Nauplius
THE JOURNAL OF THE BRAZILIAN CRUSTACEAN SOCIETY

e-ISSN 2358-2936
www.scielo.br/nau
www.crustacea.org.br

ORIGINAL ARTICLE

Shrimps of genus *Lysmata* Risso, 1816 (Caridea: Lysmatidae) from Queimada Grande Island region, southeastern Brazil

Rafael de Carvalho Santos[1] orcid.org/0000-0003-3176-7995
Douglas Fernandes Rodrigues Alves[2] orcid.org/0000-0003-4363-6511
Abner Carvalho-Batista[3] orcid.org/0000-0001-8193-1269

1 Universidade Estadual Paulista (UNESP), Faculdade de Ciências Bauru, Laboratório de Biologia de Camarões Marinhos e de Água doce (LABCAM). Bauru, São Paulo, Brazil.
RCS E-mail: rafa_bio@hotmail.com.br

2 Universidade Federal de Uberlândia (UFU), Laboratório de Ecologia de Ecossistemas Aquáticos (LEEA). Avenida Pará, 1720, 38405-320, Uberlândia, Minas Gerais, Brazil.
DFRA E-mail: douglas_biologo@yahoo.com.br

3 Universidade Paulista (UNIP), Instituto de Ciências da Saúde. Avenida Marquês de São Vicente, 3001, 05037-040, São Paulo, São Paulo, Brazil.
AC-B E-mail: carvbatis@gmail.com

ZOOBANK: http://zoobank.org/urn:lsid:zoobank.org:pub:9DC934BC-1EB3-4B01-96DD-AEDEE7C24106

ABSTRACT

The objective of this study is to report the first occurrences of three species from the genus *Lysmata* Risso, 1816 in an area of the Queimada Grande Island (QGI), a conservation unit on the southern coast of São Paulo, southeastern Brazil. The specimens were sampled manually in August 2018 from a small rocky formation from the QGI region. The species *Lysmata bahia* Rhyne and Lin, 2006, *Lysmata uncicornis* Holthuis and Maruin, 1952, and *Lysmata vittata* (Stimpson, 1860) are reported, of which the last two are not native to the Western Atlantic waters. The present study reports *L. uncicornis* for the first time on the coast of São Paulo State. The records informed herein not only provide more information about biodiversity, but can also help in the development of management plans and conservation.

KEYWORDS

Aquarium trade, Decapoda, Geographical distribution, Peppermint shrimp, Western Atlantic

Corresponding Author
Rafael de Carvalho Santos
rafa_bio@hotmail.com.br

SUBMITTED 25 November 2020
ACCEPTED 31 March 2021
PUBLISHED 21 July 2021

DOI 10.1590/2358-2936e2021032

Introduction

The genus *Lysmata* Risso, 1816, which belongs to the family Lysmatidae Dana, 1852b, is composed of widely distributed species with distinct behavior (social and sexual) and life habits in different marine environments (Bauer, 2000; Rhyne and Lin, 2006; Baeza, 2009; Soledade *et al.*, 2013). Currently, the genus includes 47 species distributed worldwide (Pachelle *et al.*, 2020), with 18 reported in the Atlantic (Chace, 1972; Rhyne and Lin, 2006; Baeza and Anker, 2008; Anker and Cox, 2011; De Grave and Fransen, 2011; Rhyne *et al.*, 2012; Soledade *et al.*, 2013; Gan and Li, 2016; Pachelle *et al.*, 2016; Prakash and Baeza, 2017; Wang and Sha, 2018; De Grave and Anker, 2018; González-Ortegón *et al.*, 2020) and 11 of these on the Brazilian coast in which three of them, *Lysmata lipkei* Okuno and Fiedler, 2010, *Lysmata uncicornis* Holthuis and Maruin, 1952, and *Lysmata vittata* (Stimpson, 1860), are exotic (Pachelle *et al.*, 2020).

The genus *Lysmata* has species that are highly valuable in the ornamental aquarium industry (Calado *et al.*, 2003; Baeza and Behringer, 2017; Giraldes *et al.*, 2018; González-Ortegón *et al.*, 2020) because they help control pests (anemones of the genus *Aiptasia* Gosse, 1858) in aquariums, and are visually appealing due to their vivid color patterns (Karplus, 2014; Giraldes *et al.*, 2018). Due to the popularity of *Lysmata* in the aquarium trade, the demand for them has grown among marketed marine invertebrates (Wabnitz *et al.*, 2003; Calado *et al.*, 2007; Rhyne *et al.*, 2017). Therefore, areas where *Lysmata* species occur are targeted for the commercialization of these organisms, including the southeastern coast of Brazil.

Queimada Grande Island (QGI) is part of an Area of Relevant Ecological Interest (AREI) encompassing Queimada Grande and Queimada Pequena Islands; a "sustainable use" marine protected area on the southern coast of São Paulo State, Brazil (Pivetta *et al.*, 2012). Additionally, QGI is part of the Marine Environmental Protected Area "Litoral Centro", and this area has different types of zones, according to the zoning protocol — version 18/12/2018 — measuring the level of permission for human activity (APAMLC, 2018). Queimada Pequena Island is inside a Zone of Special Protection (ZSP), forbidding any human activity in a radius of 1 km from the island coast. QGI is inside a Zone for Low-Scale Uses (ZLSU) within a radius of 3 km from the island coast and a Zone of Intensive Use (ZUI) beyond this 3 km, allowing some fisheries activities. Studies on the fauna of the subtidal region in QGI have already been reported, including on reef fish (Pivetta *et al.*, 2012) and coral reefs (Pereira-Filho *et al.*, 2019). Despite this, the biodiversity of crustaceans has not yet been studied in this area. Thus, the aim of the present study is to register the occurrence of *Lysmata bahia* Rhyne and Lin, 2006, *L. uncicornis,* and *L. vittata* at Queimada Grande Island, using an integrative approach (morphological and molecular analysis). In addition, we expanded the knowledge about the distribution of two invasive species in the Western Atlantic, with a relevant record of these species in a conservation unit area.

Material and Methods

Sampling of Lysmata *shrimps*

Sampling was accomplished by artisanal collectors who catch ornamental marine organisms. The shrimps were removed from areas near the Queimadas Area of Relevant Ecological Interest (AREI) (Fig. 1) by free divers who collected the shrimps using a hand net from a small rocky formation with biogenic substrate at 6 to 12 m deep (C.H.A. Marques, artisanal fisherman, personal communication). The collection information and the shrimps were voluntarily transferred to one of us (AC-B) to be used in the present study. The sampled specimens were individually stored in plastic bags, kept in insulated boxes with ice and transported to the laboratory. Individuals were identified according to an identification key (Pachelle *et al.*, 2020) and deposited in the carcinological collection of the Museum of Zoology at the University of São Paulo (MZUSP).

Morphology analysis

Each shrimp was measured and sexed. The carapace length (CL, the distance from the posterior orbital margin to the posterior margin of the carapace) was measured with a Vernier caliper (accuracy 0.01 mm). Due to protandric hermaphroditism reported in many species of the genus *Lysmata* (see Bauer, 2006; Alves *et al.*, 2019), individuals were simply divided into ovigerous (ov.) and non-ovigerous (non-ov.)

specimens. For identification shrimps were examined using a Leica MZ12S stereomicroscope equipped with a camera lucida. The following morphological characters were analyzed: [1] armature of the rostrum, [2] presence or absence of sharp tooth on pterygostomial margin, [3] number of free articles on accessory ramus of lateral antennular flagellum, [4] reach of rostrum in relation to distal margin of third article of antennular peduncle, [5] reach of stylocerite in relation to row of spiniform setae on dorsal surface of first article of antennular peduncule, [6] length of carpus of first pereopod in relation to height in lateral view, [7] number of subdivisions on carpus of second pereopod, [8] length of merus of second pereopod in relation to ischium length, [9] number of fused articles on lateral antennular flagellum before bifurcation with accessory ramus, [10] number of subdivisions on merus of second pereopod, and [11] intraorbital process form. These characters were used because of their importance in the previous identification of *Lysmata* species (Rhyne and Lin, 2006; Giraldes *et al.*, 2018; Pachelle *et al.*, 2020).

