

CALLIASMATA NOHOCHI, NEW SPECIES (DECAPODA: CARIDEA: HIPPOLYTIDAE), FROM ANCHIALINE CAVE SYSTEMS IN CONTINENTAL QUINTANA ROO, MEXICO

Elva Escobar-Briones, Maria Elena Camacho, and Javier Alcocer

A B S T R A C T

A third species of *Calliasmata*, *C. nohochi*, is described from anchialine cave systems in Quintana Roo, Mexico. The new species closely resembles *C. rimolii* from the Dominican Republic, of which only female specimens are known. *Calliasmata nohochi* is characterized by a cephalon covered with minute scales and pits, longer pleura 5, and different spinulation on pereopods 3–5 from that observed in the other two species of *Calliasmata*. Differences from *C. pholidota* are more conspicuous, and include the absence of ventral spines on pleura 3–5, the form and spinulation of the appendix masculina of the second pleopod of the male, and dimorphism in the segmentation of the upper flagellum of the antennular peduncle, and in the second pereopods. Sexual dimorphism is observed among specimens of *C. nohochi* in the proportions, form, and spinulation of the antennular peduncle and flagellum, pereopods 2–4, and pleopod 2.

Two species belonging to the family Hippolytidae have been described in the genus *Calliasmata*. *Calliasmata pholidota* Holthuis, 1973, is restricted to crevicular habitats and anchialine pools in the Sinai Peninsula (Ras Muhammad), Ellice Island (Funafuti), and the Hawaiian Archipelago—Maui (Cape Kinau), and Hawaii (Lua o Palahemo). The second species, *Calliasmata rimolii* Chace (1975), was described from the eastern Dominican Republic, where it occurs in underwater anchialine caves.

The use of specialized cave-diving procedures permitting access to anchialine submerged cave systems in Quintana Roo has resulted in the discovery of a rich and diverse troglobitic crustacean community (Iliffe, 1993). A new species of *Calliasmata*, recorded from the continental anchialine cave systems of Naranjal and Nohoch Nah Chich, in the state of Quintana Roo, Mexico, is herein described.

The Yucatan Peninsula of Mexico is a flat limestone plain with no surface streams or rivers. All drainage is subterranean through extensive networks of submerged cave systems. Crack House and Mayan Blue Cenote are the two caves where specimens of this new species were collected. These two underwater caves belong to the Nohoch Nah Chich and Naranjal systems, two of the longest underwater cave systems in the world, at 22.3 and 15.5 km in length, respectively. They are both located about 5 km inland from the Quintana Roo Caribbean coast near the city of Tulum (Fig. 1). Primary orientation

of the caves is perpendicular to the coast. In the case of Nohoch Nah Chich, a connection with the sea is known. Cave passages are developed primarily at the halocline in 15–25 m water depth, where mixing between fresh and salt water occurs. Location of the cave systems and the water characteristics are described in Table 1.

MATERIALS AND METHODS

Location of each of the cave entrances and their elevation above mean sea level was recorded with a Magellan Field ProV GPS Receiver Model 35004 bearing 12 m RPS horizontal accuracy and geoidal height. Specialized cave-diving techniques were used to sample the specimens which were collected by the senior author with baited scavenger traps. These were deployed inside the cave at positions marked on a permanent line during 24-h periods under the halocline at distances of 33–66 m from the cave entrance in each system.

The description of the species follows the pattern of Holthuis (1973) for caridean shrimps from salt-water pools. The individuals were sexed, and cephalic and total lengths (CL and TL in mm) were measured with a dissecting microscope to compare similar species (Chace, 1975; Hobbs *et al.*, 1977). Figures were drawn with the aid of a camera lucida attached to stereoscopic and compound microscopes. Specimens are deposited in the Colección Nacional de Crustáceos (CNCR), Instituto de Biología, Universidad Nacional Autónoma de México.

***Calliasmata nohochi*, new species**

Figs. 2a–f, 3a–l, 4a–g

Type Material.—Holotype ♂, CNCR 15734, CL 10.7 mm, TL 28.1 mm, Crack House Cave, Nohoch Nah Chich system, Quintana Roo, Mexico; paratypes CNCR 15734a, 1 ♂ CL 11.2 mm, TL 29.5 mm, Crack House Cave, Quintana Roo, Mexico; CNCR 15732, 1 ♂ CL 8.2 mm, TL 14.3 mm, Cenote Mayan Blue—Tunnel B, Naranjal system,

Table 1. Sampling sites, positioning, characterization, and reference specimens of *Callinastrea nohochi* in the Colección Nacional de Crustáceos.

Dates	Cave	Latitude N	Longitude W	Altitude (m)*	Distance (m)**	Depth (m)	Temperature °C	D.O. mg/l	Specimens	Deposit number IB-LNAM†
15–16 Mar 95	Mayan Blue, Tunnel B	20°11.61	87°29.74	5	33	15	25–26.4	1.8–2.0	1 female	CNCR 15730
3–4 Oct 95	Mayan Blue, Tunnel B	20°11.61	87°29.74	5	66	22	25–26.4	1.8–2.0	1 male	CNCR 15732
4–5 Oct 95	Crack House	20°17.26	87°23.99	2	50	16	25–26	1.8–1.9	1 male	CNCR 15734 holotype
4–5 Oct 95	Crack House	20°17.26	87°23.99	2	50	16	25–26	1.8–1.9	1 male	CNCR 15734a paratype

* Above sea level.

** Along permanent line.

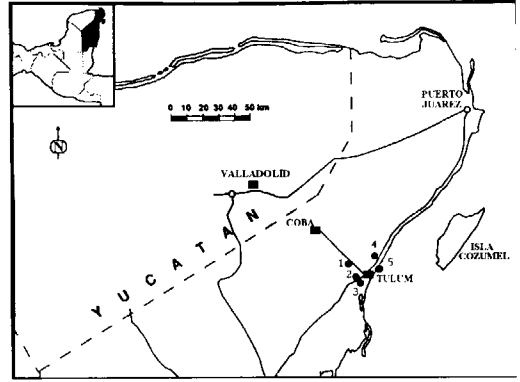


Fig. 1. Area of study. Symbols show sites of collection of specimens. 1 = Carwash, 2 = Naharone (also known as Cristal), 3 = Mayan Blue, 4 = Crack House (in the Nohoch Nah Chich system), 5 = Casa Cenote.

