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The Indo-West Pacific alpheid shrimp *Athanas dimorphus* Ortmann, 1894: first record for Brazil and the western Atlantic

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Abstract

The alpheid shrimp *Athanas dimorphus* Ortmann, 1894, common and widespread throughout the Indo-West Pacific, is reported for the first time from Brazil, representing the first invasive alpheid species in Brazil, and the first species of the genus *Athanas* Leach, 1816 introduced to the western Atlantic. The present record is based on several specimens collected at two localities in Ceará, Pedra Rachada beach near the town of Paracuru, and Meireles beach in Fortaleza. *Athanas dimorphus* is very common at the second site, suggesting that a population of this species is now established in northwestern Brazil. An updated list of marine and freshwater decapods accidentally or voluntarily introduced to Brazil is provided.

Key words: Decapoda, Caridea, Alpheididae, new record, invasive species

Introduction

The shrimp genus *Athanas* Leach, 1814 is distributed in tropical, subtropical and warm-temperate areas of the Indo-West Pacific and eastern Atlantic, mostly in shallow waters (Anker and Jeng, 2007). In the phylogenetic system of the family Alpheididae (Anker *et al.*, 2006), *Athanas* together with several allied genera form a morphologically well-defined clade, characterised by the presence of an articulated triangular plate on the sixth abdominal somite, the absence of arthrobranch on the third maxilliped, and a reduced number of mastigobranchs (Anker *et al.*, 2006; Anker and Jeng, 2007). Biogeographically interesting is the fact that this clade is entirely absent from the American waters, *i.e.* from the eastern

Pacific and the western Atlantic.

In April 2011, a single specimen belonging to the genus *Athanas* was collected from an intertidal pool at Pedra Rachada beach, near the town of Paracuru, Ceará, Brazil (Fig. 1). In June 2011, seven specimens of *Athanas* were collected and many more observed in the rocky intertidal area of Meireles beach, Fortaleza, Ceará. These specimens were examined and identified as the Indo-West Pacific species *Athanas dimorphus* Ortmann, 1894, based on descriptions and illustrations provided by Coutière (1899), Banner and Banner (1973) and Chace (1988). In the present study, *A. dimorphus* is reported as the first invasive alpheid for the Brazilian coast, also representing the first species of *Athanas* introduced to the western Atlantic.

