



***Lysmata jundalini*, a new peppermint shrimp (Decapoda, Caridea, Hippolytidae) from the Western Atlantic**

ANDREW L. RHYNE^{1,2,5}, RICARDO CALADO³ & ANTONINA DOS SANTOS⁴

¹Department of Biology and Marine Biology, Roger Williams University, One Old Ferry Road, Bristol, RI 02809, USA

²New England Aquarium, Research Department, New England Aquarium, One Central Wharf Boston, MA 02110

³Departamento de Biologia & CESAM, Universidade de Aveiro, Campus Universitário de Santiago, 3810-193 Aveiro, Portugal

⁴Instituto Nacional de Recursos Biológicos - IPIMAR, Avenida de Brasília s/n, 1449-006 Lisbon, Portugal

⁵Corresponding author. E-mail: arhyne@rwu.edu

Abstract

A new peppermint shrimp species, *Lysmata jundalini* **sp. nov.**, is described based on five specimens collected in shallow subtidal waters on Enrique Reef at the University of Puerto Rico, Mayagüez Isla, Magueyes Laboratories. *Lysmata jundalini* **sp. nov.** was identified from fresh material collected at the reef crest and back reef among coral rubble in June 2005 and April 2009. The new species is most closely related to the Atlantic *Lysmata intermedia* and eastern Pacific *L. holthuisi*. It can be readily distinguished from all those in the genus *Lysmata* by its color pattern, the presence of a well developed accessory branch, the number of free vs. fused segments of the accessory branch, the number of carpal segments of the second pereiopod and well developed pterygostomial tooth.

Key words: Hermaphrodite, *Lysmata intermedia* complex, cryptic taxa

Introduction

The caridean shrimp genus *Lysmata* Risso, 1816 is commonly placed within the family Hippolytidae Bate, 1888. However, as referred by De Grave *et al.* 2009, the cladistic analysis performed by Christoffersen (1987) on the relationships of hippolytid genera, suggests that the genus *Lysmata* should be once again re-assigned to the Lysmatidae Dana, 1852 (Bracken *et al.* 2009). The molecular phylogeny of the genus has already started to be addressed (Baeza *et al.* 2009a, b; Baeza 2010, Fiedler *et al.* 2010) and may help to clarify the origins of the puzzling sexual system of these shrimp – protandric simultaneous hermaphroditism (Lin and Zhang 2001, Bauer 2004, Baeza 2006, 2007).

Lysmata species have become popular organisms in the marine aquarium trade. These shrimp have become increasingly traded either for their dazzling coloration and fish cleaning behavior (i.e. *L. amboinensis* and *L. debelius*) (Calado *et al.* 2003) or by their ability to control pest organisms in modern reef aquaria (i.e. peppermint shrimp such as *L. wurdemanni*) (Rhyne *et al.* 2004, Calado and Narciso 2005, Calado 2008, Rhyne *et al.* 2009). The increased research interest on *Lysmata*, either due to their sexual system, popularity in the aquarium trade or renewed focus on aquaculture production, has provided the first clues for the existence of numerous cryptic species complexes within this genus. In fact, Rhyne and Lin (2006) only reported the existence of a “peppermint shrimp complex” in the Western Atlantic after the authors repeatedly recorded the existence of subtle but consistent morphological and coloration differences among *Lysmata* specimens stocked for culture and reproductive trials (Williams 1984, Chace 1997). After the description of four new *Lysmata* species for Atlantic waters by Rhyne and Lin (2006), five more species have already been described for this region (Baeza and Anker 2008, Rhyne and Anker 2008, Baeza *et al.* 2009, Laubenheimer and Rhyne 2010). So far, the total number of species in the genus *Lysmata* recorded in the Atlantic Ocean is 20: five in the Eastern Atlantic, 14 in the Western Atlantic and one true amphiatlantic species (Udekem d’Acoz 1999, Laubenheimer and Rhyne 2010).

The present study reports the occurrence of a new *Lysmata* species from Caribbean waters, particularly the

southwestern reef tracks of Puerto Rico. The diagnosing morphological features of this new species are described in detail and illustrated. The use of color pattern and existing biochemical sequence data supporting this description is also discussed.