Quintana Roo, Mexico; CNCR 15730, 1 ♀ CL 13.5 mm, TL 33.5 mm. Cenote Mayan Blue–Tunnel B, Quintana Roo, Mexico.

Type Locality.—Crack House Cave, Nohoch Nah Chich system.

Description of Male.—Integument of carapace finely pitted with minute sharp, elongated scales implanted. Scales more densely implanted on anterior surface of carapace. Rostrum formed by simple spine, directed ventrally in lateral view, reaching distal half of eye peduncle, upper margin concave, lower margin sharply pointed, concave, reaching half distance of antennal spine (Fig. 2a, b).

Antennal spine reaching distal end of ocular peduncle. Pterygostomial region rounded, not produced anteriorly (Fig. 2c), posterior margin without cardiac notch (Fig. 2a). Abdomen smooth, sparsely covered by scales, setules, or pits. Pleura 1–4 broad, subquadrate, posterior angles devoid of spines. Pleuron of first somite broad, anterior and posterior angle slightly rounded, devoid of spines; pleuron of second somite wide, rounded with short, blunt lobe on distal margin; pleura 3 and 4 with distal margin rounded, without ventral spine.

Anterior margin of pleura 5 and 6 rounded; posteroventral angle of fifth segment acute. Pleuron of sixth somite bearing acutely triangular posterolateral lobe, devoid of movable plate. Somite 6, 1.3 times length of somite 5 and 0.7 middorsal length of telson (Fig. 2a). Telson broken at distal tip. Upper

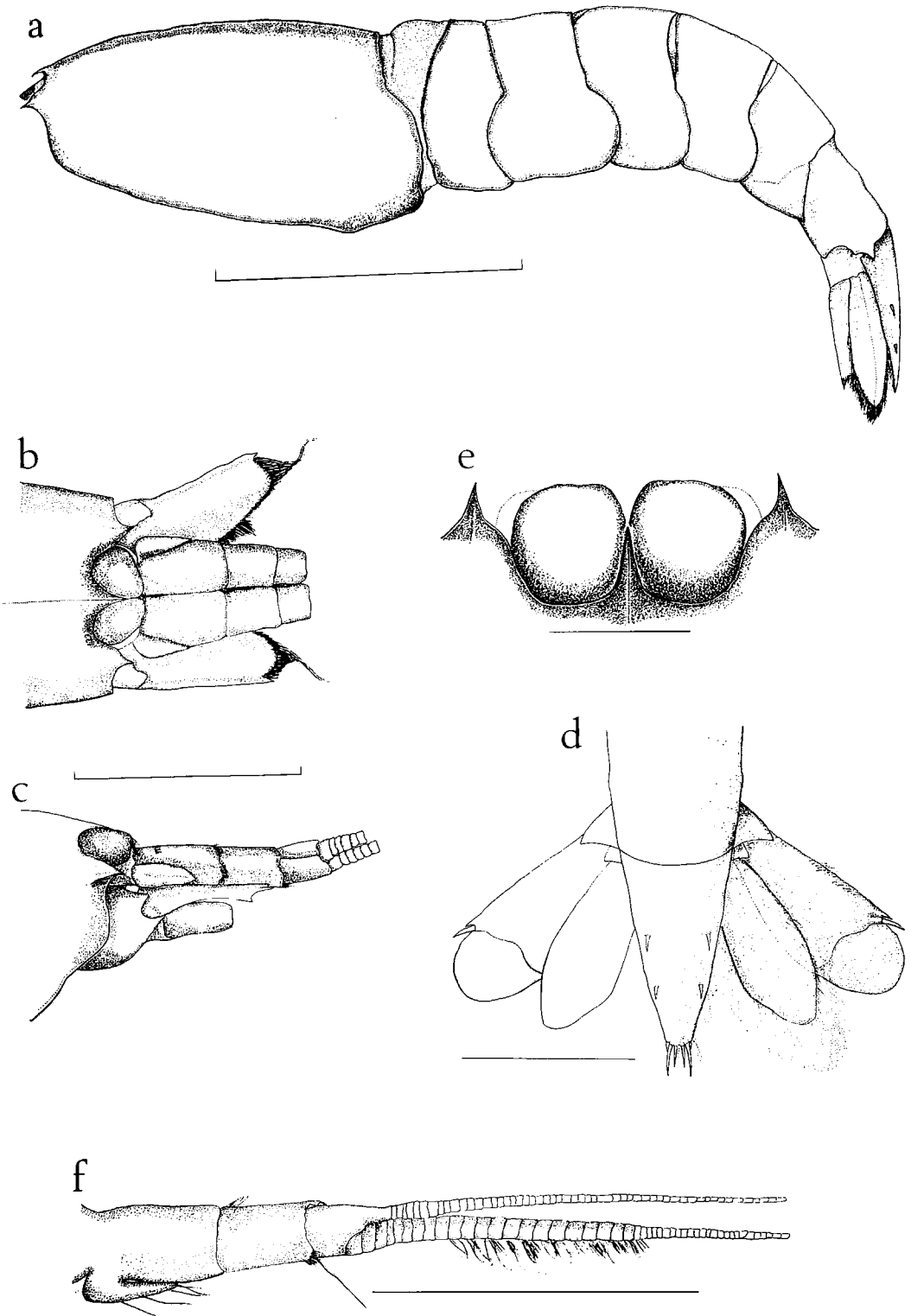


Fig. 2. *Calliasmata nohochi*, new species. a, body, lateral view (paratype), scale 1 cm; b, dorsal view of anterior portion of carapace, scale 5 mm; c, lateral view (holotype), scale 5 mm; d, dorsal view of telson and uropods (paratype), scale 5 mm; e, eyestalks and rostrum in dorsal view (holotype), scale 1 mm; f, antennule and antennular peduncle (paratype), scale 5 mm.

surface of telson bearing 2 pairs of dorsal spines, first pair placed on anterior half of telson, second pair closer to posterior margin.

Eyestalks free, not fused laterally or dorsally, close together, short, broad, triangular, reaching over end of antennal spine of carapace; distal portion of lateral margin with scalelike projection (Fig. 2e). Pigment on eyes dispersed as irregular black stains.