Figure 1. Sampling region in the Area of Relevant Ecological Interest (AREI) Queimada Grande and Queimada Pequena Islands and the Marine Environmental Protected Area "Litoral Centro" in the Zone of Special Protection (Queimada Pequena Island) and Zone for Low-Scale Use (Queimada Grande Island), southeastern Brazil.

Molecular analysis of Lysmata *shrimps*

Molecular analysis was based on the 16S rRNA mitochondrial DNA segment following the protocols provided by Schubart *et al.* (2000). The analysis was carried out to genetically compare the specimens received, with 27 species of *Lysmata* and *Exhippolysmata* Stebbing, 1915 (Tab. 1).

Total genomic DNA was extracted from abdominal muscle tissue using the Wizard® Genomic DNA Purification Kit (Promega, Madison, WI, USA) following the manufacturer's protocol. For amplification of the 16S gene segment, we used primers 16 L2 (5′-TGCCTGTTTATCAAAAACAT-3′) and 1472 (5′-AGATAGAAACCAACCTGG-3′) (Schubart *et al.*, 2000; 2002). PCR reactions were performed in a Veriti® Thermal Cycler (Applied Biosystems, Foster City, CA, USA) and included 12.5 mL of PCR Buffer Go Taq Green (Promega, Madison, WI, USA), 1.0 mL of each primer, 8.5 mL of Milli-Q water (Milipore, Billerica, MA, USA) and 2 mL of each sample at a final volume of 25 mL. PCR cycles proceeded as follows: initial denaturation at 95 °C for 5 min; 40 cycles of 95 °C for 45 sec, 52 °C for 45 sec, and 72 °C for 1 min; and final extension at 72 °C for 5 min. Negative controls (sterile water) were used in all reactions. The results were checked on a 1.5 % agarose gel stained with GelRed. The PCR products were purified using the Wizard® SV Gel and PCR Clean-Up System (Promega) and sequenced on an ABI 3500 Genetic Analyzer (Applied Biosystems) in the Bioinformatics and Evolutionary Biology Laboratory in the Genetics Department at the Federal University of Pernambuco, Brazil.

Table 1. Details of specimens and sequences used in the phylogenetic analyses in this study. The new sequences obtained in this study are highlighted. CCDB = Crustacean Collection of Biology Department of FFCLRP, University of São Paulo; IEO-CDCAD = Decapoda and Stomatopoda Crustacean Collection of Spanish Institute of Oceanography in Cadiz; CNCR = National Crustacean Collection of the Universidad Nacional Autónoma de México; LCP/UFSC = Laboratory of Crustaceans and Plankton Collection of Santa Catarina Federal University; MNRJ = Crustacean Collection of National Museum of Rio de Janeiro; MZUSP = Zoological Collection of Museum of Zoology of the University of São Paulo; RMNH = Naturalis Biodiversity Center (formerly Rijksmuseum van Natuurlijke Historie); SMF = Collection of the Senckenberg Natural History Museum; UMML = Collection of The Marine Laboratory, University of Miami.

Species	Catalogue Number	Sampling locality	GenBank 16S
Lysmata amboinensis De Man, 1888	UMML 32.9451	Philippines	EU861488
Lysmata ankeri Rhyne and Lin, 2006	CCDB 4715	Ubatuba, São Paulo, Brazil	KU312981
Lysmata ankeri Rhyne and Lin, 2006	UMML 32.9452	USA	EU861501
Lysmata argentopunctata Wicksten, 2000	CNCR 20998	Mexico	GQ227814
Lysmata bahia Rhyne and Lin, 2006	UMML 32.9453	Panama	EU861503
Lysmata bahia Rhyne and Lin, 2006	MZUSP 37511	Sergipe, Brazil	MH102006
Lysmata bahia Rhyne and Lin, 2006	MZUSP 37511	Sergipe, Brazil	MH102007
Lysmata bahia Rhyne and Lin, 2006	MZUSP 41122	Peruíbe, São Paulo, Brazil	MT459816
Lysmata bahia Rhyne and Lin, 2006	MZUSP 41122	Peruíbe, São Paulo, Brazil	MT459817
Lysmata boggessi Rhyne and Lin, 2006	UMML 32.9454	USA	EU861505
Lysmata californica (Stimpson, 1866)	UMML 32.9455	USA	EU861498
Lysmata debelius Bruce, 1983	UMML 32.9456	Philippines	EU861492
Lysmata galapagensis Wicksten, 2000	UMML 32.9457	Panama	EU861480
Lysmata grabhami (Gordon, 1935)	UMML 32.9459	Haiti	EU861489
Lysmata gracilirostris Wicksten, 2000	UMML 32.9458	Panama	EU861502
Lysmata hochi Baeza and Anker, 2008	UMML 32.9460	USA	EU861507
Lysmata holthuisi Anker, Baeza and De Grave, 2009	UMML 32.9466	Panama	EU861483
Lysmata intermedia (Kingsley, 1878)	UMML 32.9461	Panama	EU861484
Lysmata intermedia (Kingsley, 1878)	Not vouchered	USA	HQ315580
Lysmata intermedia (Kingsley, 1878)	MZUSP 37512	Sergipe, Brazil	MH102008
Lysmata lipkei Okuno and Fiedler, 2010	Not vouchered	Okinawa, Japan	HQ315574

Table 1. Cont.

Species	Catalogue Number	Sampling locality	GenBank 16S
Lysmata lipkei Okuno and Fiedler, 2010	MZUSP 37513	Sergipe, Brazil	MH102009
Lysmata lipkei Okuno and Fiedler, 2010	MZUSP 37513	Sergipe, Brazil	MH102010
Lysmata moorei (Rathbun, 1901)	UMML 32.9462	Panama	EU861481
Lysmata nayaritensis Wicksten, 2000	UMML 32.9463	Panama	EU861506
Lysmata nilita Dohrn and Holthuis, 1950	SMF 32005	Italy	EU861482
Lysmata olavoi Fransen, 1991	SMF 32006	Portugal	EU861494
Lysmata pederseni Rhyne and Lin, 2006	UMML 32.9464	Belize	EU861504
Lysmata rafa Rhyne and Anker, 2007	UMML 32.9465	Haiti	EU861495
Lysmata seticaudata (Risso, 1816)	UMML 32.9614	Portugal	GQ227827
Lysmata udoi Baeza *et al.*, 2009	UMML 32.9603	Venezuela	GQ227815
Lysmata uncicornis Holthuis and Maurin, 1952	MNRJ 27976	Florianópolis, Santa Catarina, Brazil	MH142085
Lysmata uncicornis Holthuis and Maurin, 1952	LCP/UFSC-106	Florianópolis, Santa Catarina, Brazil	MH142086
Lysmata uncicornis Holthuis and Maurin, 1952	RMNH D.7812	Casablanca, Morocco	MT002801
Lysmata uncicornis Holthuis and Maurin, 1952	IEO-CDCAD18/2464	Cadiz, Spain	MN294751
Lysmata uncicornis Holthuis and Maurin, 1952	MZUSP 41123	Peruíbe, São Paulo, Brazil	MT459814
Lysmata uncicornis Holthuis and Maurin, 1952	MZUSP 41123	Peruíbe, São Paulo, Brazil	MT459815
Lysmata vittata (Stimpson, 1860)	RMNH D 35616	Thailand	GQ227828
Lysmata vittata (Stimpson, 1860)	RMNH D 35616	Thailand	GQ227829
Lysmata vittata (Stimpson, 1860)	Not vouchered	Bahia, Brazil	JX912539
Lysmata vittata (Stimpson, 1860)	Not vouchered	Bahia, Brazil	JX912540
Lysmata vittata (Stimpson, 1860)	MZUSP 37509	Sergipe, Brazil	MH102011
Lysmata vittata (Stimpson, 1860)	MZUSP 37509	Sergipe, Brazil	MH102012
Lysmata vittata (Stimpson, 1860)	MZUSP 41124	Peruíbe, São Paulo, Brazil	MT459818
Lysmata wurdemanni (Gibbes, 1850)	CCDB 5510	Ubatuba, São Paulo, Brazil	KU312984
Lysmata wurdemanni (Gibbes, 1850)	UMML 32.9468	USA	EU861500
Exhippolysmata ensirostris (Kemp, 1914)	UMML 32.9602	China	GQ227819
Exhippolysmata oplophoroides (Holthuis, 1948)	UMML 32.9469	Ubatuba, São Paulo, Brazil	EU861510