Material and methods

Specimens were collected among coral rubble in June of 2005 and again in April of 2009 from the shallow reef crest and back reef of Enrique Reef at the University of Puerto Rico, Mayagüez Isla, Magueyes Laboratories where they were first photographed and fixed in ethanol. The 2005 specimens were placed in 100% ethanol and frozen at -80°C for molecular studies (see Fielder *et al.* 2010) while 2009 material was collected specifically for the descriptive work and fixed in 70% ethanol. Drawings and measurements of these specimens were made with a camera lucida mounted on a Wild M8 dissecting stereomicroscope. Setae observations were made using a Zeiss microscope. Total length (TL) was measured from the tip of the rostrum to the posterior end of the telson. Carapace length (CL) was measured from the posterior orbital margin to the posterior margin of carapace. The type material is deposited in National Museum of Natural History, Smithsonian Institution, Washington, DC, USA (USNM), Oxford University Museum of Natural History (OUMNH), and National Museum of Natural History, Portugal (MNHN-UL)

Systematic account

Order Decapoda Latreille, 1802

Suborder Pleocyemata Burkenroad, 1963

Family Hippolytidae Bata, 1888 (Lysmatidae Dana, 1852 in Christoffersen 1987)

Genus *Lysmata* Risso, 1816

Lysmata jundalini sp. nov.

(Figures 1–4)

Type material. *Holotype*: adult ovigerous hermaphrodite 6.49 mm CL (25.56 mm TL; 3.66 mm rostrum; 6.49 mm CW) [MNHN-UL B12-004200]. *Paratypes*: 4 males 3.81–4.36 mm CL (17.84–20.50 mm TL; 2.50–2.92 mm rostrum) [MNHN-ULMB12-004201]. The specimens were collected by Dr. Nikolaos Schizas on 20/04/2009 at the reef crest around Cayo Enrique, La Parguera, Puerto Rico ($7^{\circ}56.22\text{N}$ / $67^{\circ}03.06\text{W}$), at a depth of 0.5 m.

Diagnosis. Integument not rigid and carapace smooth without supraorbital and hepatic tooth but with antennal and, generally, pterygostomial tooth. Rostrum armed dorsally and usually ventrally, without ventral blade or tongue-like lobe extending ventrally from lateral carina. Mandible without palp and incisor process. First maxilliped with caridean lobe clearly discrete, epipod bilobate. Pereiopods without exopods. Second pereiopods symmetrical and fingers no longer than palm. Pleon with 1st pleuron entire and 6th somite without prominent spines. Telson bearing 2 pairs of dorsolateral spines.

Description. A small shrimp (Fig. 1), with carapace smooth as long as high at the posterior end, glabrous, with posterolateral margin broadly rounded and anteriorly slightly funnelled. Rostrum straight, slightly curved upwards at tip with a lateral carina, reaching the end of the third segment of the antennular peduncle, 0.56 times as long as carapace in the female and 0.68 times for the males; with 6–7 acute dorsal teeth, being 3 in postrostral position, ventral margin with 2–3 teeth, close to rostrum tip; stiff setae arising from rostral dorsal carina between teeth (Fig. 2a, b). Antennal tooth long and sharply separated from ventral angle of the orbit. Pterygostomial tooth well developed and acute, with a row of plumose setae on the anterior-ventral margin (Fig. 2a, b). Eyes moderately large and rounded, divergent not reaching dorsal margin of rostrum.

Pleon smooth (Fig. 1), the first three pleomeres with rounded margins, fourth and fifth with sharp posterolateral tooth, sixth with acute posteroventral tooth and a pair of posterior teeth on each side of telson.