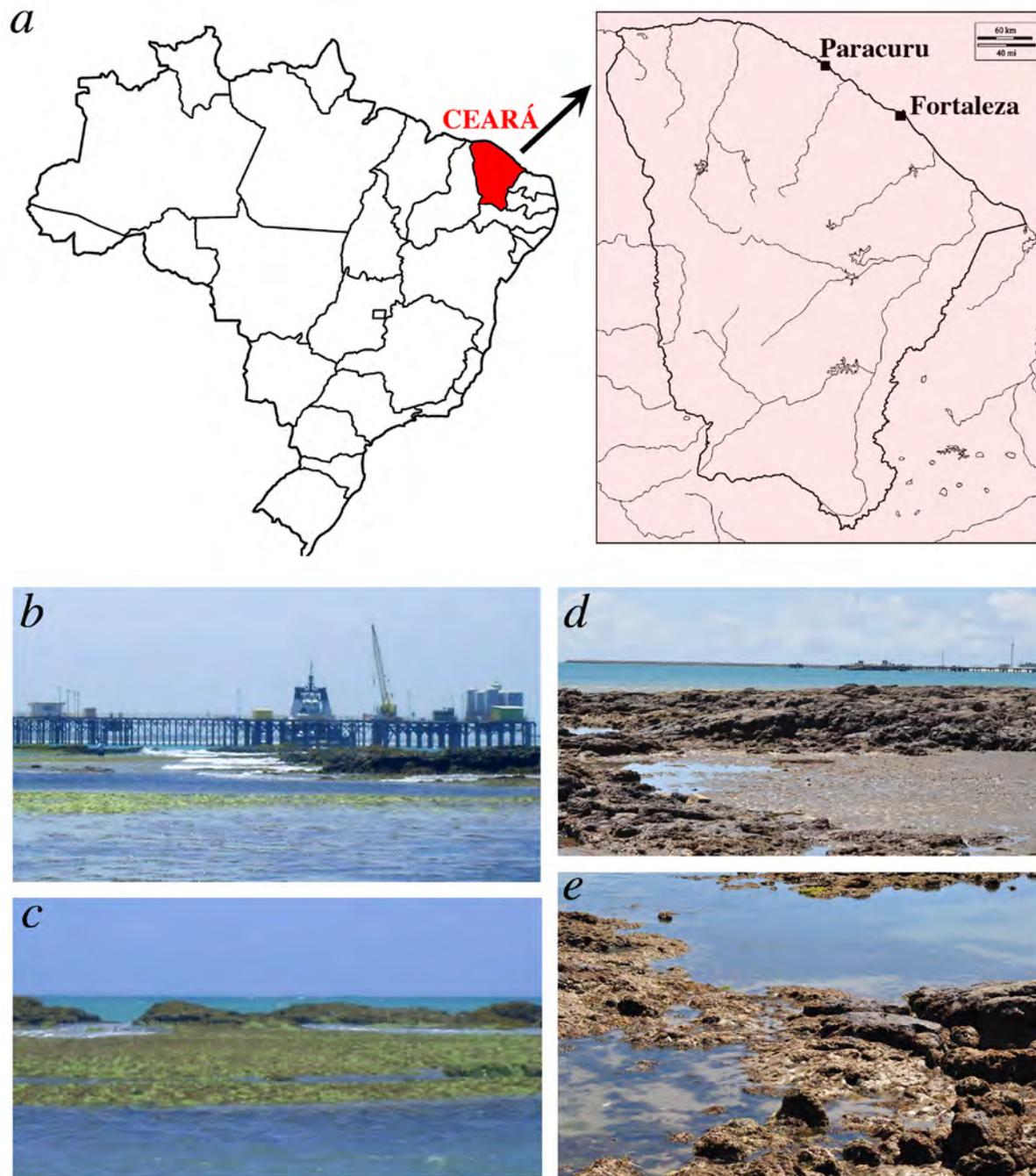


Figure 1. Collection sites of *Athanas dimorphus* in Ceará, Brazil: a – geographical location of Paracuru relative to Fortaleza; b – Paracuru, oil terminal jetty; c – Paracuru, Pedra Racharda beach, exposed rocky area abundantly covered with algae; d – Fortaleza, rocky section of Meireles beach with Mucuripe port in the background; e – Meireles microhabitat where *A. dimorphus* was most abundant.

Material and Methods

All specimens were captured by hand, in tide pools or by flipping rocks at low tide, placed in a small field jar with seawater, and transferred to Labomar (UFC) in Fortaleza, where some of them were photographed alive and preserved in ethanol 75%. Voucher specimens of *A. dimorphus* are deposited in

the Coleção de Crustáceos da Universidade Federal do Pernambuco, Recife (UFPE) and Museu de Zoologia, Universidade de São Paulo, São Paulo (MZUSP). The remaining specimens will be deposited in the reference collection of Universidade Federal do Ceará, Fortaleza (UFC). Carapace length (cl) and total length (tl) were measured in mm along the dorsal mid-line from the tip of the rostrum