Forward and reverse sequences were aligned to obtain the consensus sequence in BioEdit v.7.0.5 (Hall, 1999). Consensus sequences alignment was performed using ClustalW (Thompson *et al.*, 1994) enforcement in BioEdit v.7.0.5 (Hall, 1999). The selection of an optimal model of base substitution, based on AICc and conducted in MEGA 7 (see Kumar *et al.*, 2016), identified an HKY + G + I evolutionary model (-lnL = -3914.411). Phylogenetic analysis was estimated via the Maximum Likelihood (ML) method in MEGA 7. The robustness of the ML tree topologies was assessed by bootstrap resampling of the observed data 1000 times. To verify intra- and interspecific genetic divergence among the studied sequences, a matrix of genetic divergence was calculated in MEGA 7 based on the p distance (Kumar *et al.*, 2016).

Results

In the present study, five individuals of *Lysmata* were collected from areas around Queimada Grande Island, with two *L. bahia*, two *L. uncicornis*, and one *L. vittata*.

Systematics

Order Decapoda Latreille, 1802

Infraorder Caridea Dana, 1852a

Family Lysmatidae Dana, 1852b

***Lysmata* Risso, 1816**

***Lysmata bahia* Rhyne and Lin, 2006**

Lysmata bahia Rhyne and Lin, 2006: 191, figs. 16–18, pls. 1F, 2; Barros-Alves *et al.*, 2015: 3, figs. 1C,

3; Pachelle *et al.*, 2016: 16, tab. 1; Pachelle *et al.*, 2020: 60, figs. 3–4.

Hyppolysmata (*Hippolysmata*) *wurdemanni*: Fausto Filho, 1970: 56; Coelho and Ramos, 1972: 153 (*partim*?) [not *L. wurdemanni* (Gibbes, 1850), see Rhyne and Lin, 2006]

Lysmata wurdemanni: Chace, 1972: 129 (remarks on São Paulo material); Coelho *et al.*, 2006: 121, tab. 3 (*partim*?) [not *L. wurdemanni* (Gibbes, 1850)]

Material examined. 1 ov. specimen (10.86 mm CL), 1 non-ov. specimen (10.26 mm CL), MZUSP 41122, Queimada Grande Island, Peruíbe, São Paulo State, Brazil, collector Marques, C.H.A. (artisanal fisherman), 01.viii.2018.

First record for São Paulo. Santos harbor (Rhyne and Lin, 2006).

Distribution. Western Atlantic: Panama and Brazil (Ceará, Sergipe, Bahia, Rio de Janeiro, São Paulo) (Rhyne and Lin, 2006; Barros-Alves *et al.*, 2015; Pachelle *et al.*, 2016; Terossi *et al.*, 2018; Pachelle *et al.*, 2020; present study).

Remarks. *Lysmata bahia* was first reported from Brazil by Fausto Filho (1970) as *Hippolysmata wurdemanni* Gibbes, 1850, followed by the first occurrence in São Paulo as *Lysmata wurdemanni* (Gibbes, 1850) by Chace (1972), which were later considered paratypes of *L. bahia* by Rhyne and Lin (2006). It is also one of the three species that belongs to the *L. wurdermanni* complex in Brazil, along with *Lysmata ankeri* Rhyne and Lin, 2006 and *L. wurdermanni* (see Pachelle *et al.*, 2020). The analyzed specimens presented all the diagnostic characteristics of *L. bahia,* according to Pachelle *et al.* (2020). The two specimens presented long stylocerites, almost reaching the distal margin of the first article of the antennular peduncle, which is a characteristic that differentiates *L. bahia* from *L. ankeri* and *L. wurdemanni* (which have a comparatively shorter stylocerite) (Pachelle *et al.*, 2020). However, the two specimens presented the carpus of the first pereiopod about 4 times longer than tall, instead of 4.5 times, as indicated by Pachelle *et al.* (2020).

Lysmata uncicornis Holthuis and Maurin, 1952

Lysmata uncicornis Holthuis and Maurin, 1952: 198, figs. 1–2; Lagardère, 1971: 99, figs. 232–235; González-Ortégon *et al.*, 2020: 26, figs. 1–4.

Lysmata arvoredensis Giraldes, Macedo, Brandão, Baeza and Freire, 2018: 5, figs 1–4F.

Material examined. 2 ov. specimens (10.09, 10.12 mm CL), MZUSP 41123 (Fig. 1), Queimada Grande Island, Peruíbe, São Paulo State, Brazil, collector Marques, C.H.A. (artisanal fisherman), 01.viii.2018.

First record for São Paulo. Present study.

Distribution. Eastern Atlantic: from Morocco to Congo; Gulf of Cadiz (between Spain and Portugal). Western Atlantic: Brazil (Santa Catarina [as *L. arvoredensis*] and São Paulo) (Holthuis and Maurin, 1952; Lagardère, 1971; Giraldes *et al.*, 2018; González-Ortegón *et al.*, 2020; present study).

Remarks. *Lysmata uncicornis* was recently classified as a senior synonym of *L. arvoredensis* (see González-Ortégon *et al.*, 2020). The record of *L. uncicornis* in São Paulo mentioned by Pachelle *et al.* (2020) was made via photographic register from a mussel farm in 2012, but was not tracked and remained an uncertain record. Therefore, the present study offers the first documented record of the occurrence of this species on the coast of São Paulo State, based on morphological and molecular analysis, and is the northern limit for the species in Western Atlantic waters. The occurrence of *L. uncicornis* in Brazilian waters may be associated with the introduction of non-native species by anthropogenic influence related to the marine aquarium trade (González-Ortégon *et al.*, 2020). Both specimens presented all diagnostic characteristics and expected morphological variation for *L. uncicornis,* according to Pachelle *et al.* (2020) (Fig. 2). The species differs from *L. bahia* by the proportion of the length and height of the carpus of the first pereiopod (longer in *L. bahia*); by the number of subdivisions in the carpus of the second pereiopod (22–24 versus 29–32 in *L. bahia*); and the length of the free portion of the accessory ramus of the antennular flagellum (shorter in *L. uncicornis*).