Antennule with triangular stylocerite with blunt end in lateral view, reaching half of first peduncle article, lateral margin with sparse long setae (Fig. 2f). First segment of antennular peduncle 1.3 times longer than segment 2 and 2.3 times longer than segment 3; dorsolateral flagellum with 2 rami, fused basal portion consisting of 21–27 segments; shorter free ramus consisting of 1 single reduced article; inner ramus slender, consisting of single, narrow, multiarticulate branch (Fig. 2f). Scaphocerite well developed, twice as long as wide, reaching distal end of second segment of antennular peduncles, outer margin straight, ending in small tooth, directed anteroventrally, reaching anterior margin of blade (Fig. 2b).

Carpocerite 0.66 length of scaphocerite. In lateral view with 2 spines distally, one above (covered by scaphocerite) and one below at base of scaphocerite (Fig. 2c).

Mandible lacking palp and incisor process. Molar process ending in 2 crests, major one ending in 6 sclerotized blunt teeth in upper row and lower one with 1 tooth (Fig. 3a).

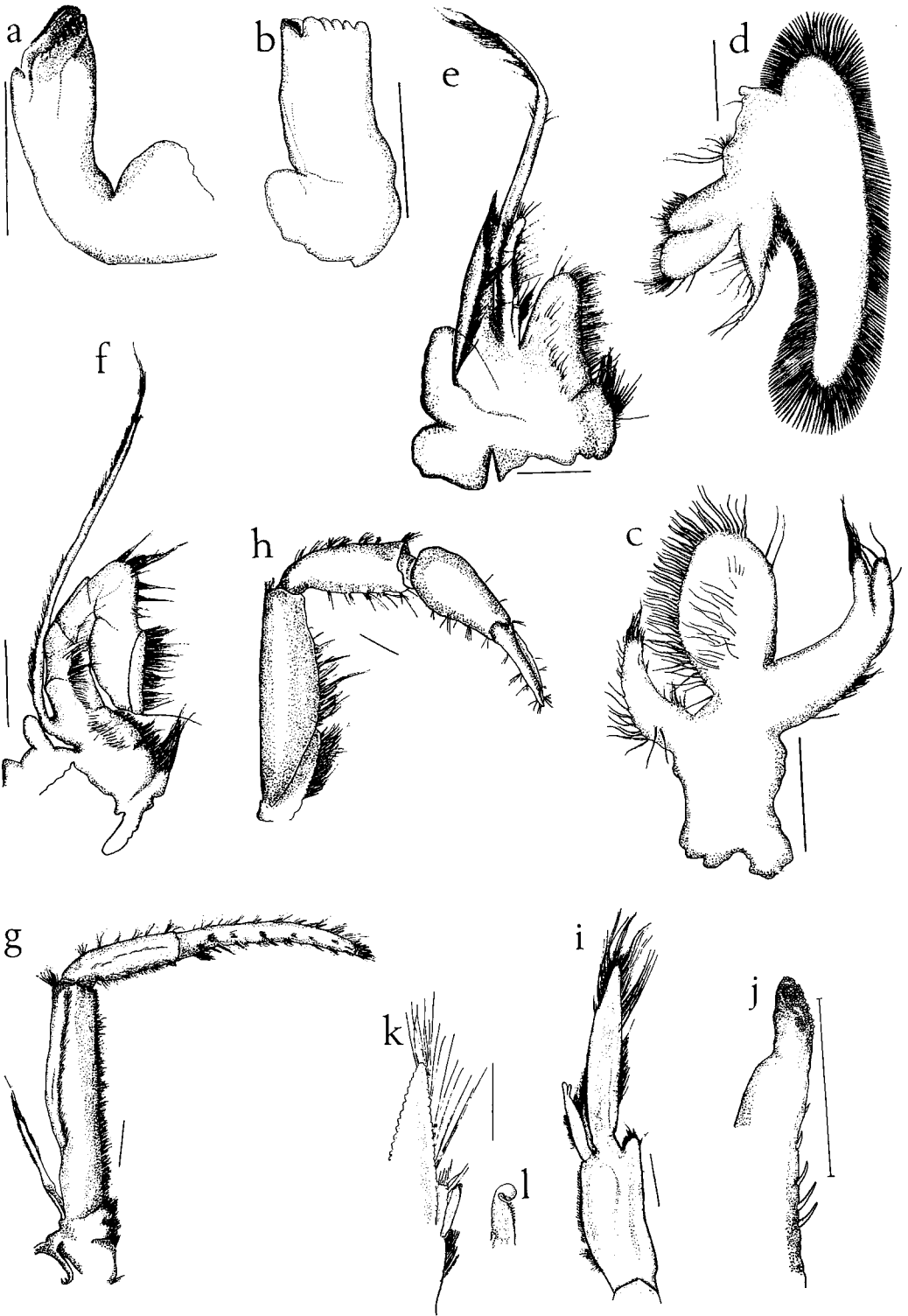
Maxilla 1 with lower lacinia slender and both margins bearing setae increasing in size at apex; upper lacinia broad, ovate, covered by rows of marginal spines and setae; palp bilobed, upper lobe blunt, ending in single seta, lower lobe exhibiting several shorter distal setae (Fig. 3c). Maxilla 2 with lower endite short, bilobed, ending in plumose setae, superior lobe well developed, divided by deep notch, upper lacinia ovate, more robust than lower lacinia; both laciniae bearing rows of shorter spines and long, dense

spinules along inner margins. Palp well developed, simple, reaching distal portion of anterior face of upper lacinia, bearing few plumose setae along both margins and 1 distal seta; scaphognathite distally elongated, tapering toward distal end, setae longest anteriorly (Fig. 3d). Maxillipeds with well-developed multiarticulated exopods. Disposition of epipods, exopods, and branchiae as in other two species of *Calliasmata*.