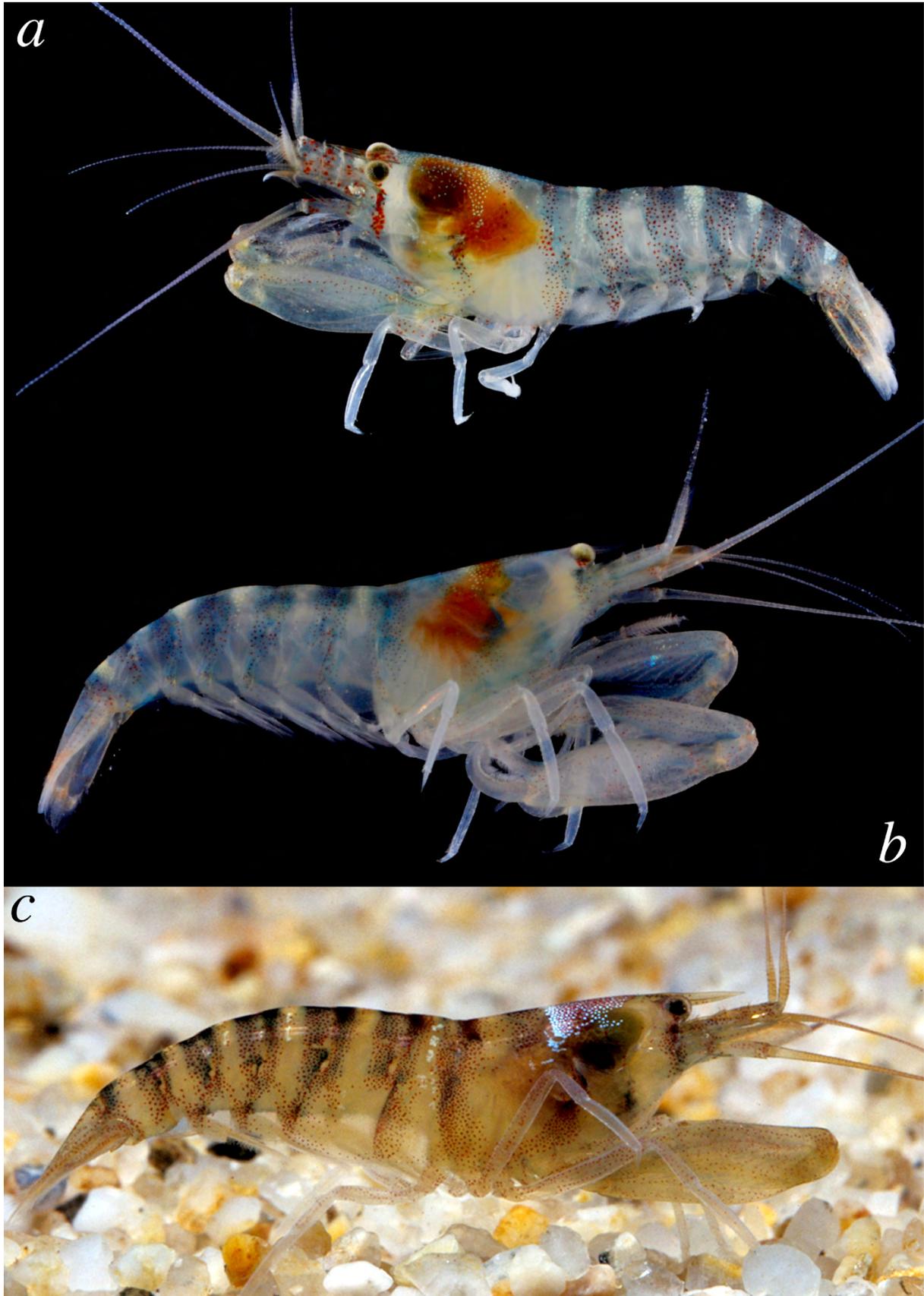


Figure 2. *Athanas dimorphus* Ortmann, 1894, a – male (MZUSP 24400) from Meireles, Ceará, Brazil, lateral view with chelipeds completely folded; b – different male from Meireles (UFPE 14749), lateral view with chelipeds partly extended; c – male from Japan, for comparison, aquarium photo (a, b, photographs by A. Anker; c, photograph by M. Itoh).



Figure 3. *Athanas dimorphus* Ortmann, 1894, ovigerous female from Paracuru, Ceará, Brazil (UFPE 14748), a – dorsal view; b – lateral view (photographs by A. Anker); note differences in the cheliped size and shape compared to males in Fig. 2.

to the posterior margin of the carapace and telson, respectively.

Athanas dimorphus Ortmann, 1894
(Figs. 2, 3)

Athanas dimorphus Ortmann, 1894: 12, pl. 1, fig. 1 (type locality: Dar es Salaam, Tanzania); Banner and Banner, 1973: 313, Fig. 6, Banner and Banner, 1983: 76; Chace, 1988: 61 (for full synonymy see Banner and Banner, 1973 and Chace, 1988).

Material examined: Brazil, Ceará: 1 ovigerous female (cl 6.0 mm, tl 15.5 mm), Paracuru, Pedra Rachada beach, 03°25'S - 39°04'W, rocky intertidal, low tide, under

rocks in tidal pool, under rock, colls. C.B. Mendes, P. Pachelle, 16 April 2011 [UFPE 14748]; 1 male (cl 4.5 mm, tl 12.9 mm), Fortaleza, Meireles beach, 03°43'S - 38°29'W, rocky intertidal, low tide, under rocks, colls. A. Anker, N. Feitosa, 15 June 2011 [UFPE 14749]; 1 male (cl 4.9 mm, tl 12.7 mm), 1 ovigerous female (cl 5.3 mm, tl 13.8 mm), same collection data as for previous specimen [MZUSP 24400]; 4 specimens of both sexes, same collection data as for previous specimens [UFC].

