine habitats. Thus, *B. geracei* found in seawater and *A. imula* found in brackish water represent interesting ecological "missing links" in the evolutionary development of troglobitic cirolanids.

Preliminary laboratory experiments indicate that *B. geracei* is tolerant of significant changes in salinity. One specimen was gradually acclimated to salinity as low as 1.0%, while another specimen survived salinity greater than 6.0%. These experiments add credence to the idea that the ancestors of the freshwater cave cirolanids were euryhaline species living in anchialine environments.

NATURAL HISTORY

During the summers of 1978-81 and the winter of 1980, I made about 12 excursions to Lighthouse Cave to collect specimens and observe the population of *B. geracei*. I was also able to keep specimens alive in the laboratory for up to 8 months. Thus, it is probable that more is now known about *B. geracei* than any other troglobitic cirolanid in the western hemisphere, and the following observations may be useful to future workers.

The population of *B. geracei* seems to be fairly constant throughout the year and from year to year. A few specimens can nearly always be found except at high tide. Individuals often sit quietly on the silty substrate, on the tops of rocks, or upside down under ledges. Occasionally they swim rather erratically toward the surface of the water, then back to a substrate. According to observations in the laboratory (sometimes using time-lapse photography) individuals will often remain stationary for several hours.

Females are larger (length to about 15 mm) and outnumber the smaller males (length to about 8 mm) in a ratio of about 5 to 1. Individuals grow very slowly; in many months of laboratory observation, only 1 specimen molted. Individuals shorter than 4 mm have never been found, nor have females with brood plates or pouches. Ovaries frequently contain poorly developed eggs, and males often have sperm in their sperm ducts. I suspect that the production of young is an infrequent event as a mechanism for conserving energy; however, Collins & Holsinger (1981) suggested that the lack of ovigerous females of *Antrolana lira* might be due to a tendency of these females to be more secretive and not attracted to bait.

Bahalana geracei is not gregarious. Although individuals can be kept in the same container for weeks, they tend to avoid each other, and for good reason — cannibalism does occur. On one occasion a large female was observed to attack and eat a male that wandered too close. These two specimens and five others had been living together in a 5-gallon aquarium for at least 3 weeks.

Feeding behavior is unpredictable. Various specimens have eaten frozen shrimp, cockroaches, terrestrial isopods, pieces of earthworm, mealworms, and asellote isopods. However, on any given occasion one individual might feed while others in the same container show absolutely no interest in the food, even though they had not eaten for several weeks. In the natural habitat, *B. geracei* probably preys or scavenges on a large variety of aquatic and terrestrial animals.

Food is held firmly by the first three pairs of pereiopods and is brought periodically to the mouth where mandibles bite and tear off small pieces. Feeding usually lasts about 5 minutes.

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