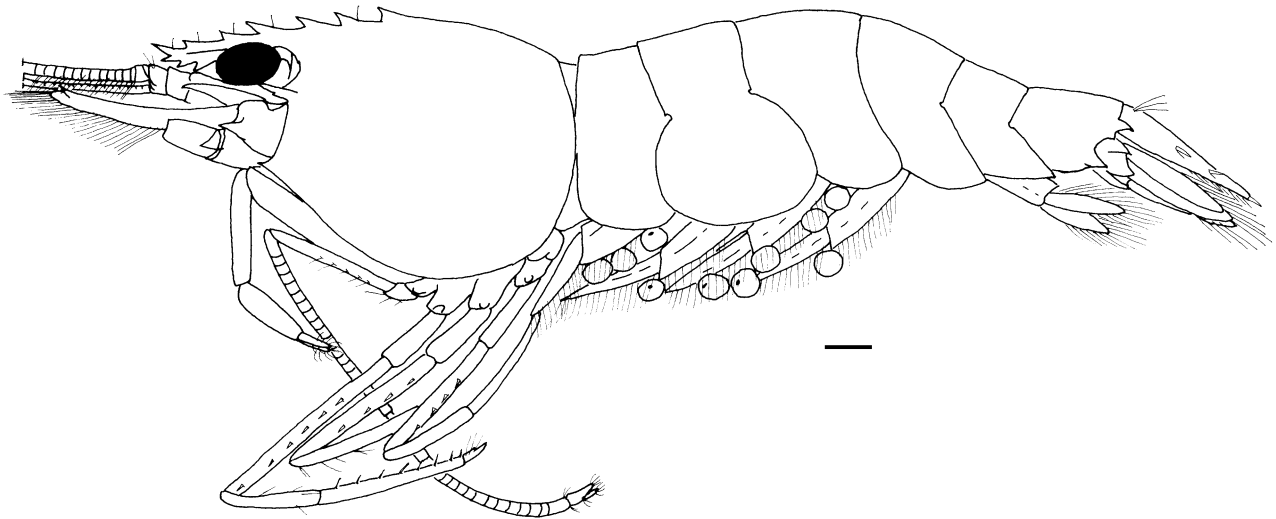


FIGURE 1. *Lysmata jundalini*, **sp. nov.**, ovigerous hermaphrodite holotype, 6.49 mm CL. Lateral view. Scale bar: 1.0 mm.

Telson (Fig. 2k) about 1.7 times as long as sixth pleomere; lateral margins of telson with many long setae on distal half and 3 long setae on the middle at proximal; dorsal surface with two pairs of spines, the first pair usually on 0.4 and second one on 0.7 of telson; posterior margins with a pair of short acute spines, and one pair of long acute ones, 2 long setae present between the long and strong spines, above that it presents six long and fine spines and three small ones.

Basal segment of the antennular peduncle with stylocerite just reaching the border of this segment and greatly overreaching the eye. Lateral antennular flagellum with aesthetascs extending from 4th segment to accessory branch. Dorsal antennular flagellum with accessory branch 3-segmented, 24 segments before bifurcation; ratio length of accessory branch/length of flagellum before bifurcation is 0.15 (Fig. 2c). Antenna with scaphocerite slender more than 4 times as long as wide; scaphocerite distal tooth acute distinctly overreaching blade (Fig. 2d).

Mandibles unequal but subsimilar, without palp and incisor process. Maxillula (Fig. 2e) with slender, curved palp, with 1 terminal strong plumose and 9 simple setae; upper lacinia broad, with 8 stout, dentate marginal spines and, two rows of more slender setae; lower lacinia slender, with row of long simple setae along the dorsal and inner margin. Maxilla (Fig. 2f) with elongated palp, with 2 long plumose and 2 short simple seta; inner lacinia bilobed, with row of simple setae on distal margins, scaphognathite well developed, very large and not very broad, with 91 plumose setae along the margin.

First maxilliped (Fig. 2g) with basal endite broad with a row of dense setulose setae; exopod with caridean lobe small, not distinctly separated from flagellum, with 9 sparsely plumose marginal setae, flagellum slender, with several plumose setae on the distal half; epipod bilobed. Second maxilliped (Fig. 2h) with endopod stout, dactylar segment terminal, distally elongated, with rows of long marginal and submarginal setae; propod longer than wide, with row of densely distributed setae; carpus short, with 2 simple small setae; merus with 3 long setae; basis with tuft of dense setae; exopod long and slender with plumose setae along external margin; coxa medially rounded, with subquadrate large epipod laterally. Third maxilliped (Fig. 2i) with long and slender endopod, distal segment with 9 spines distributed terminally; exopod short, slender, reaching more than 2/3 of the proximal endopod segment, with plumose setae on the distal half and 3 short and simple setae near base.

First pereopod (Figs 3a, a') with simple chela, reaching beyond the end of scaphocerite; palm about 3 times as long as dactylus, five times as long as high; carpus almost as long as merus; merus with row of long spines. Second pereopod (Figs 3b, b') with carpus twice as long as merus, composed of 28 articles; merus subequal to ischium in length, composed of 13–17 articles; ischium with row of 12 spinules. Third to fifth pereopods similar, decreasing in length from third to fifth. Third pereopod (Figs 3c, c') with unarmed ischium; merus with 8 stout ventrolateral spines, almost two times as long as carpus; propodus slightly shorter than merus with spines and spinules along ventral and ventromesial margins; dactylus about 1/6 length of propodus, biunguiculate, with three additional slender spines on flexor margin, terminal unguis longer than ventral unguis. Fourth pereopod (Fig. 3d) with 6 stout spines along ventrolateral margin of merus, which is almost two times as long as carpus; propodus as long as merus with 4 spines distally on ventral margin. Fifth pereopod (Fig. 3e) merus with 4 stout spines along lateral margin.