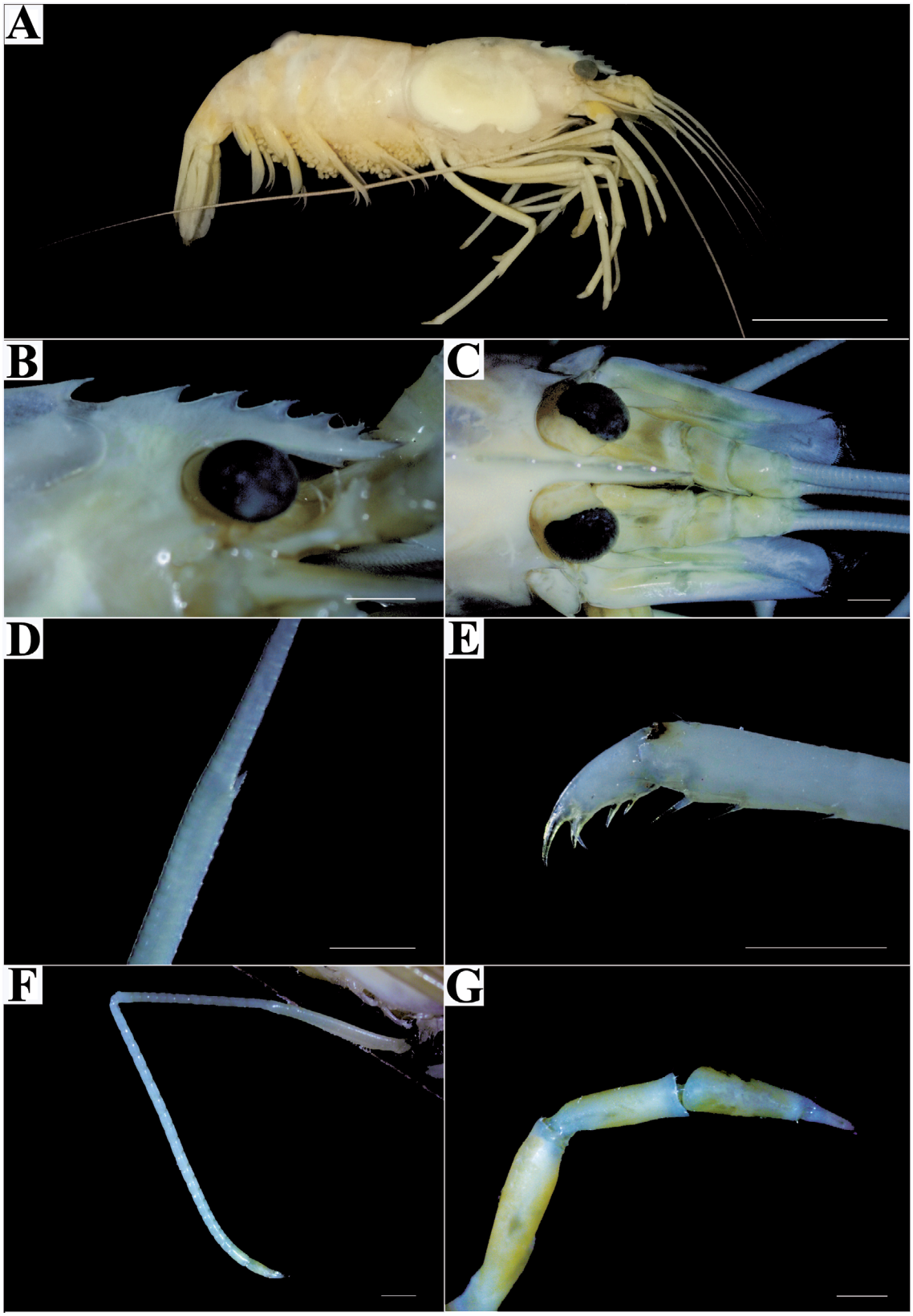

Figure 2. *Lysmata uncicornis* Holthuis and Maurin, 1952. **A**, Specimen collected in the area near to the border of the protected area of Queimada Grande Island, lateral view; **B**, lateral view, rostrum details and absence of pterogostomial spine; **C**, dorsal view, reach of rostrum in relation to distal margin of third article of antennular peduncle; **D**, dorsal antennular flagellum with trace of accessory branch; **E**, dactyl of pereopod 3, lateral view; **F**, second pereopod, lateral view, number of subdivisions on carpus; **G**, first pereopod, lateral view, length of carpus in relation to height. Scale bars, **A** = 1cm; **B**–**F** = 1mm. Photographs by R. C. Santos.

Lysmata vittata (Stimpson, 1860)

Hippolysmata vittata Stimpson, 1860: 26.

Nauticaris unirecedens Spence Bate, 1888: 608, pl. 110, fig. 1

Hippolysmata vittata var. *subtilis* Thallwitz, 1891: 22.

Lysmata vittata: Bruce, 1990: 601, figs. 23–28; Soledade *et al.*, 2013: 67; Alves *et al.*, 2018: figs. 1B, 3; Terossi *et al.*, 2018: 83.

Hippolysmata durbanensis Stebbing, 1921: 20, pl. 5.

Lysmata rauli Laubenheimer and Rhyne, 2010: 299, figs. 1–3; Soledade *et al.* 2013: 67, fig. 2C.

Material examined. 1 non-ov. specimen (7.02 mm CL), MZUSP 41124, Queimada Grande Island, Peruíbe, São Paulo State, Brazil, collector Marques, C.H.A. (artisanal fisherman), 01.viii.2018.

First record for São Paulo. São Vicent Estuary (Soledade *et al.*, 2013).

Distribution. Indo-West Pacific: from Mozambique to Hong Kong; Philippines, Japan, Russia, Australia, and New Zealand. Mediterraean Sea. Western Atlantic: Brazil (Sergipe, Bahia, Rio de Janeiro, São Paulo) (Barnard, 1955; Chace, 1997; Ahyong, 2010; Laubenheimer and Rhyne, 2010; Marin *et al.*, 2012; Soledade *et al.*, 2013; Abdelsalam, 2018; Alves *et al.*, 2018; Pachelle *et al.*, 2018; Terossi *et al.*, 2018; Present study).

Remarks. It is the first non-native species of *Lysmata* reported on the Brazilian coast (Soledade *et al.*, 2013), followed by *L. lipkei* (see Pachelle *et al.*, 2016). Recently recognized as a senior synonym of *L. rauli* (see Laubenheimer and Rhyne, 2010) and due to its wide distribution and diverse color patterns may be considered a species complex (Marin *et al.* 2012; Soledade *et al.*, 2013; Anker and De Grave 2016; Pachelle *et al.*, 2018; 2020). The analyzed specimen was very damaged, with several broken appendages. However, despite the damage the identification by morphological characteristics was possible, since the rostrum and some appendages were still intact. Thus, it was possible to verify: [1] the presence of a sharp tooth on the pterygostomial margin; [2] seven dorsal and three ventral teeth on the rostrum; [3] a single short free article in the accessory ramus of the antennular flagellum; [4] stylocerite longer, overreaching distal margin of cornea; [5] intraorbital process of carapace longer than wide in lateral view; and [6] first pereopod carpus short, about three times as long as wide in lateral view. These characteristics can be used as morphological evidence, allowing the analyzed specimen to be identified according to the key proposed by Pachelle *et al.* (2020). The proposition of *L. vittata* as a senior synonym of *L. rauli* may be carefully checked using more extensive material and through morphological and molecular analysis because of the possibility of *L. vittata* being a species complex (Marin *et al.*, 2012; Soledade *et al.*, 2013; Terossi *et al.*, 2018; Pachelle *et al.*, 2018; 2020).

Molecular analysis

The two sequences obtained for *L. bahia* from QGI (Brazil) matched with the sequence from a *L. bahia* specimen from Sergipe State (Brazil) and Panama (Fig. 3). The genetic divergence among these three *L. bahia* specimens varied from 0 to 0.004 (p distance). The two sequences obtained for *L. uncicornis* specimens from QGI (Brazil) matched with the sequences of *L. uncicornis* from Florianópolis, Santa Catarina State, Brazil (Fig. 3). There were no differences among the four sequences of this species (p distance = 0). The sequence of *L. vittata* from Ilha da Queimada Grande matched with the sequences of *L. vittata* from Thailand and Sergipe and Bahia States (Brazil) (Fig. 3). The genetic divergence among the five *L. vittata* specimens varied from 0 to 0.007 (p distance).

