



A new species of *Lysmata* (Crustacea, Decapoda, Hippolytidae) from Venezuela, southeastern Caribbean Sea

J. ANTONIO BAEZA^{1,2,3}, JUAN A. BOLAÑOS⁴, JESÚS E. HERNANDEZ⁴ & RÉGULO LÓPEZ⁴

¹Smithsonian Tropical Research Institute, Apartado Postal 0843-03092, Balboa, Ancón, Republic of Panama

²Smithsonian Marine Station at Fort Pierce, 701 Seaway Drive, Fort Pierce, FL 34949, USA

³Departamento de Biología Marina, Facultad de Ciencias del Mar, Universidad Católica del Norte, Larrondo 1281, Coquimbo, Chile

⁴Grupo de Investigación en Carcinología, Escuela de Ciencias Aplicadas del Mar, Núcleo Nueva Esparta, Universidad de Oriente, Isla Margarita, Venezuela. E-mail: baezaa@si.edu

Abstract

Lysmata udoi n. sp., a new peppermint shrimp, is described from Venezuela, southeastern Caribbean Sea. All individuals were collected from dens of the toadfish *Amphichthys cryptocentrus* (Valenciennes, 1837) in the subtidal zone. This new species can be distinguished from other closely related species of *Lysmata* by the number of teeth, length and shape of the rostrum, the relative length of the antennular peduncle, and the number of carpal articles of the second pereiopod. The color pattern is distinctive. The fourth abdominal segment almost lacks color, but bears a posterior red thin line with three short forward projections. Morphological and molecular characters demonstrate that *L. udoi* n. sp. is most closely related to the Gulf of Mexico *L. boggessi* Rhyne and Lin, 2006 and the Caribbean *L. rafa* Rhyne and Anker, 2007 and *L. ankeri* Rhyne and Lin, 2006. Field observations suggest that *L. udoi* n. sp. is a protandric simultaneous hermaphrodite, with a primary male phase followed by a simultaneous hermaphrodite phase.

Key words: *Lysmata*, Lysmatidae, Hippolytidae, Caribbean, Venezuela, hermaphrodite

Introduction

Shrimps from the genera *Lysmata* Risso, 1816 and *Exhippolysmata* Stebbing, 1916 are unique among decapod crustaceans because of their enigmatic sexual system. All species so far studied are protandric simultaneous hermaphrodites, in which individuals consistently mature and reproduce initially as males, and later in life, become functional simultaneous hermaphrodites (Bauer & Holt 1998; Braga *et al.* 2009; Baeza 2009).

Shrimps from genera *Lysmata* and *Exhippolysmata* are also recognized because their wide diversity of lifestyles. Many species are not conspicuous in terms of coloration, occur in dense aggregations, and dwell freely among rocks at intertidal and/or subtidal temperate and subtropical zones (e.g., *L. californica* (Stimpson, 1866)—Bauer & Newman 2004, *L. nayaritensis* Wicksten, 2000—Baeza *et al.* 2008, *Exhippolysmata oplophoroides* (Holthuis, 1948)—Braga *et al.* 2009). Other species live in small groups sometimes developing symbiotic associations with sessile macroinvertebrates (i.e., *L. pedersenii* Rhyne and Lin, 2006 inhabiting tube sponges—Baeza 2009). Lastly, a few species have a striking coloration, live as socially monogamous pairs, and apparently provide cleaning services to fishes (e.g., the red blood shrimp *L. splendida* Burukovsky, 2000 and *L. debelius* Bruce, 1983 and the lady scarlet shrimp *L. amboinensis* (De Man, 1888) and *L. grabhami* (Gordon, 1935)—Limbaugh *et al.* 1961; Bruce 1983; Fiedler 1998). Because of this lifestyle diversity, shrimps from the genus *Lysmata* and *Exhippolysmata* have captured the attention of systematists, aquaculturists, natural historians and evolutionary biologists (d'Udekem d'Acoz 2003; Rhyne & Lin 2006; Rhyne & Anker 2007; Baeza & Bauer 2004; Baeza 2006, 2007a, b, c, 2008). They currently are

being used to explore the importance of the environment in favouring particular behavioural and morphological features (See, for example, Baeza 2009; Baeza *et al.* 2009).