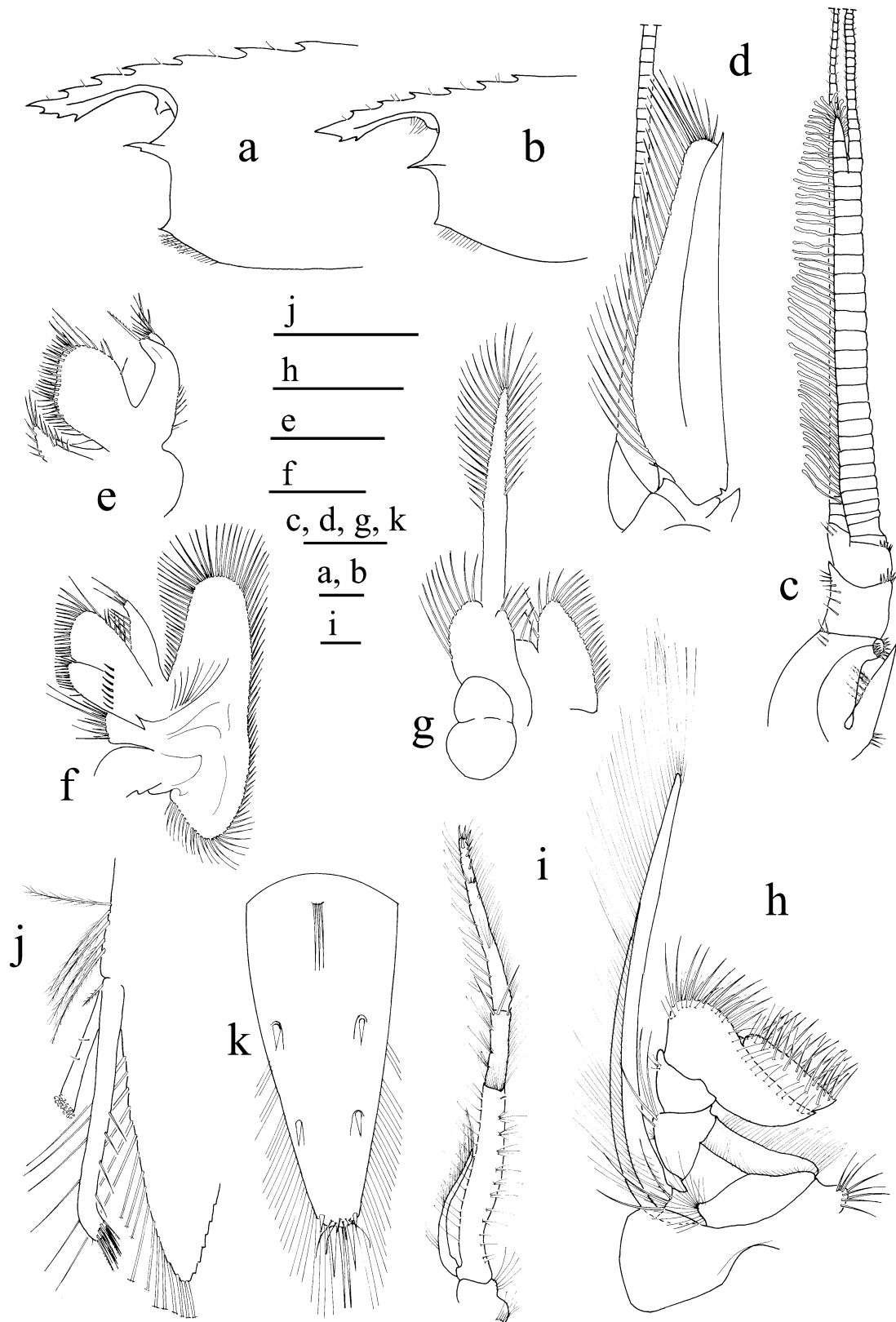


FIGURE 2. *Lysmata jundalini*, **sp. nov.**, ovigerous hermaphrodite holotype. a—rostrum and anterior portion of thorax, lateral view; male paratype. b—rostrum and anterior portion of thorax, lateral view; ovigerous female holotype. c—antennule; d—antenna; e—maxilulla; f—maxilla; g—first maxilliped; h—second maxilliped; i—third maxilliped; male paratype. j—appendix interna and masculine; ovigerous hermaphrodite holotype. k—telson. Scale bars: 1.0 mm (a–i; k); 0.5 mm (j).