	Maxillipeds			Pereiopods				
	1	2	3	1	2	3	4	5
pleurobranchs	—	—	—	+	+	+	+	+
arthrobranchs	—	—	+	—	—	—	—	—
podobranchs	—	+	—	—	—	—	—	—
epipods	+	+	+	+	+	+	+	—
exopods	+	+	+	—	—	—	—	—

Maxilliped 1 with 2 endites separated by deep notch; palp well developed and 3-segmented, with basal projection and row of setae on inner surface; exopod long, with flagellum and narrow, well-differentiated caridean lobe, large wide epipod present, divided into 2 lobes, superior wider and larger than lower lobe, with rows of long, plumose setae on inner margin (Fig. 3e). Maxilliped 2 (Fig. 3f) with well-developed exopod; large, wide epipod; endopod composed of 7 articles, basal segments bearing dense spinules, being less numerous on other segments, terminal segment bent ventrally. Maxilliped 3 (Fig. 3g) reaching beyond antennular peduncle with more than half terminal segment, all segments bearing long setae along ventral margin, last segment bearing 10 rows of movable spines and 10 pairs of long, thick spines on dorsal margin, distal pair more robust; rows of long setae present. Ratio of last 3 segments: last segment 6.8 times longer than wide and 1.6 length of penultimate segment, upper end with short teeth and sparse setae. Penultimate segment 3.5 times as long as wide and 0.44 length of previous segment, bearing on up-

Fig. 3. *Calliasmata nohochi*, new species. a, mandible, showing molar process in male, scale 1 mm; b, mandible molar process in female, scale 1 mm; c, maxilla 1 (holotype), scale 1 mm; d, maxilla 2 (holotype), scale 1 mm; e, maxilliped 1 (holotype), scale 1 mm; f, maxilliped 2 (holotype), scale 1 mm; g, maxilliped 3 (holotype), scale 1 mm; h, first pereiopod (holotype), scale 1 mm; i, first pleopod (holotype), scale 1 mm; j, endopod of first pleopod (holotype), scale 1 mm; k, second pleopod, showing appendices masculinae and interna (holotype), scale 1 mm; l, detail of appendix interna (holotype), scale 1 mm.



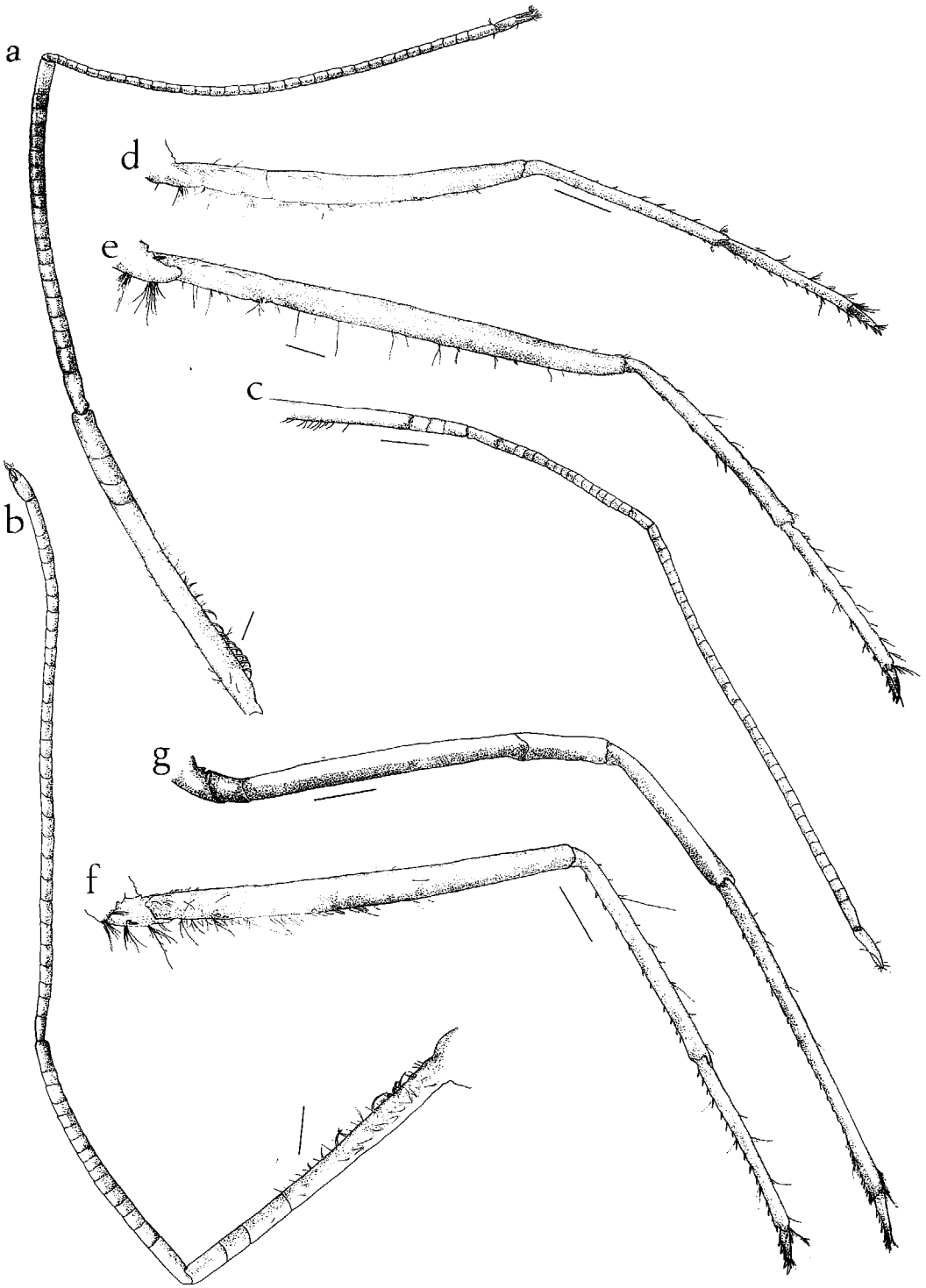


Fig. 4. *Calliasmata nohochi*, new species. a, right second pereiopod (holotype), scale 1 mm; b, left second pereiopod of male, scale 1 mm; c, left second pereiopod of female, scale 1 mm; d, third pereiopod of male, scale 1 mm; e, third pereiopod of female, scale 1 mm; f, fourth pereiopod (holotype), scale 1 mm; g, fifth pereiopod (holotype), scale 1 mm.

per end long spinules and tufts of long setae. Exopod well developed, epipod present.