In the Caribbean and Western Atlantic, there are 13 species of *Lysmata* (Baeza 2009). An intensive sampling program conducted throughout the Caribbean yielded four specimens originally collected from Cubagua Island, Venezuela. These specimens were similar to *L. ankeri* Rhyne and Lin, 2006, *L. boggei* Rhyne and Lin, 2006 and *L. rafa* Rhyne and Anker, 2007. However, detailed examination of the material in the laboratory and careful comparison with other species from the Caribbean indicated that the specimens pertained to an undescribed species. Here, we describe the species as new and provide information on its general ecology. Color photographs and GenBank (16S) numbers are provided.

Materials and methods

Specimens were collected using SCUBA from the shallow subtidal zone (3–7 m) at Isla Cubagua and Isla Margarita, Venezuela, transported to the laboratory, and preserved in 95–99% ethanol. The material was deposited at the Museo Oceanológico Hermano Benigno Roman, Estación de Investigaciones Marinas de Margarita, Fundación La Salle de Ciencias Naturales, Venezuela. All shrimp lengths are carapace lengths (CL, mm), measured in mm from the orbital margin to the margin of the carapace.

We were interested in the position of the new species within the Neotropical clade of peppermint shrimps (Baeza *et al.* 2009). Therefore, we construct a molecular phylogeny using the 16S DNA fragment. Tissue extraction, PCR amplification with specific primers, product cleanup, and sequencing were conducted as described in Baeza *et al.* (2009). A total of 17 sequences; two sequences from two specimens of the new species and 10 sequences from other 6 species comprising the Neotropical clade of peppermint shrimps were included in the present phylogenetic analysis. Other 5 sequences from the species *L. californica* (Stimpson, 1866), *L. galapagensis* Schmitt, 1924, *L. moorei* (Rathbun, 1901), *L. holthuisi* Anker *et al.* 2009 and *L. intermedia* (Kingsley, 1879) were included as outgroups during the phylogenetic analyses.

Alignment of the set of sequences was conducted in ClustalW as implemented in MEGA 4.1 (Tamura *et al.* 2007). Selection of an optimal model of base substitution was conducted with MrModeltest v2.2 (Nylander 2004). The optimal model found by MrModeltest v2.2 (selected by the hierarchical Likelihood Ratio Test) was a GRT+G evolutionary model (-lnL = 1650.4279). The calculated parameters were as follow: assumed nucleotide frequencies A= 0.2648, C= 0.1977, G= 0.2239, T= 0.3137; substitution rate matrix with A–C substitution = 7.5163, A–G= 18.0544, A–T= 12.2219, C–G= 6.9445, C–T= 35.1822, G–T= 1.0; rates for variable sites assumed to follow a gamma distribution (G) with shape parameter = 0.4158. This model was implemented in MrBayes (for Bayesian Inference analysis) and Treefinder (for maximum likelihood analysis - Jobb *et al.* 2004). In MrBayes, the analysis was performed for 6, 000, 000 generations. Every 100th tree was sampled from the MCMC analysis obtaining a total of 60, 000 trees and a consensus tree with the 50% majority rule was calculated for the last 59, 900 sampled trees. The robustness of the ML tree topologies was assessed by bootstrap reiterations of the observed data 1000 times. Support for nodes in the BI tree topology was obtained by posterior probability. Genetic distances were calculated using the GRT+G evolutionary model in Treefinder.

Taxonomy

Family Hippolytidae Dana, 1852

Genus *Lysmata* Risso, 1816

***Lysmata udoi* n. sp.**

(Figures 1–3)

Type material. Holotype: simultaneous hermaphrodite (carapace length [CL] 8.0 mm, CL+ rostrum [R] 14.55 mm), MOBR-C-1547, Caribbean coast, Cubagua Island, Venezuela, from dens of the “sapo bocón” toadfish, *Amphichthys criptocentrus* (Valenciennes, 1837), 2–4 m, colls. R. Lopez and J. A. Baeza, 15–20 Aug 2008. Paratypes: 1 ovigerous simultaneous hermaphrodite (CL 7.77 mm, CL + R 13.66 mm), MOBR-C-1548, same collection data as for holotype; 1 male (CL 7.35 mm, CL+R 13.95 mm), MOBR-C-1549, same collection data as for holotype.