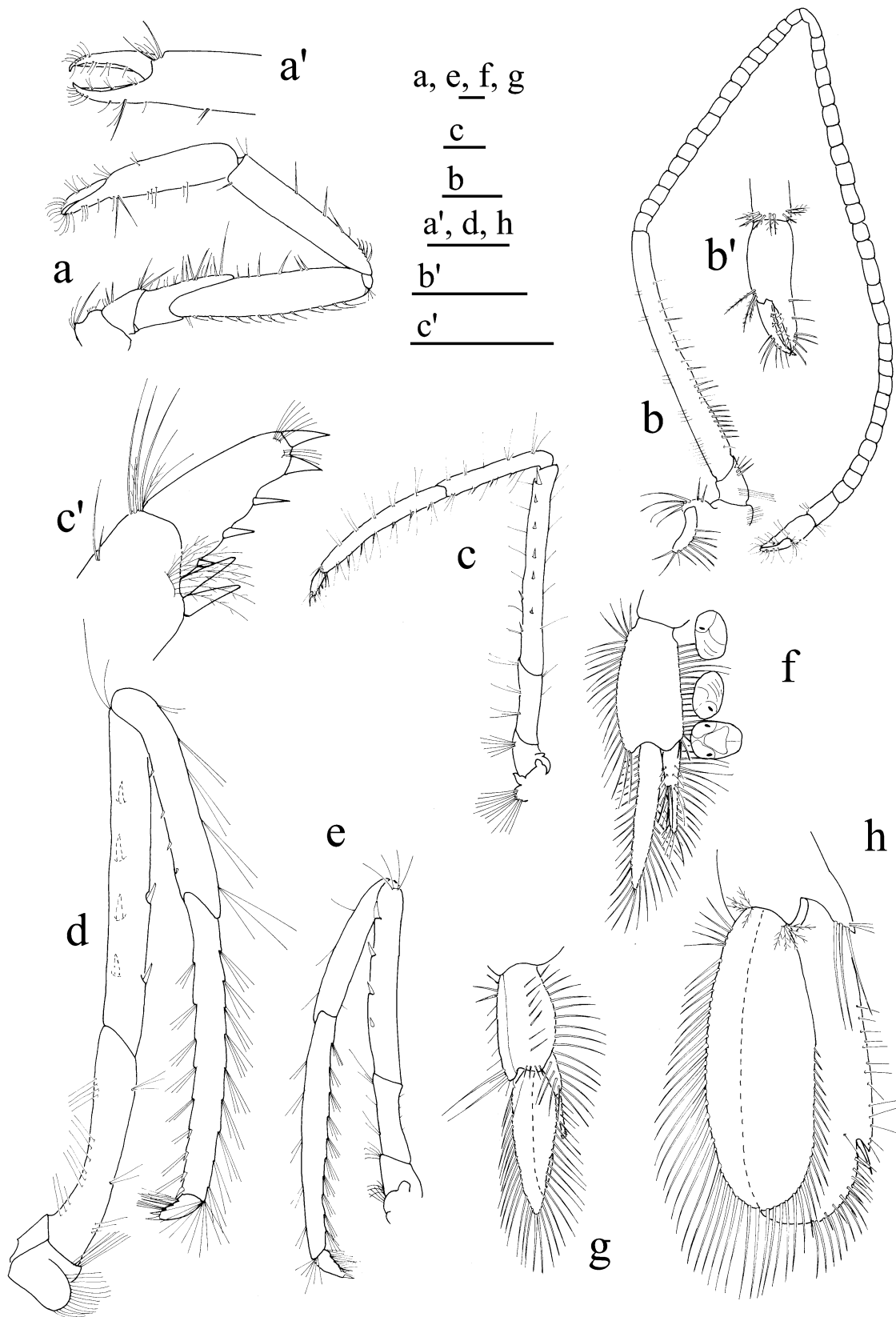


FIGURE 3. *Lysmata jundalini*, **sp. nov.**, ovigerous hermaphrodite holotype. a—first pereiopod; a'—detail of the chela of first pereiopod; b—second pereiopod; b'—detail of the chela of second pereiopod; c—third pereiopod; c'—detail of the chela of the third pereiopod; d—fourth pereiopod; e—fifth pereiopod; f—first pleopod; g—fifth pleopod; h—uropod. Scale bars: 1.0 mm (a–c; d–h); 0.5 mm (c').