First pereiopods (Fig. 3h) with well-developed chelae, more robust but shorter than in following legs, subequal in size and shape, reaching antennular peduncle; chela ovate, 3.5 times longer than wide, dactylus with sharply pointed tip, dark colored, 0.8 times length of propodal palm, lower margin bearing tufts of long setae, cutting edges with dispersed setae; carpus rectangular, 0.6 times length of merus, 2.2 times longer than wide and 0.6 times length of chela, merus 3.8 times longer than wide, subequal to chela with row of strong spines and long, slender setae on lower margin (Fig. 3h). Merus 1.2 times longer than chela. Ischium 3.7 times longer than wide, bearing small spines and long setae on lower margin.

Second pereiopods (Fig. 4a, b, c) long and slender, length unequal. Right longer than left, reaching distal margin of merus end of antennular peduncle. Chelae small, narrow and elongated, 4.5 times longer than wide, finger 0.8 times length of palm, dactylus equally long as palm ending in sharply pointed tips bent ventrally, bearing tufts of long setae. Carpus multiarticulated, 34 segments, 10.4 times longer than chela, 1.2 times longer than merus, and 1.3 times longer than ischium. Merus length subequal to ischium with 20 annulations. Ischium divided in 4 segments, proximal being longest; inner margin with row of 8 spines with curved tips and several short stiff hairs (Fig. 4a). Left second pereiopod (Fig. 4b) not overreaching antennal peduncle. Small, narrow, elongated chelae 2.6 times longer than wide, dactylus 0.3 times length of palm, bearing setae. Carpus with 28 segments, 14 times longer than chelae, 1.4 times longer than merus, and 1.8 times longer than ischium. Merus with 16 annulations, subequal in length to ischium. Ischium with segmentation similar to longer pereiopod, inner margin with row of 8 spines with curved tips and several short stiff hairs.

Third pereiopod overreaching antennal peduncle by distal margin of carpus. Dactylus slender, 4 times as long as wide, ending in sharp pointed tip, curved ventrally, and lower margin armed with 4 robust spines; flexor margin defined with line from tip of dactylus; propodus approximately 4.3 times as long as dactylus, with 10 spines combined with setae; carpus 1.5 times longer than propodus, with 8 pairs of spines along pos-

terior margin; merus 8.3 times longer than wide, 1.3 times as long as carpus, armed with 4 strong, robust spines; ischium (Fig. 4d) 3.3 times longer than wide, with strong spine on proximal margin.

Fourth pereiopod (Fig. 4f) narrower than third, dactylus similar, more than 4.4 times as long as wide; propodus 5 times as long as dactylus, its upper margin bearing tufts of setae, lower margin provided with 16 pairs of spines with scattered tufts of setae; carpus 15.3 times as long as wide, 1.5 times as long as propodus; carpus with distal projection ending in long distal setae, row of 11 spines along lower margin. Merus 8.7 times longer than wide, 1.3 times as long as carpus. Lower margin of merus and ischium with single spine each. Ischium 2.8 times longer than wide.

Fifth leg narrower than previous 2 legs, extending with propodus beyond antennal peduncle; dactylus slender, 4 times as long as wide, ending in curved tip and bearing 4 posterior spines; propodus 7.1 times as long as wide, posterior margin bearing 16 pairs of small spines, distal portion of margin provided with row of long, dense tufts of hairs and setae continuing on anterodistal margin; carpus 0.5 times as long as propodus and 10 times longer than wide, its posterior margin devoid of spines; merus 1.5 times longer than carpus and 12 times longer than wide; ischium 6 times as long as wide, posterior margin of these 2 articles bearing no spines or spinules (Fig. 4g).

Endopod of first pleopod bilobed, 0.44 as long as exopod (Fig. 3i), with retinacular hooks along mesial lobe, larger lobe provided with numerous small tubercles, its inner margin bearing 5 strong spines (Fig. 3j). Second pleopod with distinct appendix masculina ending in several long spines, longer than appendix interna (Fig. 3k). Appendix interna articulating on mesial margin of appendix masculina, with widened hooklike tip and turned downward (Fig. 3l).

Uropods oval and as long as telson. Outer margin of exopod ending in strong curved tooth; complete diuresis (Fig. 2d). Color of living specimens pale red or translucent pink.

Description of Female.—Integument of carapace finely pitted with minute sharp, elongated scales as in male. Pleura 1–4 broad, subquadrate, devoid of spines on posterior angles. Pleuron 6, 1.1 times longer than 5 and 0.6 times as long as telson. Telson elongate,

Table 2. Morphologic comparison among the three species of *Calliasmata*.