Description. Rostrum elongate, slender, slightly curved upwards, about 0.9 times as long as carapace, slightly surpassing end of antennular peduncle (Fig. 1a–b); dorsal margin with six teeth, posterior tooth situated just anterior to middle of carapace, second tooth just posterior of postorbital margin, single seta present between all teeth; ventral margin with five teeth, most-proximal ventral tooth situated at the same level of fifth most-proximal dorsal tooth at mid-length level of first antennular segment; tip of rostrum bidentate (Figs. 1b). Carapace smooth, 1.2–1.3 times as long as high, posteroventral margin rounded; pterygostomial angle rounded, without tooth (Fig. 1c). Eyes moderately large, not reaching dorsal margin of rostrum (Fig. 1a–d). Antennal tooth long, reaching to posterior margin of cornea (Fig. 1a–c). Antennular peduncle not reaching scaphocerite, about 0.75 times as long as scaphocerite, first segment about 2.0–2.2 as long as second segment, second segment about 1.6 times as long as third segment; disto-dorsal margin of all three peduncular segments furnished with series of spinules; stylocerite overreaching anterior margin of eye, reaching or just over-reaching mid-length of first antennular segment (Fig. 1a–c); ventro-mesial carina with small, anteriorly directed tooth (Fig. 1d); lateral antennular flagellum long, with aesthetascs extending from fourth to 31st segment (Fig. 1e); accessory branch of outer ramus rudimentary (Fig. 1e). Scaphocerite 4.4–4.8 times as long as wide, lateral margin slightly concave, distolateral tooth considerably over-reaching distal margin of blade (Fig. 1f).

Abdomen more than twice carapace length. Pleura of first four abdominal somites with rounded margin (pleuron of fourth somite without postero-lateral tooth); pleuron of fifth somite with sharp posterolateral tooth; sixth somite about 1.3 times longer than fifth somite, with acute posteroventral tooth and acute posterior tooth flanking base of telson (Fig. 1g). Telson about 1.7–1.9 times as long as sixth abdominal somite, tapering posteriorly; dorsal surface with two pairs of spines (Fig. 1h); posterior margin medially acute, with pair of long slender spines each flanked by shorter spine (Fig. 1h–i); two long plumose setae present between long spines (Fig. 1h–i).

Mouthparts typical for genus, third maxilliped over-reaching scaphocerite; exopod about 0.6 times as long as antepenultimate segment of endopod; ultimate segment 1.6–1.7 times as long as penultimate segment; with tip furnished with 9 spines, 3 distal, 3 subdistal and other 3 more proximal (Fig. 1j–k). First pereopod with simple chela (Fig. 2a–b), reaching beyond end of scaphocerite when fully extended, ischium with row of spines along ventral margin (Fig. 2b–c); carpus about 0.8–0.9 times the length of the merus, chela subequal to carpus, palm about three times as long as dactylus, six times as long as high (Fig. 2a–b). Second pereopods slender, subequal in length, ending in small simple chelae; merus with 20 articles, carpus about 1.7 times the length of the merus, reaching beyond third article of antennular peduncle, with 33 articles (Fig. 2d). Ischium with row of proximal spines along ventral margin (Fig. 2e).

Third to fifth pereopods similar, decreasing in length from third to fifth. Third pereopod reaching beyond third article of antennular peduncle, merus with seven spines, about 2.5–2.7 times as long as ischium; carpus about half as long as merus, unarmed; propodus about 1.5 times as long as carpus; dactylus about 1/6 times as long as propodus (Fig. 2f), biunguiculate, dorsal unguis slightly longer than ventral one, flexor margin of dactyl armed with 3 pinules, decreasing in size from proximal to distal. Fourth pereopod similar to third, carpus reaching beyond third article of antennular peduncle. Fifth pereopod similar, with merus about 1.4 times carpus length, reaching beyond third article of antennular peduncle, bearing three spines; propodus with rows of dense setae on distal end of flexor margin (Fig. 2g). Uropod typical for the genus, without special features (Fig. 1l).

Color in life. Body translucent with red longitudinal and diagonal stripes (Fig. 3), carapace with inverted V-shaped band, abdominal pleura with narrow longitudinal stripes (dorsal showing from 5 to 3, none of them running entirely along the length of the abdomen); third pleuron with wide transverse band; fourth pleuron almost lacking pigments, with the exception of a transverse band (not as conspicuous as on third pleuron) with three longitudinal short lines (two lateral and one medial) projecting interiorly, but not reaching middle section of the pleuron; telson and uropods with intense red longitudinal bands. Color of early embryos and eggs pink. Late stage embryos turning silver brown.