Discussion

Through morphological and molecular analyses, the present study confirms the first record of three species from the genus *Lysmata* in areas surrounding the Queimada Grande Island, southern coast of São Paulo State, of which two species are non-native to the Western Atlantic. Integrative techniques, such as DNA (16S) and morphological characters, contributed and complemented the identification process of *Lysmata*, which had already proven to be arduous due to ambiguous morphological characteristics, and

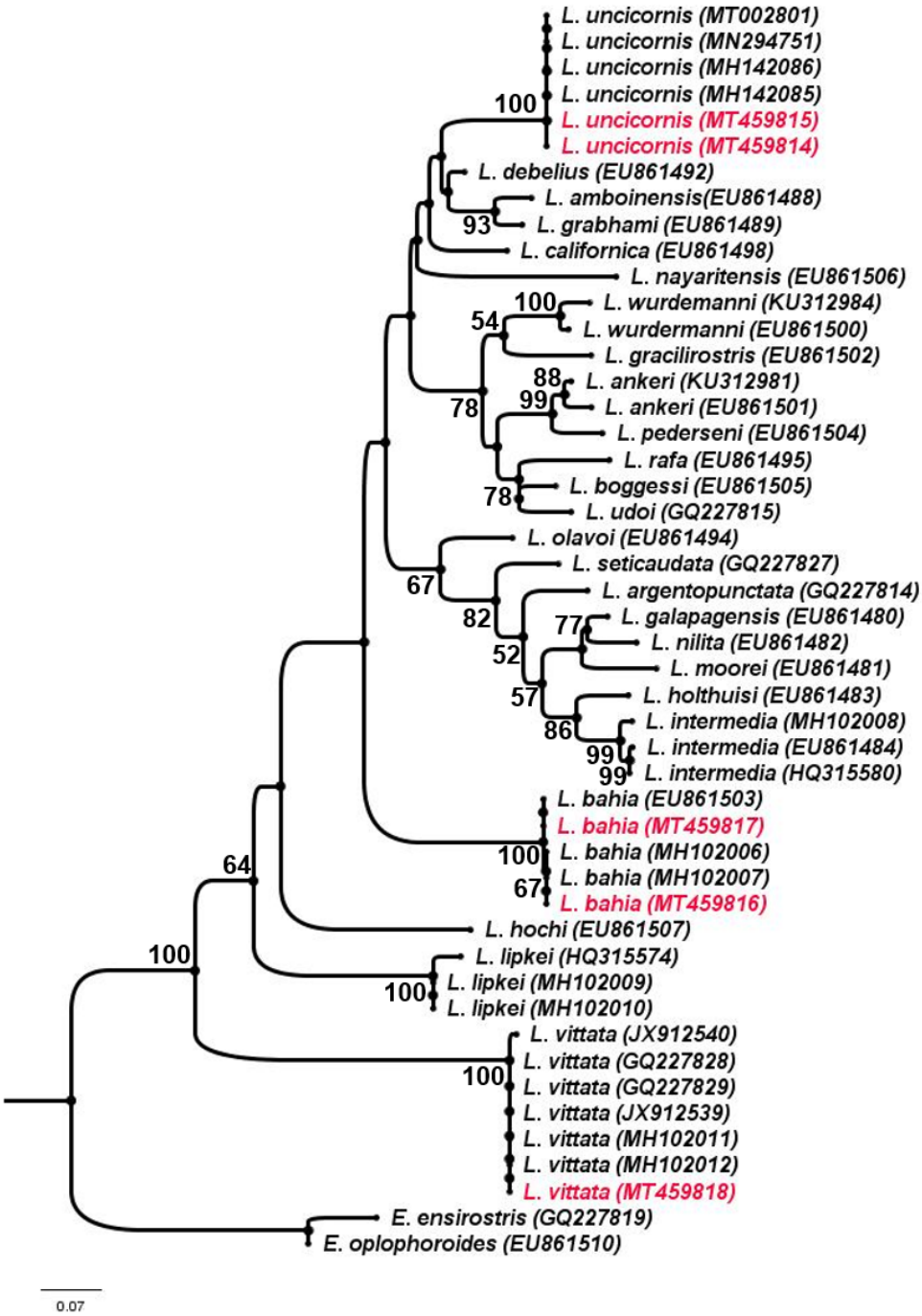

Figure 3. Phylogenetic tree of genus *Lysmata* (Risso, 1816), including *Lysmata bahia* Rhyne and Lin, 2006, *Lysmata uncicornis* Holthuis and Maurin, 1952, and *Lysmata vittata* (Stimpson, 1860) from Queimada Grande Island, Brazil (indicated in red), constructed via Maximum Likelihood analysis of the 16S DNA gene. Numbers are support values for 1000 bootstraps; values < 50 % were not included.

consequently, by the presence of species complexes (Rhyne and Lin, 2006; Baeza, 2010; Soledade *et al.*, 2013; Baeza and Behringer, 2017; Wang and Sha, 2018; González-Ortegón *et al.*, 2020; Pachelle *et al.*, 2020).

Lysmata bahia is widely distributed on the Brazilian coast since its description by Rhyne and Lin (2006). The present record is the southern-most limit of this species occurrence in the Western Atlantic, after the occurrence record in Santos Bay, São Paulo State (Rhyne and Lin, 2006; Alves *et al.*, 2018; Terossi *et al.*, 2018). Regarding the non-native species found in the QGI area, *L. vittata* has already been well established in Brazilian waters (Soledade *et al.*, 2013; Alves *et al.*, 2018; 2019), while there have been few

occurrence records for *L. uncicornis* on the coast of Brazil (Giraldes *et al.*, 2018; Gonzáles-Ortegón *et al.*, 2020; Pachelle *et al.*, 2020).

Our results confirm the presence of *L. uncicornis* on the coast of São Paulo State. This species was previously recorded in São Paulo by Pachelle *et al.* (2020), however, this record could not be confirmed because the specimen was lost. Thus, the present study extends the range of *L. uncicornis* in the Western Atlantic (from 27°25' S to 24°29' S of latitude) (Giraldes *et al.*, 2018, González-Ortégon *et al.*, 2020; Pachelle *et al.*, 2020). *Lysmata uncicornis* is the sixth species of *Lysmata* to be confirmed on the São Paulo State coast, along with *L. ankeri*, *L. bahia*, *Lysmata intermedia* (Kingsley, 1878), *L. vittata*, and *L. wurdemanni*, and is the second non-native species to be recorded there (Soledade *et al.*, 2013; Pachelle *et al.*, 2016; Barros-Alves *et al.*, 2016; Terossi *et al.*, 2018; Pachelle *et al.*, 2020).

The dispersal vector responsible for the presence of exotic *Lysmata* species on the São Paulo coast is still uncertain, nevertheless, ballast water transportation, as previously registered for other Decapoda crustaceans, as well as the high demand of *Lysmata* specimens for the marine aquarium trade are the most likely causes (Mantelatto and Dias, 1999; Calado, 2009; Pachelle *et al.*, 2011; Tavares, 2011; Soledade *et al.*, 2013; Barros-Alves *et al.*, 2016). The increased demand for these shrimps may result in deregulated exploitation, as well as inappropriate trade, which can lead to the introduction of exotic species, as is the case for *L. lipkei*, *L. uncicornis*, and *L. vittata* on the Brazilian coast, which are originally from Indo-West Pacific (Alves *et al.*, 2018).

The introduction of non-native species by the ornamental aquarium trade needs to be explored (González-Ortegón *et al.*, 2020; Alves *et al.*, 2021). According to Mainka and Howard (2010), the occurrence of invasive species is currently one of the largest causes of biodiversity loss on the planet along with climate change. The ecological consequences of this introduction can be direct, with the loss of native species, or indirect, through the transmission of pathogens (Rodríguez and Suárez, 2001; Tavares, 2003; Almeida *et al.*, 2012).