Diagnosis: Rostrum long, straight, usually overreaching second antennular

Table 1. Non-native species of marine or marine-brackish water (*) and freshwater (†) decapod crustaceans recorded in Brazil from the 19th century to 2011. Abbreviations for Brazilian states: AL, Alagoas; BA, Bahia; CE, Ceará; MA, Maranhão; PE, Pernambuco; RJ, Rio de Janeiro; RN, Rio Grande do Norte; RS, Rio Grande do Sul; SE, Sergipe; SC, Santa Catarina; SP, São Paulo. Other abbreviations: EP, East Pacific; IWP, Indo-West Pacific; NEA, North-East Atlantic; NWA, North-West Atlantic; SWA, South-West Atlantic.

Species	Family	Natural distribution	First records in Brazil	Population established in the wild	Current distribution in Brazil	References
1. <i>Athanas dimorphus</i> Ortmann*	Alpheidae	IWP	2011 (CE)	Yes	CE	Present study
2. <i>Bellia picta</i> H. Milne Edwards*	Belliidae	EP: Chile	1989 (RS)	No	---	Tavares, 2011 (and references)
3. <i>Cancer pagurus</i> L.*	Cancridae	NEA	2004 (SP)	No	---	Tavares, 2011 (and references)
4. <i>Carcinus maenas</i> (L.)*	Carcinidae	NEA	1861 (RJ), 1899 (PE)	No	---	Carlton and Cohen, 2003
5. <i>Charybdis helleri</i> (A. M-Edwards)*	Portunidae	IWP	1996 (RJ, SP)	Yes	CE, RJ, SP, SC, RS	Tavares and Mendonça, 1996; Negreiros-Fransozo, 1996; Mantelatto and Dias, 1999; Ferreira <i>et al.</i> , 2001; Bezerra and Almeida, 2005; Tavares, 2011 (and references); present study
6. <i>Fenneropenaeus penicillatus</i> (Alcock)*	Penaeidae	IWP	1985 (BA)	No	---	Tavares, 2011 (and references)
7. <i>Halicarcinus planatus</i> (Fabricius)*	Hymenosomatidae	EP: Chile; SWA: Argentina, Uruguay	2003 (RJ)	No	---	Tavares, 2003, 2011
8. <i>Liocarcinus navigator</i> (Herbst)*	Portunidae	NEA	2002 (RJ)	No	---	Tavares, 2011 (and references)
9. <i>Litopenaeus stylirostris</i> (Stimpson)*	Penaeidae	EP: Mexico to Peru	1983 (RN)	No	---	Tavares, 2011 (and references)
10. <i>Litopenaeus vannamei</i> (Boone)*	Penaeidae	EP: Mexico to Colombia	deliberate introduction to NE Brazil in the early 1990s	Yes	CE, RN, PE, BA	Santos and Coelho, 2002; Luvesuto <i>et al.</i> , 2007; Tavares, 2011
11. <i>Macrobrachium rosenbergii</i> (De Man)*	Palaemonidae	S Asia: India to W Indonesia	deliberate introduction to SP in 1977 (from Hawaii)	Yes? (isolated captures, wild populations yet to be confirmed)	SP	Magalhães <i>et al.</i> , 2005 (and references); see also Wowor and Ng, 2007, 2008, for nomenclature of <i>M. rosenbergii</i>
12. <i>Marsupenaeus japonicus</i> (Bate)*	Penaeidae	IWP	deliberate introduction to RN in 1978	Yes? (isolated captures)	RN?	Tavares, 2011 (and references)
13. <i>Metapenaeus monoceros</i> (Fabricius)*	Penaeidae	IWP	1995	No	RS	D'Incao, 1995; Tavares, 2011
14. <i>Penaeus monodon</i> Fabricius*	Penaeidae	IWP	deliberate introduction to RN and BA in 1982-1985	Yes	MA, PE, SE, AL, SP	Santos and Coelho, 2002; Tavares, 2011 (and references)
15. <i>Pilumnoides perlatus</i> (Poeppig)*	Pilumnoididae	EP: Peru, Chile	2000 (SP)	No	---	Tavares, 2011 (and references)
16. <i>Procambarus clarkii</i> (Girard)†	Cambaridae	S USA, N Mexico	around 1986 (SP)	Yes	SP	Magalhães <i>et al.</i> , 2005; Melo da Silva and Siquiera Bueno, 2005
17. <i>Pyromaia tuberculata</i> (Lockington)*	Inachoididae	EP: Mexico to Colombia	around 1985 (PA)	Yes	PA, SP, RJ, SC, RS	Tavares, 2011 (and references)
18. <i>Rhithropanopeus harrisi</i> (Gould)*	Panopeidae	NWA	around 1982	Yes	RS	Tavares, 2011 (and references)
19. <i>Scylla serrata</i> (Forskål)*	Portunidae	IWP	1983 (SP)	No? (isolated captures)	---	Tavares, 2011 (and references)
20. <i>Talipotus dentatus</i> (H. M-Edwards)*	Epiplatidae	EP: Chile	1996 (RJ)	No	---	Tavares & Mendonça, 2011 (and references)