Size. The male specimen is 7.35 mm CL; the hermaphrodites are 7.77–8.04 mm CL.

Ecology. In crevices or cracks used by the toadfish *Amphichthys cryptocentrus* (Valenciennes, 1837), in sand, coral rubble, or live coral bottoms. Additional diving observations indicated that this species inhabits their refuges in small groups. Only the larger shrimp within a group were found brooding embryos suggesting that the species is a protandric simultaneous hermaphrodite as reported for other species of *Lysmata* whose sexual system has been studied (Baeza 2009).

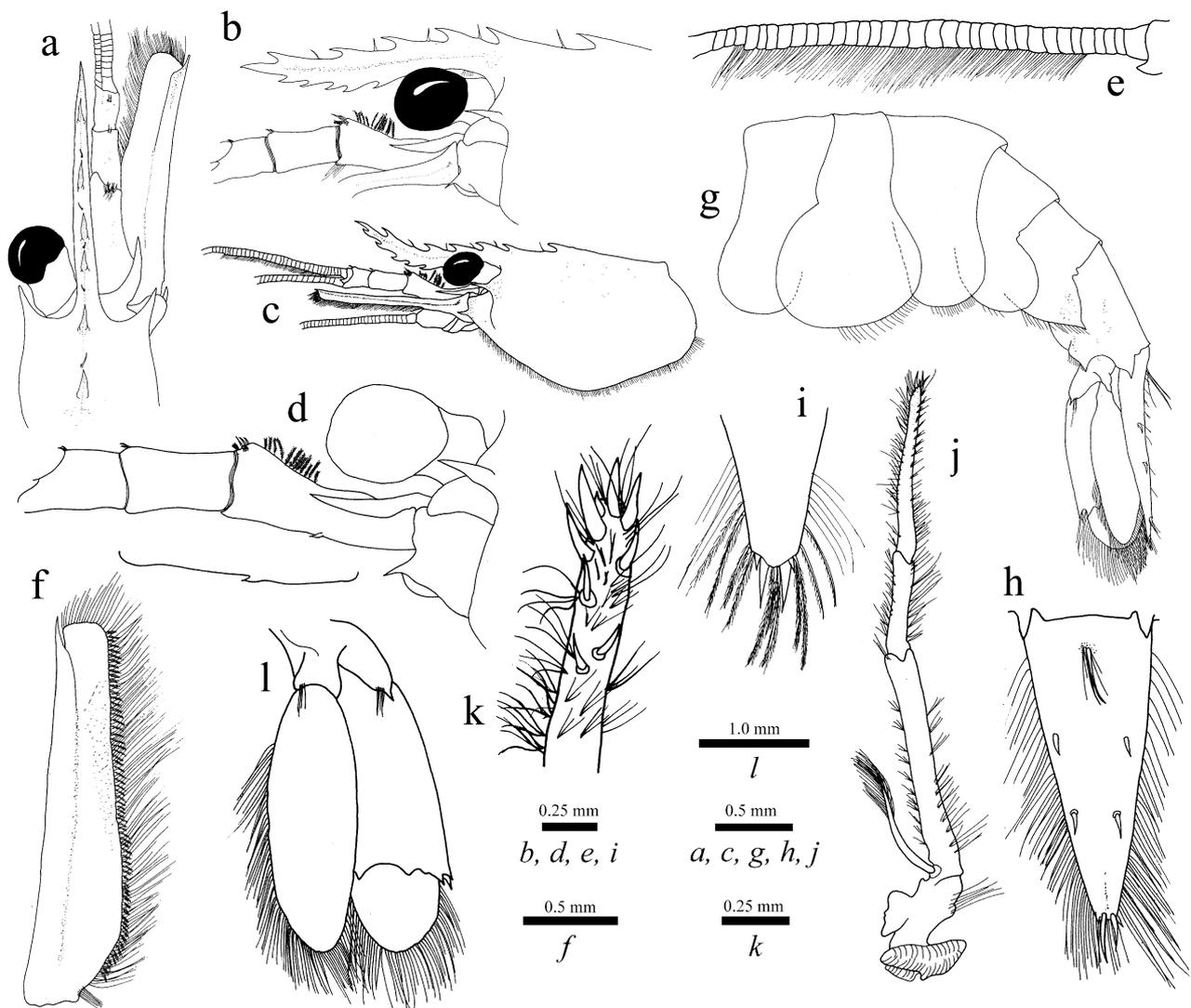


FIGURE 1. *Lysmata udoi* n. sp.: holotype, simultaneous hermaphrodite (MOBR-C-1547) [a, b, d-l], paratype, male (MOBR-C-1549) [c]; a, frontal region, dorsal view; b, same, lateral view; c, carapace and rostrum, lateral view; d, detail of frontal region showing stylocerite, lateral view; e, lateral antennular flagellum, lateral view; f, scaphocerite, dorsal view; g, abdomen, lateral view; h, telson, dorsal view; i detail of telson showing furca, dorsal view; j, third maxilliped, lateral view; k, tip of third maxilliped showing spines; l, uropods.