Character	<i>Calliasmata nohochi</i> , new species, this study		<i>Calliasmata rimoliti</i> Chace, 1975		<i>Calliasmata pholidota</i> Holthuis (1973)	
	yes	no	devoid	yes	yes	no
Carapace and integument with setules	yes	no	no, short	short, slightly overreaching distal margin of eyes widely rounded	short, slightly overreaching distal margin of eyes widely rounded	short, slightly overreaching distal margin of eyes widely rounded
Rostrum exceeding eyes	no	almost reaching distal margin of eyes rounded, posterior margin without cardinal notch	almost reaching distal margin of eyes rounded	almost reaching distal margin of eyes rounded	bluntly topped rectangle	bluntly topped rectangle
Carapace margin	rounded	rounded	rounded	rounded	wide rounded short blunt lobe	wide rounded short blunt lobe
Pleuron 1	without ventral spine, posteroventral angle acute spine	without ventral spine, posteroventral angle acute spine	without ventral spine, posteroventral angle acute spine	without ventral spine, posteroventral angle acute spine	with strong sharp spine	with strong sharp spine
Pleura 3-5	posteroventral angle acute spine	posteroventral angle acute spine	posteroventral angle acute spine	posteroventral angle acute spine	bluntly triangular, posteroventral angle with curved spine	bluntly triangular, posteroventral angle with curved spine
Pleuron 6	1.3	1.3	0.33	0.33	6 slightly longer than 5	6 slightly longer than 5
Pleuron 6/pleuron 5	distal half with long plumose setae	distal half with long plumose setae	distal setae not mentioned	distal setae not mentioned	distal setae not mentioned	distal setae not mentioned
Telson	absent	absent	absent	absent	three	three
Eyes	triangular	triangular	blunt, outer angle triangular	blunt, outer angle triangular	short and broad	short and broad
Antennule stylocerite	half basal segment	half basal segment	fails to reach second segment fused with 19-21 segments	fails to reach second segment fused with 19-21 segments	fails to reach second segment fused with 24 or 25 segments	fails to reach second segment fused with 24 or 25 segments
Outer antennal flagellum	carpus with 31 segments	carpus with 31 segments	carpus with 31 segments	carpus with 31 segments	carpus with 26-50 segments	carpus with 26-50 segments
Pereiopod 2	lower margin of carpus with 10-12 spines in female, 10 in males	lower margin of carpus with 10-12 spines in female, 10 in males	lower margin of carpus with 10 spines	lower margin of carpus with 10 spines	carpus lower margin of carpus with 12-15 spines	carpus lower margin of carpus with 12-15 spines
Pereiopod 3	propodus 5 times longer than dactylus, lower margin with 16 (male) and 13 (female) spines	propodus 5 times longer than dactylus, lower margin with 16 (male) and 13 (female) spines	propodus 4 times longer than dactylus, lower margin with 12 spines	propodus 4 times longer than dactylus, lower margin with 12 spines	propodus 4 times longer than dactylus, with less than 15 spines	propodus 4 times longer than dactylus, with less than 15 spines
Pereiopod 4	lower margin with 16 spines in male and 11 pairs in female, 7 times longer than dactylus	lower margin with 16 spines in male and 11 pairs in female, 7 times longer than dactylus	lower margin with 20 spines, 6 times longer than dactylus	lower margin with 20 spines, 6 times longer than dactylus	lower margin with 20-25 spines, 5 times longer than dactylus	lower margin with 20-25 spines, 5 times longer than dactylus
Pereiopod 5	half as long as exopod	half as long as exopod	half as long as exopod	half as long as exopod	more than half as long as exopod	more than half as long as exopod
Pleopod 1	endopod with appendix masculina and interna	endopod with appendix masculina and interna	only females	only females	male with appendix masculina and interna	male with appendix masculina and interna
Pleopod 2	shorter than appendix masculina	shorter than appendix masculina	unknown	unknown	shorter than appendix masculina	shorter than appendix masculina
Appendix interna	with 8 spines	with 8 spines	unknown	unknown	with spines	with spines
Appendix masculina	subequal to telson	subequal to telson	subequal to telson	subequal to telson	reach well beyond telson	reach well beyond telson
Uropodal rami	CL: 10.7-12.2 males, 13.5 female	CL: 10.7-12.2 males, 13.5 female	CL: 12 mm	CL: 12 mm	CL: 10-13 mm	CL: 10-13 mm
Size						

triangular, 2.2 times as long as wide, with posterior margin ending in median spine, dorsal spinulation similar to male. Posterior margin bearing 3 pairs of spines following size pattern of *C. pholidota* (Fig. 2d). Lateral margin with long, plumose setae. First segment of antennular peduncle twice as long as 2 distal articles together; dorsolateral flagellum with 2 rami, fused basal portion of 19 articles in female. Mouthparts similar to male. Molar process ending in 2 crests, major one ended in 6 sclerotized blunt teeth and lower one in 1 tooth, between crests numerous, short hairs (Fig. 3b). Maxilliped 3 overreaching antennular peduncle with more than half of terminal segment, all segments bearing long setae on lower margin, last segment bearing 10 rows of movable spines. Last segment 6.1 times longer than wide and 1.7 times length of penultimate segment.

Second pereopods long and slender, reaching end of antennal peduncle with distal half of carpus, one pereopod missing. Chelae narrow and elongated, 3.7 times longer than wide, dactyli 0.6 times length of palm, bearing setae. Carpus multiarticulated ($N = 31$), 9 times longer than chelae, 2.1 times longer than merus and 2.2 times longer than ischium. Merus length subequal to ischium with 17 annulations. Ischium with 4 annulations, proximal largest (Fig. 4c).

Third pereopod (Fig. 4e) dactylus slender, 4.5 times as long as wide, ending in sharp pointed tip, curved ventrally, lower margin armed with 2 spines on flexor margin; propodus approximately 3.7 times as long as dactylus, with 7 pairs of spinules and tufts of setae along posterior margin; carpus 1.5 times longer than propodus with 6 pairs of spines along posterior margin; merus 1.3 times longer than wide, 1.3 times as long as carpus, with 3 spines on distal half of inner posterior margin.

Fourth pereopod narrower than third, dactylus similar, more than twice as long as wide; propodus 5 times as long as dactylus, upper margin bearing tufts of setae, and lower margin provided with 13 pairs of spines with scattered tufts of setae; carpus 11.7 times as long as wide, 1.2 times as long as propodus and bearing 7 pairs of spines on posterior margin. Merus 9.2 times longer than wide, 1.3 times as long as carpus, lower margin of both merus and ischium devoid of spines. Ischium 4 times longer than wide.

Fifth leg narrower than preceding two legs, reaching beyond antennal peduncle with propodus; dactylus slender, 5.5 times as long as wide, ending in curved tip, bearing 4 posterior spines; propodus 5.1 times longer than dactylus, posterior margin bearing 11 pairs of small spines, distal portion of margin provided with row of long tufts; carpus 0.5 times as long as propodus and 7.7 times longer than wide; merus 1.5 times longer than carpus and 11.7 longer than wide; ischium 5 times as long as wide.

Etymology.—The specific epithet is the first word of the name of the cave system Nohoch Nah Chich (Mayan name for the large house of birds).

Habitat.—The specimens were found in anchialine habitats, in total darkness below the halocline. They were collected from two tidal, submerged karstic caves situated at distances ranging from 10–12 km from the coastline of Quintana Roo, Mexico. Their occurrence is limited to marine waters (35.2‰). The three known species described so far are restricted to anchialine habitats. The environmental conditions in which shrimp were found are: warm waters (25–26.4°C), with pH 7, hypoxic 1.8–2.0 mg/l dissolved oxygen, and SO_4^- ranging from 975–3,450 mg/l. The total absence of light and the depth of collection (Table 1) differ notably from the occurrence of the two previously described species.