The present study is the first to report crustacean species in areas near to Queimada Grande Island AREI, but is limited to the genus *Lysmata*. We highlight the importance of carrying out new studies that use new sampling techniques in this area in order to more effectively determine the local diversity in different substrates, as well as mechanisms that may evaluate the process of non-native species introduction and how it occurs; such as molecular analysis. This information could facilitate management and conservation measures that decrease the possible impacts that invasive species have on native species in this conservation unit.

Acknowledgements

The authors thank MSc. Isabela R.R. Moraes and Dra. Jessica Colavite for help with the figure 2 construction. The authors thank the anonymous reviewers that improved the quality of the manuscript and the free divers who collected and donated the specimens used in the study. This research was financed by "Fundação de Amparo à Pesquisa do Estado de São Paulo-FAPESP/SP" (scholarship Nº 2018/00739-0, granted to RCS).

References

Abdelsalam, K.M. 2018. First record of exotic Lysmatid shrimp *Lysmata vittata* (Stimpson, 1860) (Decapoda: Caridea: Lysmatidae) from the Egyptian Mediterranean coast. *Mediterranean Marine Science*, 19: 124–131.

Ahyong, S.T. 2010. New species and new records of Caridea (Hippolytidae: Pasiphaeidae) from New Zealand. *Zootaxa*, 2372: 341–357.

Almeida, A.O.; Simões, S.M.; Costa, R.C. and Mantelatto, F.L. 2012. Alien shrimps in evidence: new records of the genus *Athanas* Leach, 1814 on the coast of São Paulo, southern Brazil (Caridea: Alpheidae). *Helgoland Marine Research*, 66: 557–565.

Alves, D.F.R.; Lima, D.J.M.; Hirose, G.L.; Martinez, P.A.; Dolabella, S.S. and De Paiva Barros-Alves, S. 2018. Morphological and molecular analyses confirm the occurrence of two sympatric *Lysmata* shrimp (Crustacea, Decapoda) in the southwestern Atlantic. *Zootaxa*, 4526: 41–55.

Alves, D.F.R.; López Greco, L.S.; Barros-Alves, S. de P. and Hirose, G.L. 2019. Sexual system, reproductive cycle and embryonic development of the red-striped shrimp *Lysmata vittata*, an invader in the western Atlantic Ocean. *PLOS ONE*, 14: e0210723.

Alves, D.R.R.; Barros-Alves, S.P.; Dolabella, S.S.; Almeida, A.C. and Martinez, P.A. 2021. Invasive shrimp *Cinetorhynchus erythrostictus* (Decapoda: Caridea) misidentified in the marine

aquarium trade: Niche overlap with a native congeneric species. *Estuarine, Coastal and Shelf Science*, 258: 107411.

Anker, A. and Cox, D. 2011. A new species of the shrimp genus *Lysmata* Risso, 1816 (Crustacea, Decapoda) from Guam. *Micronesica*, 41: 197–214

Anker, A. and De Grave, S. 2016. An updated and annotated cheklist of marine and brackish caridean shrimps of Singapore (Crustacea, Decapoda). *Raffles Bulletin of Zoology*, 34: 343–454.

Anker, A.; Baeza, J.A. and De Grave, S. 2009. A new species of *Lysmata* (Crustacea, Decapoda, Hippolytidae) from the Pacific coast of Panama, with observations of its reproductive biology. *Zoological Studies*, 48: 682–692.

APAMLC. FF. 2018. Área de Proteção Ambiental Marinha do Litoral Centro de São Paulo. Fundação Florestal. Minuta de zoneamento da APA Marinha do Litoral Centro. Available at https://www.sigam.ambiente.sp.gov.br/sigam3/Repositorio/511/Documentos/APAM_LC/Minuta_Zoneamento_APAMLC_Comite%20final_limpo_v1.pdf. Accessed on 28 February 2021.

Baeza, A. 2009. Protrandic simultaneous hermaphroditism is a conserved trait in *Lysmata* (Caridea: Hippolytidae): implications for the evolution of hermaphroditism in the genus. *Smithsonian Contributions to Marine Science*, 38: 95–110.

Baeza, J.A. 2010. Molecular systematics of peppermint and cleaner shrimps: phylogeny and taxonomy of the genera *Lysmata* and *Exhippolysmata* (Crustacea: Caridea: Hippolytidae). *Zoological Journal of the Linnean Society*, 160: 254–265.

Baeza, A. and Anker, A. 2008. *Lysmata hochi* n. sp., a new hermaphroditic shrimp from the Southwestern Caribbean Sea (Caridea: Hippolytidae). *Journal of Crustacean Biology*, 28: 148–145.

Baeza, J.A. and Behringer, D.C. 2017. Integrative taxonomy of the ornamental 'peppermint' shrimp public market and population genetics of *Lysmata boggessi*, the most heavily traded species worldwide. *PeerJ*, 5: e3786.

Baeza, J.A.; Bolaños, J.A.; Hernandez, J.E. and López, R. 2009. A new species of *Lysmata* (Crustacea, Decapoda, Hippolytidae) from Venezuela, southeastern Caribbean Sea. *Zootaxa*, 2240: 60–68.

Barnard, K.H. 1955. Additions to the fauna-list of South Africa Crustacea and Pycnogonida. *Annals of the South African Museun*, 43: 1–107.

Barros-Alves, S.D.P.; Alves, D.F.R.; Silva, S.L.R.; Guimarães, C.R.P. and Hirose, G.L. 2015. New records of decapod crustaceans from the coast of Sergipe state, Brazil. *Check List*, 11: 1–7.

Barros-Alves, S.D.P.; Alves, D.F.R.; Hirose, G.L. and Cobo, V.J. 2016. New records of caridean shrimps, *Lysmata ankeri* and *L.* cf. *intermedia*, from southeast coast of Brazil. *Marine Biodiversity Records*, 9: 34: 1–9.

Bauer, R.T. 2000. Simultaneous hermaphroditism in caridean shrimps: A unique and puzzling sexual system in the Decapoda. *Journal of Crustacean Biology*, 20: 116–128.

Bauer, R.T. 2006. Same sexual system but variable sociobiology: evolution of protandric simultaneous hermaphroditism in *Lysmata* shrimps. *Integrative and Comparative Biology*, 46: 430–438.

Bruce, A.J. 1983. *Lysmata debelius* new species, a new hippolytid shrimp from the Philippines. *Revue française d'Aquariologie*, 9: 115–120.

Bruce, A.J. 1990. Redescriptions of five Hong Kong carideans first described by William Stimpson, 1860. p. 569–610. In: B. Morton (ed), The Marine Flora and Fauna of Hong Kong and Southern China. Proceedings of the Second International Marine Biological Workshop, Hong Kong, 1986. Hong Kong, Hong Kong University Press.

Calado, R. 2009. Marine Ornamental Shrimp: Biology, Aquaculture and Conservation. Chichester, John Wiley & Sons Press, 280p.

Calado, R.; Narciso, L.; Morais, S.; Rhyne, A.L. and Lin, J. 2003. A rearing system for the culture of ornamental decapod crustacean larvae. *Aquaculture*, 218: 329–339.

Calado, R.; Vitorino, A.; Dionísio, G. and Dinis, M.T. 2007. A recirculated maturation system for marine ornamental decapods. *Aquaculture*, 263: 68–74.

Chace, F. 1972. The Shrimps of the Smithsonian-Bredin Caribbean Expeditions with a Summary of the West Indian Shallow-water Species (Crustacea: Decapoda: Natantia). *Smithsonian Contributions to Zoology*, 98: 1–179.