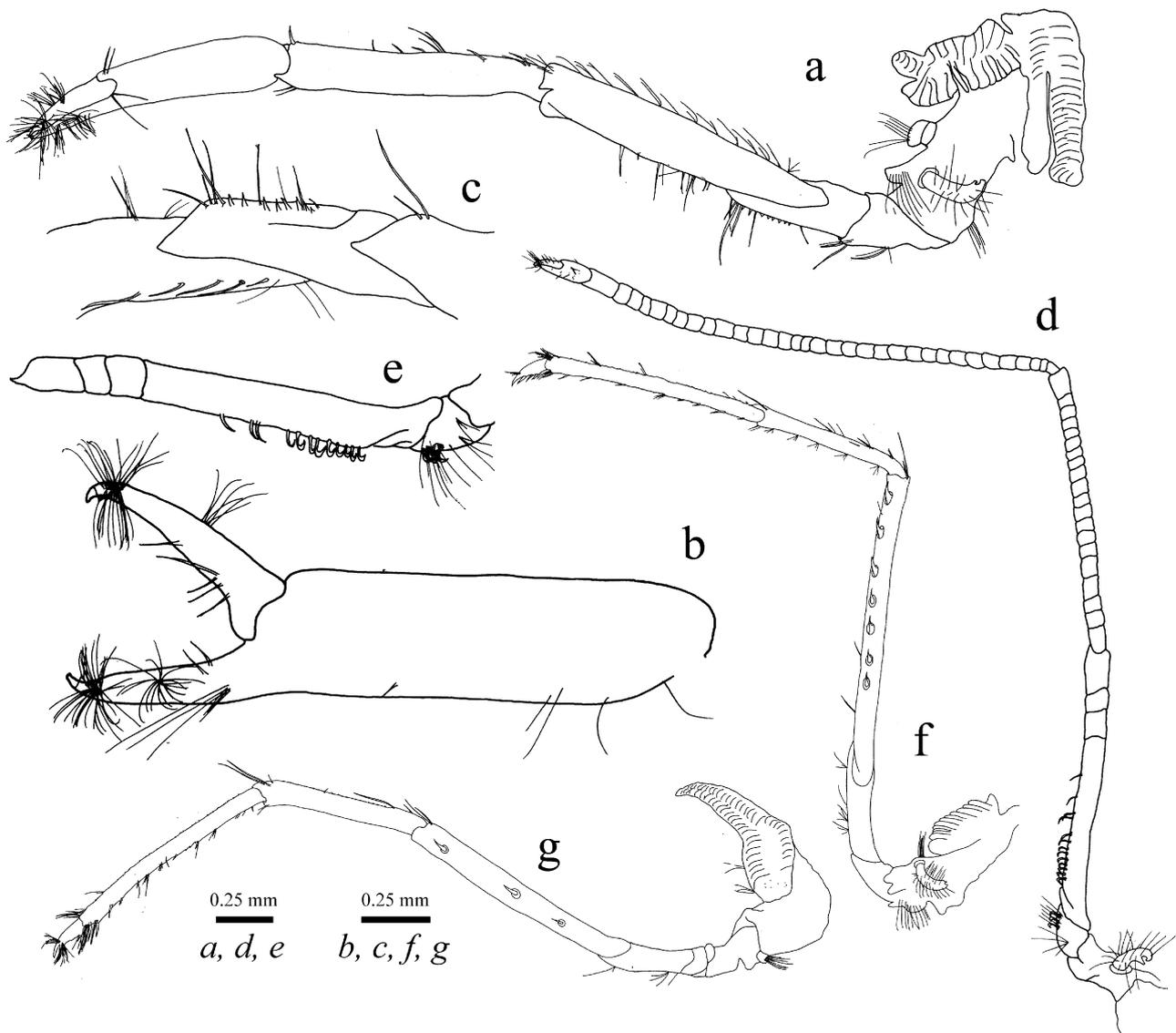


FIGURE 2. *Lysmata udoi* n. sp.: holotype, simultaneous hermaphrodite (MOBR-C-1547); a, first pereiopod; lateral view b, same, chela with fingers opened; c, same, detail of ischium; d, second pereiopod; e, same, detail of ischium; f, third pereiopod; g, fifth pereiopod.

Type locality. Cubagua Island, South Caribbean, Venezuela.

Distribution. Presently only known with certainty from Isla Cubagua and Isla Margarita, Venezuela.

Etymology. The new species is named after the Universidad de Oriente, Venezuela.

Variation. The material presents no or moderate variation compared to other closely related species (see below). With respect to rostral teeth, the current material exhibits no variation with all of specimens having 6 dorsal and 5 ventral teeth. Segmentation of the merus in the second pereiopod usually ranged between 20 and 23 articles, with often a minor difference between the left and right pereiopod. One specimen (MOBR-C-1548) presented greater variation with 26 and 19 articles in the left and right pereiopod, respectively. Similarly, segmentation of the carpus in the second pereiopod varied between 33 and 37, and differed by 3 or less articles between the left and right pereiopod. Lastly, variation in the number of movable spines on the meri of the ambulatory pereiopods was slightly more variable: 5–9, 4–8 and 3–4 on the third, fourth and fifth pereiopod respectively. A difference of 1 or 2 spines between the left and right pereiopods was observed.