Remarks.—Of the two previously described species, *Calliasmata nohochi* closely resembles *C. rimolii* Chace, 1975. Differences observed between the two species are the presence of scales and pits on the carapace, a longer pleuron 5, the fused portion of the antennular dorsolateral flagellum with 21–27 segments, and the spinulation and correlation of pereopodal articles in the former (Table 3).

The presence of minute scales is one of the characters of the genus. These scales are present in *C. nohochi* but absent in *C. rimolii*, to which the former is more closely related. This ornamentation on the cephalon of *C. nohochi* was conspicuous under the dissecting microscope. Both species, *C. rimolii* and *C. nohochi*, depart from the generic condition in the absence of the armed pleura 3–5. A posterodistal spine occurs on pleura 5 only.

Calliasmata pholidota (Holthuis) shows

Table 3. Habitat and ecological notes of troglobitic caridean shrimps recorded in Quintana Roo, Mexico.

Species	Habitat	Distribution in Mexico	Closest species	Ecological notes
<i>Procaris</i> sp. undescribed	anchialine	Cozumel, Q. Roo	other <i>Procaris</i>	being described
<i>Typhlatya mitchelli</i> Hobbs and Hobbs, 1976	fresh water	Yucatan Peninsula	intermediate form	2 m
<i>Typhlatya pearsei</i> Creaser, 1936	fresh water	Yucatan Peninsula	<i>T. consobrina</i> and <i>T. campecheae</i>	0.5–8 m, 0.78 mg/l O ₂
<i>Agostocaris bozanic</i> Kensley, 1988	anchialine	Cozumel, Q. Roo	<i>A. williamsi</i>	34 ppt, 18–41 m
<i>Creaseria morleyi</i> (Creaser, 1936)	fresh water	Yucatan and Q. Roo	none known	5 m
<i>Janicea antiguensis</i> (Chace, 1972)	anchialine	Cozumel, Q. Roo	<i>Somerstiella sterri</i>	euhaline
<i>Parhippolyte sterri</i> (Wickstein, 1996)	anchialine	Cozumel, Q. Roo	<i>Janicea antiguensis</i>	21 ppt, 12 m
<i>Yagerocaris cozumel</i> Kensley, 1988	anchialine	Cozumel, Q. Roo	<i>Calliasmata pholidota</i>	euhaline, 9–12 m
<i>Calliasmata nohochi</i> , new species	anchialine	Continental Q. Roo	<i>Calliasmata rimoliti</i>	35.2 ppt, 16–22 m

marked differences when compared with *C. rimoliti* and *C. nohochi*. These differences are related to the proportions and different spinulation patterns between the articles of the pereopods. Other differences are cited in Table 2.

Ecological differences related to the habitat may be noted as well. *Calliasmata pholidota* was collected from crevicular habitats and anchialine pools in several localities in the Indo–West Pacific region, while *C. rimoliti* and *C. nohochi* were obtained from anchialine cave systems at distances of 0.5–12 km from the coast in the Dominican Republic and Quintana Roo, Mexico, respectively.

DISCUSSION

As with many other recorded cave-limited crustaceans and fishes known from the Yucatan peninsula, *Calliasmata nohochi* is considered to be endemic to continental systems of Quintana Roo and may well be derived from marine ancestors (Table 3). Most of the crustaceans described from caves in Quintana Roo are restricted to anchialine systems, including both the insular and the continental portions. The major diving effort has been carried out in the Naranjal (Mayan Blue–Najarone) and Carwash cave systems (Iliffe, 1993; Kallmeyer and Carpenter, 1996) from which most of the continental cave Crustacea in Quintana Roo have been collected and described. New exploration and study has started in the Nohoch Nah Chich system, a highly diversified location with an inland-to-coast faunistic gradient in troglobitic crustaceans.

Divergence in speciation of fauna with marine origin may be expected to be related to the time of separation from coastal populations. Those species inhabiting further inland, being troglobitic, are probably the oldest ones. The halocline in the Nohoch system has been recorded at increasing depths in the farthest inland sections of the cave system.

A significant number of decapod crustaceans have been described from various subterranean waters in North and Mesoamerica (Mexico, Central America, West Indies) and from islands in the western North Atlantic and the Caribbean Sea. Taxonomic affinities of the Yucatan troglobitic fauna to related anchialine caridean species from various oceanic islands in the western Atlantic have been recognized (*Agostocaris*, *Janicea*, *Procaris*, *Parhippolyte*, and *Typhlatya*). Species of these genera commonly

occur in the caves of the Yucatan Peninsula and the Bahamas (Holsinger, 1986, 1989), Bermuda (Hart and Manning, 1981), and the West Indies (Hobbs *et al.*, 1977). Other genera (*Agostocaris*, *Yagerocaris*, *Xyphocaris*) have been identified solely from islands in the West Indies and northern Caribbean.

The three species of *Calliasmata* occur in widely separated coastal anchialine localities (West Indies) and crevicular habitats (W. Pacific). The hypothesis presented by Hart *et al.* (1985) and Manning *et al.* (1986) suggests that this shrimp may have invaded crevicular and anchialine habitats in the Jurassic, serving as Mesozoic refugia for the ancestors of the species.

The species could have arisen from marine epigeal progenitors (Hobbs, 1994) rather than sharing common subterranean precursors. The wide distribution of the anchialine genus *Calliasmata* poses puzzling questions concerning its biogeography that may need to be supported by information on the diverse group of other cooccurring Crustacea (amphipods and other decapod Crustacea).

In connection with cooccurring decapod species, it is interesting that at the sites where the genus *Calliasmata* occurs *Macrobrachium* coexists. *Macrobrachium grandimanus* (Randall) is found with *Calliasmata pholidota*, *M. crybelum* Chace with *Calliasmata rimolii*, and *M. acathurus* (Wiegmann) with *Calliasmata nohochi*. The genus *Macrobrachium* may have invaded subterranean waters recently, having no true troglobitic adaptations.

Typhlatya coexists with *Calliasmata* both in the Yucatan peninsula and the Dominican Republic, but is absent in the western Pacific. The species belonging to the genus *Typhlatya* live in cave, anchialine, or crevicular habitats in Mexico, the Caribbean, eastern and western Atlantic, as well as on the Galapagos Island of Santa Cruz. Their widely disjunct distribution has involved vicariance and dispersal biogeography derived from marine stocks. Ancestors of extant *Typhlatya* may have occurred in crevicular habitats only along the Mid-Atlantic Ridge (Manning *et al.*, 1986).