Chace, F. 1997. The caridean shrimps (Crustacea: Decapoda) of the Albatros Philippine expedition, 1907-1910, part 7: families Atyidae, Eugonatonodidae, Rhynchocinetidae, Bathypalaemonellidae, Processidae, and Hippolitydae. *Smithsonian Contributions to Zoology*, 587: 1–106.

Coelho, P.A. and Ramos, M.A. 1972. A constituição e a distribuição da fauna de decápodos do litoral leste da América do Sul entre as latitudes de 5ºN e 39ºS. *Trabalhos do Instituto Oceanográfico da Universidade Federal de Pernambuco*, 13: 133–236.

Coelho, P.A.; Almeida, A.O.; Souza-Filho, J.F.; Bezerra, L.E.A. and Giraldes, B.W. 2006. Diversity and distribution of the marine and estuarine shrimps (Dendrobrachiata, Stenopodidea and Caridea) from North and Northeast Brazil. *Zootaxa*, 1221: 41–62.

Dana, J.D. 1852a. Conspectus of the Crustacea of the Exploring Expedition under Capt. C. Wilkes, U.S.N. Paguridea, continued, Megalopidea and Macroura. *The American Journal of Science and Arts*, 14: 116-125.

Dana, J.D. 1852b. Conspectus Crustaceorum & Conspectus of the Crustacea of the Exploring Expedition under Capt. C. Wilkes, U.S.N. Macroura. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 1852, 10–29.

De Grave, S. and Anker, A. 2018. A new, distinctly coloured species of *Lysmata* Risso, 1816 (Malacostraca: Decapoda: Lysmatidae) from the south-central Atlantic. *Zootaxa*, 4429: 390–400.

De Grave, S. and Fransen, C.H.J.M. 2011. Carideorum Catalogus: The recent species of the Dendrobranchiate, Stenopodidean, Procarididean and Caridean shrimps (Crustacea: Decapoda). *Zoologische Mededeligen*, 89: 195–589.

de Man, J.G.1888. Bericht über die von Herrn Dr. J. Brock im indischen Archipel gesammelten Decapoden und Stomatopoden. *Archiv für Naturgeschichte*, 53: 215–600.

Dohrn, P.F.R. and Holthuis, L.B. 1950. *Lysmata nilita*, a new species of prawn (Crustacea Decapoda) from the Western

Mediterranean. *Pubblicazioni della Stazione Zoologica di Napoli*, 22: 339–347.

Fausto Filho, J. 1970. Quarta contribuição ao inventário dos crustáceos decápodos marinhos do nordeste brasileiro. *Arquivos de Ciência do Mar*, 10: 55–60.

Fransen, C.H.J.M. 1991. *Lysmata olavoi*, a new shrimp of the family Hippolytidae (Decapoda, Caridea) from the Eastern Atlantic Ocean. *Arquipélago*, 9: 63–73.

Gan, Z. and Li, X. 2016. *Lysmata leptodactylus*, a new species of lysmatid shrimp (Crustacea: Decapoda: Caridea) from China. *Zootaxa*, 4138: 181–188.

Gibbes, L.R. 1850. On the carcinological collections of the United States, and an enumeration of species contained in them, with notes on the most remarkable, and descriptions of new species. *Proceedings of the American Association for the Advancement of Science*, 3: 165–201.

Giraldes, B.W.; Macedo, T.P.; Brandão, M.C.; Baeza, J.A. and Freire, A.S. 2018. *Lysmata arvoredensis* nov. sp. a new species of shrimp from the south coast of Brazil with a key to species of *Lysmata* (Caridea: Lysmatidae) recorded in the southwestern Atlantic. *PeerJ*, 6: e5561.

González-Ortegón, E.; García-Raso, J.E.; Calado, R.; de la Rosa, I.L.; Guerrero, M. and Cuesta, J.A. 2020. Atlantic expansion of the African caridean shrimp *Lysmata uncicornis* Holthuis and Maurin, 1952 (Caridea: Lysmatidae). *Marine Biodiversity*, 50: 26, 1–9.

Gordon, I. 1935. On new and imperfectly known species of Crustacea Macrura. *The Journal of the Linnean Society*, 39: 307–351.

Gosse, P.H. 1858. Synopsis of the families, genera, and species of the British Actiniae. *Annals and Magazine of Natural History*, 1: 414–419.

Hall, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleir Acids Symposium Series,* 41: 95–98.

Holthuis, L.B. 1948. Note on some Crustacea Decapod Natantia from Surinam. *Proceedings van de Koninklijke Nederlandsche Akademie van Wetenschappen*, 51: 1104–1113.

Holthuis, L.B. and Maruin, C. 1952. Note sur *Lysmata uncicornis* nov. spec. et sur deux autres espèces intéressantes de crustacés décapodes macroures de la côte Atlantique du Maroc. *Proceedings of the Koninklijke Nederlandse Akademie van Wetenschappen*, 55: 197–202.

Karplus, I. 2014. Symbiosis in Fishes: The Biology of Interspecific Partnerships. Chichester, John Wiley & Sons Press, 460p.

Kemp, S. 1914. Notes on Crustacea Decapoda in the Indian Museum. V. Hippolytidae. *Records of the Indian Museum*, 10: 81-129.

Kingsley, J.S. 1878. Notes on the North American Caridea in the Museum of the Peabody Academy of Science at Salem, Mass. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 1878: 89–98.

Kumar, S.; Stecher, G. and Tamura, K. 2016. Mega7: Molecular evolutionary genetics analysis version 7.0 for Bigger Datasets. *Molecular Biology and Evolution*, 33: 1870–1874.

Lagardère, J.P. 1971. Les crevettes des côtes du Maroc. *Travaux de l'Institut Scientifique Cherifen, Série Zoologie*, 36: 1–140.

Latreille, P.A. 1802. Histoire naturelle, générale et particulière des Crustacés et des Insectes. Paris. 476p.

Laubenheimer, H. and Rhyne, A.L. 2010. *Lysmata rauli*, a new species of peppermint shrimp, (Decapoda: Hippolytidae) from the southwestern Atlantic. *Zootaxa*, 2372: 298–304.

Mainka, A.A. and Howard, W. 2010. Climate change and invasive species: double jeopardy. *Integrative Zoology*. 5: 102–111.

Mantelatto, F.L.M. and Dias, L.L. 1999. Extension of the known distribution of *Charybdis hellerii* (A. Milne-Edwards, 1867) (Decapoda, Portunidae) along the Western Tropical South Atlantic. *Crustaceana*, 72: 617–620.

Marin, I.N.; Korn, O.M. and Kornienko, E.S. 2012. The caridean shrimp *Lysmata vittata* (Stimpson, 1860) (Decapoda: Hippolytidae): A new species for the fauna of Russia. *Russian Journal of Marine Biology*, 38: 359–363.

Okuno, J. and Fiedler, G.C. 2010. *Lysmata lipkei*, a new species of peppermint shrimp (Decapoda, Hippolytidae) from warm temperature and subtropical waters of Japan. p. 597–610. In: C.H.J.M. Fransen; S. De Grave and P.K.L. Ng (eds), Studies on Malacostraca: Lipkei Bijdeley Holthuis Memorial Volume. Crustaceana Monographs, vol. 14. Leiden, Brill.

Pachelle, P.P.G.; Mendes, C.B. and Anker, A. 2011. The Indo-West Pacific alpheid shrimp *Athanas dimorphus* Ortmann, 1894: first record for Brazil and the western Atlantic. *Nauplius*, 19: 87–96.

Pachelle, P.P.G.; Anker, A.; Mendes, C.B. and Bezerra, L.E.A. 2016. Decapod crustaceans from the state of Ceará, northeastern Brazil: an updated checklist of marine and estuarine species, with 23 new records. *Zootaxa*, 4131: 1–63.