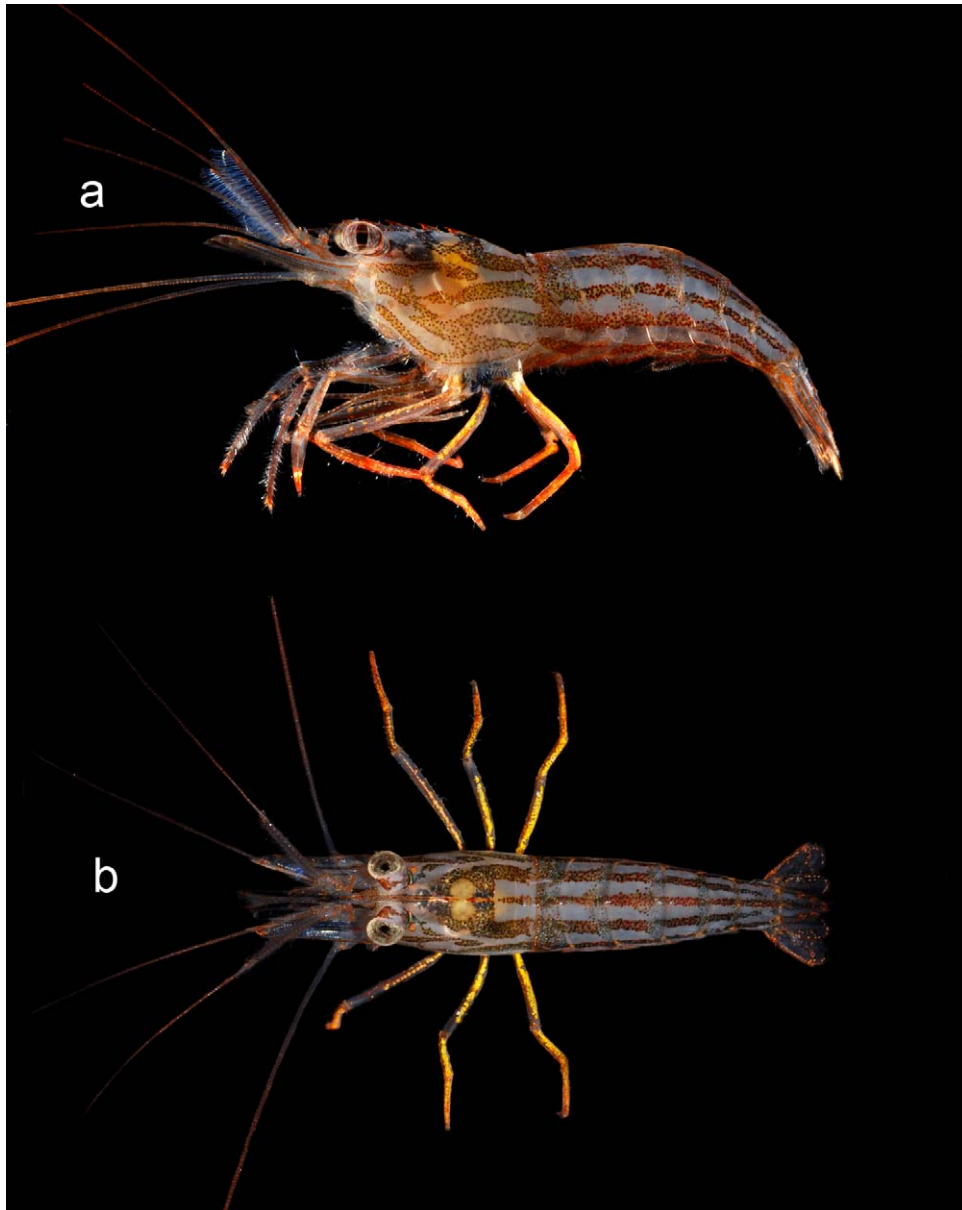


FIGURE 4. Live color pattern of *Lysmata jundalini* n. sp. a Lateral view. b Dorsal view.

Endopod of first pleopod (Fig. 3f) about half as long as exopod with row of marginal setae and nine dorsal setae. Appendix masculina (Fig. 2j) on second pleopod of males almost the size of the endopod and two times as long as appendix interna. Appendix masculina with one setose spine near base, four simple setae on distal half and twelve setose spines at posterior end. Other pleopods (Fig. 3g) with endopod slightly smaller than exopod, both with plumose setae on margins. Uropod (Fig. 3h) protopod with lateral tooth which has three long setae on margin; exopod with daeresis bearing acute tooth laterally, adjacent to distolateral spine; endopod subequal to exopod length.

Color in life. Body translucent with wide rust colored longitudinal stripes (Fig. 4a, b); lateral carapace with longitudinal strips, lacking transverse bands; dorsal with heavy singular inverted U-shaped band, abdominal pleura with wide longitudinal stripes (dorsal view showing three, with one running along entire length of abdomen reaching into carapace not connecting to U-shaped band), pleuron without conspicuous transverse bands or U-shaped pattern, pleuron transversed by a wide row of spots, often fading shortly after collection (Fig. 4b); ventral margin of abdomen, and margin of telson and uropods with brilliant red outlining. Dorsal of third to fifth pereopods with bright orange coloration; coxa of fourth pereopod with conscious blue spot, spilling over to the coxa of the third and fifth pereopod, antennular flagellum with blue hue (refer Fig. 4a). Early stage embryos and developing ovotestis green.