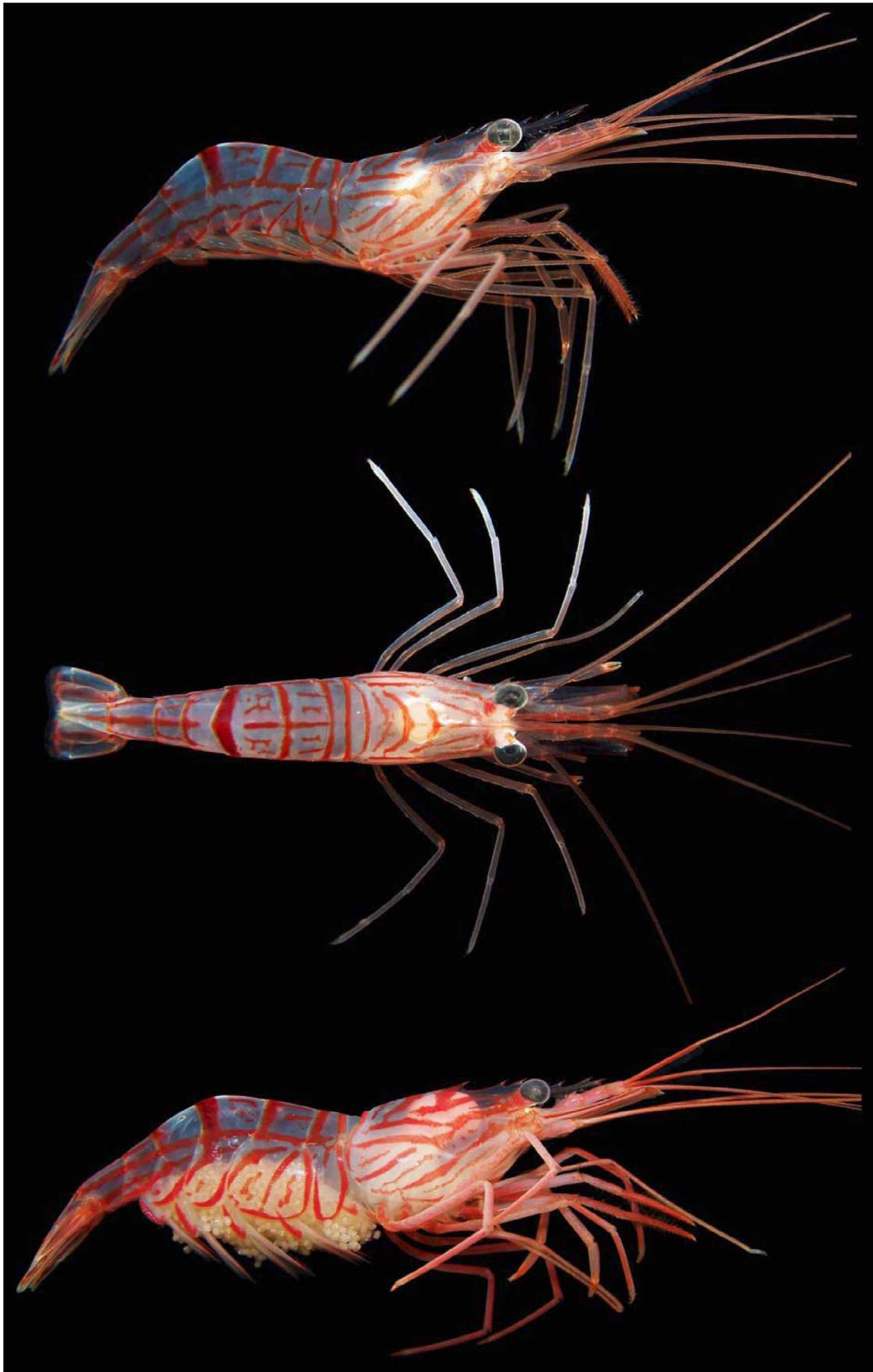


FIGURE 3. *Lysmata udoi* n. sp., habitus and color pattern of two paratypes, male (MOBR-C-1549) [top, intermediate], simultaneous hermaphrodite brooding embryos (MOBR-C-1548) [bottom]; a, c, lateral views; b, dorsal view.

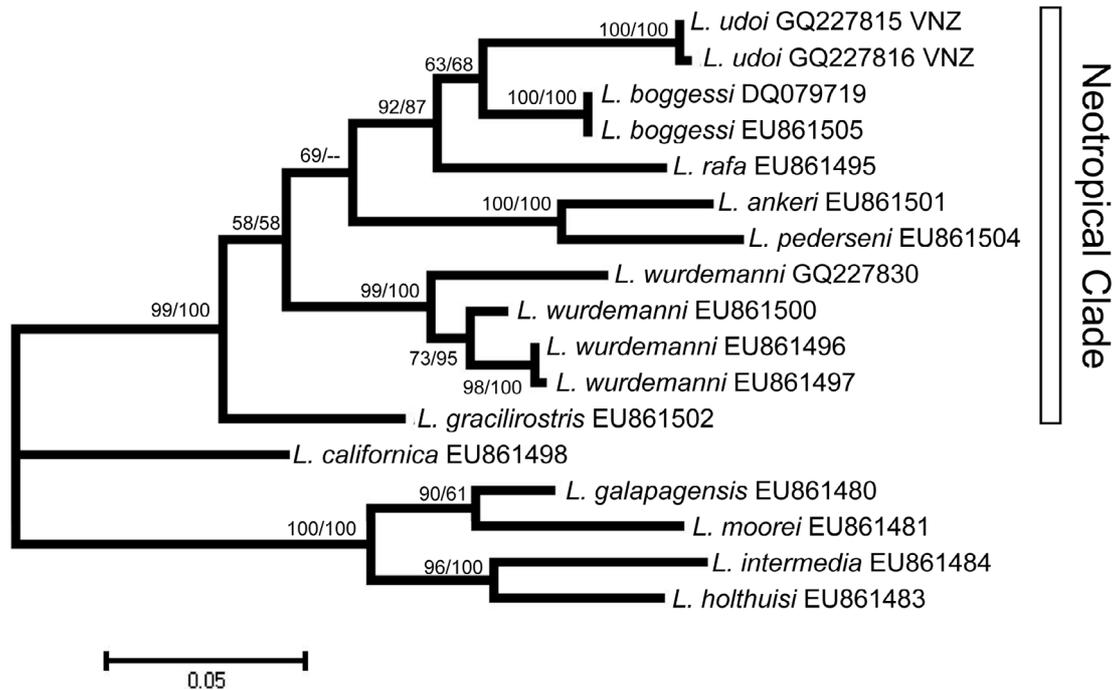


FIGURE 4. Phylogenetic tree obtained from ML analysis of the partial 16S rRNA gene for Neotropical Clade of shrimp from the genus *Lysmata*, including the new species (likelihood = -3022.873). Numbers above or below the branches represent the bootstrap values obtained from ML and the posterior probabilities from the BI analysis (ML/BI). GenBank accession numbers are shown immediately after species names. The general topology of the trees obtained from BI analysis was the same.