Pachelle, P.P.G.; Leray, M.; Anker, A. and Lasley, R. 2018. Five new records of marine shrimps (Decapoda: Caridea, Stenopodidea) from the Caribbean coast of Panama. *Zootaxa*, 4438: 128–136.

Pachelle, P.P.G.; Carvalho, L.; Alves, D.F.R. and Anker, A. 2020. A revision of the Brazilian species of *Lysmata* Risso, 1816 (Decapoda: Caridea: Lysmatidae), with discussion of the morphological characters used in their identification. *Zootaxa*, 4789: 55–90.

Pereira-Filho, G.H.; Shintate, G.S.; Kitahara, M.V.; Moura, R.L.; Amado-Filho, G.M.; Bahia, R.G.; Moraes, F.C.; Neves, L.M.; Francini, C.L.B.; Gibran, F.Z. and Motta, F.S. 2019. The southernmost Atlantic coral reef is off the subtropical island of Queimada Grande (24° S), Brazil. *Bulletin of Marine Science*, 95: 277–287.

Pivetta, A.P.D.; de Morais, M.M. and Joelico, E. 2012. Caracterização preliminar quantitativa da estrutura de assembléias de peixes recifais da Ilha da Queimada Grande–SP. *Revista Ceciliana*, 4: 7–83.

Prakash, S. and Baeza, J.A. 2017. A new species of *Lysmata* Risso, 1816 (Crustacea, Decapoda, Lysmatidae) from the Gulf of Mexico. *Zootaxa*, 4363: 576–582.

Rathbun, M.J. 1901. Investigations of the Aquatic Resources and Fisheries of Porto Rico by the United States Fish Commission Steamer Fish Hawk in 1899. The Brachyura and Macrura of Porto Rico. *Bulletin of the United States Fish Commission*. 20: 1–127.

Rhyne, A.L. and Anker, A. 2007. *Lysmata rafa*, a new species of peppermint shrimp (Crustacea, Caridea, Hippolytidae) from

the subtropical western Atlantic. *Helgoland Marine Research*, 61: 291–296.

Rhyne, A.L. and Lin, J. 2006. A western Atlantic peppermint shrimp complex: redescription of *Lysmata wurdemanni*, description of four new species, and remarks on *Lysmata rathbunae* (Crustacea: Decapoda: Hippolytidae). *Bulletin of Marine Science*, 79: 165–204.

Rhyne, A.L.; Calado, R. and Santos, A.D. 2012. *Lysmata jundalini*, a new peppermint shrimp (Decapoda, Caridea, Hippolytidae) from the Western Atlantic. *Zootaxa*, 3579: 71–79.

Rhyne, A.L.; Tlusty, M.F.; Szczebak, J.T. and Holmberg, R.J. 2017. Expanding our understanding of the trade in marine aquarium animals. *PeerJ*, 5: e2949.

Risso, A. 1816. Histoire Naturelle des Crustacés des Environs de Nice. Librairie Grecque-Latine-Allemande, Paris, 175p.

Rodríguez, G. and Suárez, H. 2001. Anthropogenic dispersal of Decapod crustaceans in aquatic environments. *Interciencia*, 26: 282–288.

Schubart, C.D.; Cuesta, J.A. and Felder, D.L. 2002. Glyptograsidae, a new brachyuran family from Central America: larval and adult morphology, and molecular phylogeny of the Grapsoidea. *Journal of Crustacean Biology*, 22: 28–44.

Schubart, C.D.; Niegel, J. and Felder, D.L. 2000. Use of mitochondrial 16S rRNA gene for phylogenetic and population studies of Crustacea. p. 817–830. In: C.J.C. Von Vaupel Klein and F.R. Schram (eds.), The Biodiversity Crisis and Crustacea. Crustacean Issues, Vol. 12. Rotterdam, Routledge and CRC Press.

Soledade, G.O.; Baeza, J.A.; Boehs, G.; Simões, S.M.; Souza Santos, P.; Costa, R.C. and Almeida, A.O. 2013. A precautionary tale when describing species in a world of invaders: morphology, coloration and genetics demonstrate that *Lysmata rauli* is not a new species endemic to Brazil but a junior synonym of the Indo-Pacific *L. vittata*. *Journal of Crustacean Biology*, 33: 66–77.

Spence Bate, C. 1888. Report on the Crustacea Macrura collected by H.M.S. Challenger during the Years 1873–76. In: J. Murray (ed.), Zoology. Report on the Scientific Results of the Voyage of H.M.S. Challenger During the Years 1873–76 Under the Command of Captain George S. Nares, R.N., F.R.S. and the Late Captain Frank Tourle Thomson, R.N. C. Wyville Thomson and J. Murray (series eds), vol. 24. Edinburgh, Neill and Company. i–xc, 942p., pls. 1–157.

Stebbing, T.R.R. 1915. South African Crustacea. Part VIII of S.A. Crustacea, for the Marine Investigations in South Africa. *Annals of the South African Museum*, 15: 57-103.

Stebbing, T.R.R. 1921. Some Crustacea from Natal. *Annals of the Durban Museum*, 3:12–26.

Stimpson, W. 1860. Prodomus descriptionis animallium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem, a Republic Federata missa, Cadwaladore Ringgold et Johanne Rodgers Ducibus, observavit et descripsit. Pars VIII, Crustacea, Macrura. *Proceedings of the Academy of Natural Sciences of Philadelphia*, 1860: 22–47.

Stimpson, W. 1866. Descriptions of new Genera and Species of Macrurous Crustacea from the Coasts of North America. *Proceedings of the Chicago Academy of Sciences*, 1: 46–48.

Tavares, M. 2003. Espécies exóticas aquáticas e saúde ambiental. *Mundo Saúde* (Impresso), 27: 530–537.

Tavares, M. 2011. Alien Decapod Crustaceans in the Southwestern Atlantic Ocean. p. 251–268. In: B.S. Galil; P.F. Clark and J.T. Carlton (eds), In the Wrong Place - Alien Marine Crustaceans: Distribution, Biology and Impacts, Invading Nature - Springer Series in Invasion Ecology. Dordrecht, Springer Netherlands.

Terossi, M.; Almeida, A.O.; Buranelli, R.C.; Castilho, A.L.; Costa, R.C.; Zara, F.J. and Mantelatto, F.L. 2018. Checklist of decapods (Crustacea) from the coast of the São Paulo state (Brazil) supported by integrative molecular and morphological data: I. Infraorder Caridea: families Hippolytidae, Lysmatidae, Ogyrididae, Processidae and Thoridae. *Zootaxa*, 4370: 76–94.

Thallwitz, J. 1891. Decapoden-Studien, insobesondere basirt auf A.B. Meyer's Sammlungen im Ostindischen Archipel, nebst einer Aufzählung der Decapoden und Stomatopoden des Dresdener Museums. *Abhandlungen und Berichte des Königlichen Zoologischen und Anthropologisch-Etnographischen Museum zu Dresden*, 3: 1–56.

Thompson, J.D.; Higgins, D.G. and Gibson, T.J. 1994. CLUSTAL W: improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position specific gap penalties and weight matrix choice. *NucleicAcids Research*, 22: 4673–4680.

Wabnitz, C.; Taylor, M.; Green, E. and Razak, T. 2003. From Ocean to Aquarium: The Global Trade in Marine Ornamental Species. Cambridge, UK, UNEP, 65p.

Wang, Y.-R. and Sha, Z.-L. 2018. Description of two new species of *Lysmata* Risso, 1816 (Decapoda, Lysmatidae) from the China seas, with remarks on *Lysmata vittata* (Stimpson 1860). *Zootaxa*, 4392: 28–40.

Wicksten, M.K. 2000. The species of *Lysmata* (Caridea: Hippolytidae) from the Eastern Pacific Ocean. *Amphipacifica*, 2: 3–22.