Size. Hermaphrodites to at least 6.49 mm CL (25.56 mm TL; 3.66 mm rostrum) males 3.81–4.36 mm CL (17.84–20.50 mm TL; 2.50–2.92 mm rostrum).

Etymology. The new species is named after our colleague and friend Dr. Junda Lin in recognition of his work on the aquaculture and sexual biology of *Lysmata*. When translated from Mandarin, Junda means “gentleman”. In this way, we have combined the given and family name of this remarkable biologist, mentor, colleague, friend and true gentleman, to the specific name *jundalini*.

Type locality and distribution. The holotype and paratypes were collected from the reef crest of Enrique Reef off the University of Puerto Rico, Mayagüez, Isla Magueyes Laboratories in 0.5 meters of water. The species has also been collected or observed throughout the Caribbean, from Yucatan peninsula in Mexico (Nuno Simões pers. comm.) to Panama (De Grave & Anker pers. comm.).

Habitat and ecology. The new species is commonly found in the rubble zone on the reef crest and hiding in the close vicinity of, but not on, the sea anemone *Stichodactyla helianthus*, as well as associated with moray eels in isolated patch reefs along the southwestern coast of Puerto Rico and wider Caribbean. This species is also often found in dense aggregations in *Porites* corals (Nuno Simões, pers. comm.).

Discussion

The new species is positioned within the “Long Branch Clade” proposed by Fielder *et al.* (2010), which consists of species with a well developed accessory branch of the lateral antennular flagellum and specifically in the *L. intermedia* species complex. As noted by Fielder *et al.* (2010) *L. intermedia* is a distinct complex of species with two putative species. *Lysmata jundalini* is reported by Fielder *et al.* (2010) as *Lysmata* cf. *intermedia* HQ315582. Based on recent molecular phylogenies (Baeza 2010, Fielder *et al.* 2010) *L. jundalini* is closely related to *Lysmata holthuisi* (Anker *et al.* 2009) from the eastern Pacific and is likely a transisthmian sister species. *Lysmata jundalini* has an ancestral position to *L. intermedia* and can be readily distinguished from both species by its conspicuous color pattern, having a brilliant orange on the dorsal region of its pereopods and a conspicuous blue spot on the coxa between the 3rd and 5th pereopods. Morphologically the new species can be separated from *L. holthuisi* by the presence of only 2 dorsal rostral teeth situated on the carapace, number of fused and free segments present on the lateral antennular flagellum (17 and 6–7 respectively) and the presence of only 2 spines on the dactylus of the 3rd to 5th pereopods. *Lysmata jundalini* can be separated from *L. intermedia* (revision based on topotypical material of Udekem d’Acoz 2000) by its color pattern (Figure 5) and morphologically by the number of fused segments on the lateral antennular flagellum (18 to 24 fused and 3 free in *L. jundalini* vs. 17 fused and 3–4 free in *L. intermedia*) and the number of spines on the dactylus of the 3rd to 5th pereopods (3 in *L. jundalini* vs. 4 in *L. intermedia*).

It is important to highlight that Rhyne and Lin (2006) reported the existence of a “peppermint shrimp complex” in the Western Atlantic after numerous authorities had recorded the existence of what were “simply considered” small morphological differences between “populations or forms” (see Williams 1984). Rhyne and Lin (2006) utilized living color patterns and interbreeding trials to identify putative species and build character sets from these separations using a morphometrical approach; after the separation of species by differences in color pattern it was possible to establish small but valid and consistent sets of morphological characters. Wicksten (2000) also utilized color to identify new species of *Lysmata* from the Gulf of California. Color has long been recognized for its utility in identification of valid taxa (Knowlton and Millis 1992). Several decapod taxa are only distinguishable from their differences in color pattern, for example *Lysmata grahbami* and *L. amboinensis* are only separable based on the color pattern of their telson and exopod of uropods. Nonetheless, recent molecular phylogenies strongly support this division (Baeza 2010, Fielder *et al.* 2010). In the recent description of *Lysmata udoi* Baeza *et al.* (2009), color pattern and genetics both confirmed the validity of this new species, while only subtle differences in morphology with other *Lysmata* species can be recorded. Numerous species of *Alpheus* are also recognized as valid based on color differences (A. Anker pers. comm.), as well as *Periclimenes* (Grippa and d’Udekem d’Acoz 1996). The lack of color in fixed material housed at world museums is certainly a huge challenge when performing a revision of certain taxa (see Debelius 2001 for examples of color pattern differences). Once the color of these specimens vanishes it becomes nearly impossible to separate closely related species present in museum collections.