Other mechanisms proposed for such global dispersal of obligate anchialine fauna include deep-sea dispersal (Hart *et al.*, 1985), stranding of cave species on the shoreline of fossil seas (Stock, 1986a; Stock *et al.*, 1986), and passive dispersal of adults or larvae by ocean currents (Newman, 1986; Iliffe *et al.*, 1984).

Quintana Roo seems to hold a rich troglobitic crustacean fauna with at least 15 species described. This large diversity may arise from the origin of this fauna in the Yucatan Peninsula itself (Wilkins, 1979). The distribution patterns of the crustaceans in these coastal plains seem to have originated from different invasion periods (Stock, 1986b), in slower evolution rates, or from a larger degree of motility of some of the troglobitic species in the Yucatan peninsula (Holsinger, 1989), e.g., *Typhlatya mitchelli* Hobbs and Hobbs, *T. pearsei* Creaser, *Creaserella anops* (Creaser), *Creaseria morleyi* (Creaser). Wilkins *et al.* (1986) proposed that the transition of marine species to freshwater caves was dependent on the existence of (anchialine, Stock *et al.*, 1986) coastal caves and suggested a secondary dispersion through the phreatic mantle.

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LITERATURE CITED

- Chace, F. A. 1975. Cave shrimps (Decapoda: Caridea) from the Dominican Republic.—Proceedings of the Biological Society of Washington 88: 29–44.
- Hart, C. W., and R. B. Manning. 1981. The cavernicolous caridean shrimps of Bermuda (Alpheidae, Hippolytidae, and Atyidae).—Journal of Crustacean Biology 1: 441–456.
- , ———, and T. M. Iliffe. 1985. The fauna of Atlantic marine caves: evidence of dispersal while maintaining ties to deep water.—Proceedings of the Biological Society of Washington 98: 288–292.
- Hobbs III, H. H. 1994. Biogeography of subterranean decapods in North and Central America and the Caribbean region (Caridea, Astacidea, Brachyura).—Hydrobiologia 287: 95–104.
- Hobbs, Jr., H. H., H. H. Hobbs III, and M. A. Daniel. 1977. A review of the troglobitic decapod crustaceans of the Americas.—Smithsonian Contributions to Zoology 244: 1–183.
- Holsinger, J. R. 1986. Zoogeographic patterns of North American subterranean amphipod crustaceans.—In: R. H. Gore and K. L. Heck, eds., Crustacean biogeography. Crustacean Issues 4: 85–106. A. A. Balkema, Rotterdam, The Netherlands.
- . 1989. Preliminary zoogeographic analysis of five groups of crustaceans from anchialine caves in the

- West Indian region.—Proceedings of the 10th International Congress of Speleology. Pp. 25–26.
- Holthuis, L. B. 1973. Caridean shrimps found in landlocked saltwater pools at four Indo-West Pacific localities (Sinai Peninsula, Funafuti Atoll, Maui and Hawaii Islands), with the description of one new genus and four new species.—*Zoologische Verhandlungen* 128: 1–48.
- Iliffe, T. M. 1993. Fauna Troglobia Acuática de la Península de Yucatán.—In: S. I. Salazar-Vallejo and N. Emilia González, eds., *Biodiversidad marina y costera de México*. Pp. 673–686. Conabio y Ciqro, México. Pp. 1–865.
- , H. Wilkens, J. Parzefall, and D. Williams. 1984. Marine lava cave fauna: composition, biogeography and origins.—*Science* 225: 309–311.
- Kallmeyer, D. E., and J. R. Carpenter. 1996. *Stygomyxis cokei*, new species, a troglobitic mysid from Quintana Roo, Mexico (Mysidacea: Stygomysidae).—*Journal of Crustacean Biology* 16: 418–427.
- Manning, R. B., C. W. Hart, and T. M. Iliffe. 1986. Mesozoic relicts in marine caves of Bermuda.—*Stygologia* 2: 156–166.
- Newman, W. A. 1986. Origin of the Hawaiian marine fauna: dispersal and vicariance as indicated by barnacles and other organisms.—In: R. H. Gore and K. L. Heck, eds., *Crustacean biogeography*. *Crustacean Issues* 4: 21–49. A. A. Balkema, Rotterdam, The Netherlands.
- Stock, J. H. 1986a. Deep sea origin of cave faunas, an unlikely supposition.—*Stygologia* 2: 105–111.
- . 1986b. Caribbean biogeography and a biological calendar for geological events.—In: R. H. Gore and K. L. Heck, eds., *Crustacean biogeography*. *Crustacean Issues* 4: 195–203. A. A. Balkema, Rotterdam, The Netherlands.
- , T. M. Iliffe, and D. Williams. 1986. The concept of “anchialine” reconsidered.—*Stygologia* 2: 90–92.
- Wilkens, H. 1979. Reduktionsgrad und phylogenetisches Alter: ein Beitrag zur Besiedlungsgeschichte der Limnofauna Yukatans.—*Zeitschrift fuer zoologische Systematik und Evolutionsforschung* 17: 262–272.
- , J. Parzefall, and T. M. Iliffe. 1986. Origin and age of the marine stygofauna of Lanzarote, Canary Islands.—*Mitteilungen aus dem Hamburgischen zoologischen Museum und Institut* 83: 223–230.

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Addresses: (EEB) Laboratorio de Ecología del Bentos, Instituto de Ciencias del Mar y Limnología, Universidad Nacional Autónoma de México, A.P. 70-305, 04510 Mexico City, Mexico. (e-mail: escobri@mar.icmyl.unam.mx); (MEC) Colección Nacional Carcinológica, Instituto de Biología, Universidad Nacional Autónoma de México, A.P. 70-153, 04510 Mexico City, Mexico. (e-mail: falvarez@servidor.unam.mx); (JA) Aquatic Ecology Lab, Environmental Conservation & Improvement Project, UIICSE, Universidad Nacional Autónoma de México Campus Iztacala, Av. de los Barrios s/n, Los Reyes Iztacala, Tlalnepantla 54090, Estado de México, Mexico. (e-mail: jalcocer@servidor.unam.mx)