Remarks. The new species is morphologically closest to *L. ankeri* Rhyne and Lin, 2006, *L. rafa* Rhyne and Anker, 2007 and *L. boggressi* Rhyne and Lin, 2006, all species recently described from the Gulf of Mexico or northern Caribbean Sea (Rhyne & Lin 2006; Rhyne & Anker 2007) that pertain to the Neotropical clade of peppermint shrimps (Baeza et al. 2009). *Lysmata udoi* resembles *L. rafa* in having a relatively long and slender rostrum and walking legs, but not as long and slender as in the latter species. Also, *L. udoi* resembles *L. ankeri* in having a moderately curved rostrum with six dorsal and five ventral teeth. Nevertheless, *L. udoi* n. sp. can be distinguished from the three species above by a combination of characters that include the number of tooth, length and shape of the rostrum (dentition: six dorsal and five ventral in *L. udoi* compared to seven or more dorsal and seven to nine ventral in *L. rafa* and usually four to five dorsal and three to five ventral in *L. boggressi*; rostrum length: 0.9 times as long as carapace in *L. udoi* compared to 1.2 in *L. rafa*, usually less than 0.8 in *L. boggressi* and 0.6–0.8 in *L. ankeri*; shape: moderately curved in *L. udoi* compared to well curved in *L. rafa* and mostly straight in *L. boggressi*), the relative length of the antennular peduncle (about 0.75 times as long as scaphocerite in *L. udoi* compared to reaching or overreaching the scaphocerite in *L. rafa* and approximately 0.5 times as long as scaphocerite in *L. ankeri*), the shape of the scaphocerite (4.4–4.8 times as long as wide in *L. udoi* compared to five to six times in *L. rafa*, approximately 4.5 in *L. boggressi* and approximately 3.9 in *L. ankeri*) and the number of carpal articles in the second pereopod (33–37 in *L. udoi* compared to 40–43 in *L. rafa*, most often 26–28 in *L. boggressi* and 33–41 [but usually 35–37] in *L. ankeri*). *Lysmata udoi* n. sp. can be distinguished from *L. ankeri*, *L. rafa* and *L. boggressi* by the color pattern. In dorsal view, *L. udoi* n. sp. shows five lines in the second and third abdominal somites, all interrupted, and no line runs entirely along the abdomen. In contrast, *L. rafa* shows three lines and the medial one runs along the entire length of abdomen. In turn, *L. boggressi* features continuous very narrow longitudinal stripes situated between broader and more intense longitudinal stripes. Also, in *L. boggressi*, the telson and uropods are dark blue and the third abdominal somite lacks the red transverse band present in the new species. Lastly, *L. ankeri* features continuous and narrow longitudinal stripes running entirely along the abdomen. As in *L. udoi*, *L. ankeri* shows

a broad, transverse, broadly U-shaped band in the third pleuron. However, this band is not as marked as in *L. udoi*. Nevertheless, the most distinctive color feature in *L. udoi* n. sp is located in the fourth abdominal somite that almost lacks color but bears a posterior thin line with three short forward projections.

Phylogenetic analyses. A 550-nucleotide sequence of the section of 16S gene was obtained the two selected specimens (Genbank accession numbers GQ227815 and GQ227816). The two sequences were a close match with 0.36% sequence divergence. The phylogenetic analyses confirmed that the new species pertains to the Neotropical clade and is more closely related to *L. boggei* Rhyne and Lin, 2006 and *L. rafa* Rhyne and Anker, 2007 (Fig. 4) than to *L. ankeri* Rhyne and Lin, 2006. Nevertheless, its status either as geminate of *L. boggei* or *L. rafa* was not supported by any one of the phylogenetic analyses (Fig. 4).

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