For those specimens in museums, the variation in the number of segments of the accessory branch and the distance from bifurcation to the anterior end of the antennular flagellum (Fig. 2c) occurring between *L. jundalini* and

L. intermedia appears to be a stable morphological character separating the two species. *Lysmata jundalini* is a good example of a species that regardless of being cryptic, can be most easily identified by its living color pattern and morphology of the accessory branch. Until other complexes and clades are fully resolved within this interesting group of shrimp, it is strongly recommended that all researchers working on the taxonomy of *Lysmata* pay a special attention to the color pattern of live specimens and the morphology of the accessory branch.

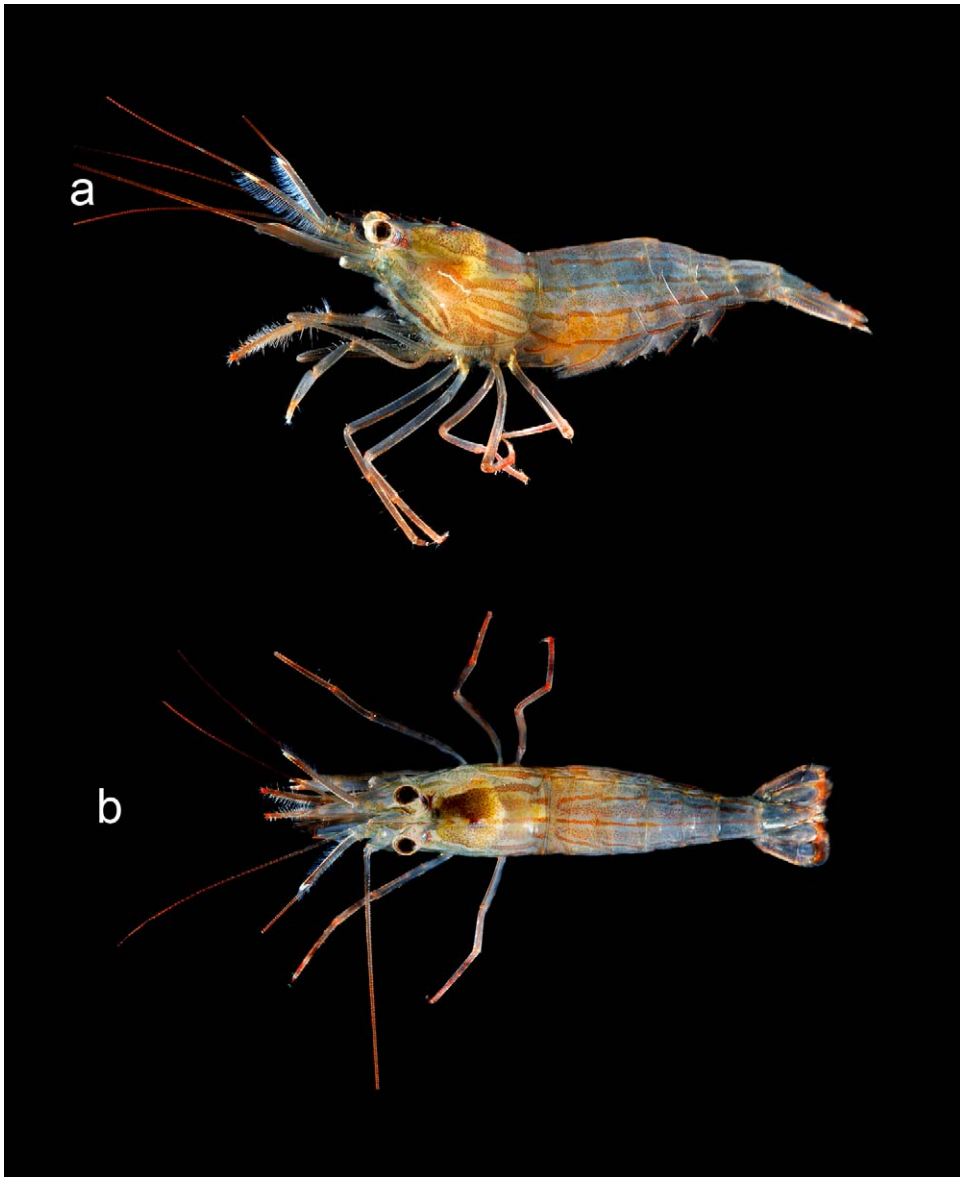


FIGURE 5. Live color pattern of *Lysmata intermedia*. a Lateral view. b Dorsal view.

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