article; orbit without supra-corneal tooth, extra-corneal tooth acute, infra-corneal tooth rounded, not overreaching extra-corneal tooth. Eyes mostly exposed in dorsal and lateral views.

Chelipeds carried folded, sexually dimorphic: male chelipeds greatly enlarged, asymmetrical or subsymmetrical; chela subcylindrical, with fingers armed with blunt teeth (in larger adult

males); merus inflated and deeply excavated on flexor surface, margins not toothed (Fig. 2); female chelipeds not enlarged, slender, symmetrical; chela slender, about half-length of merus, shorter than carpus (in mature females); merus not inflated, depressed on flexor surface (Fig. 3). Second pereopod with five carpal articles, first longest. Third pereopod with dactylus simple, conical, not biunguiculate, about one third propodus length. Telson moderately broad, distally tapering, with two pairs of dorsal spines and two pairs of posterolateral spines. Maximum TL ~18 mm. For detailed description and figures of *A. dimorphus* see Banner and Banner (1973); for diagnosis of *Athanas* see Anker and Jeng (2007).

Colour pattern: Semitransparent with bluish-greenish transverse bands formed by a combination of reddish and bluish chromatophores; carapace with a conspicuous dorsal patch of white chromatophores mixed with reddish chromatophores; dorsal bands of white chromatophores also present on abdominal somites, in-between reddish-bluish bands; walking legs and antennal and antennular peduncles with scattered red chromatophores; chelipeds hyaline white, with dispersed red chromatophores; freshly laid eggs olive-green (Figs. 2, 3).

Distribution: Widely distributed in the Indo-West Pacific, including Red Sea, East Africa, Mascarene Islands, India, Thailand, Philippines, Indonesia, South China Sea, Australia, New Caledonia, and Japan (Banner and Banner, 1983; Chace, 1988); introduced accidentally to the western Atlantic: Ceará, Brazil (present study).

Ecology: Indo-West Pacific: shallow reef flats and intertidal rocky and mixed sand-rock or mud-rock flats, sometimes with sea grass and algae; under coral rubble and rocks, in tide-pools; depth range: from the intertidal to 100 m, but most frequently found between 0 and 2 m (A. Anker, pers. obs.). Brazil: Paracuru: rocky beach area of an extensive sandstone reef

formation (Fig. 1b) with numerous tidal pools at low tide - some tidal pools in this area are almost 1 m deep; Fortaleza: rocky beach with many rocks partly covered with mud and algae (Figs. 1d, e), underside of many rocks covered with sponges and didemnid ascidians; shrimps are typically found under rocks, either solitarily or in small groups.

Discussion

Athanas dimorphus belongs to a genus not naturally occurring in Brazil and the western Atlantic. The genus *Athanas* differs from all other western Atlantic alpheid genera by the following morphological combination: (1) eyes largely exposed in dorsal view; (2) sixth abdominal somite with an articulated triangular plate; and (3) frontal region of the carapace with a long, straight rostrum and acute orbital teeth. Five species of *Athanas* are present in the eastern Atlantic, ranging from Norway to the Black Sea and Angola (see Anker and Jeng, 2007 and references therein). However, *A. dimorphus* can be easily distinguished from all of them by the shape of the male chelipeds (Fig. 2), especially the inflated, non-toothed merus and twisted fingers armed with a few large teeth and bearing a row of setae. In addition, the colour pattern of *A. dimorphus* is species-diagnostic (Figs. 2, 3), enabling an easy identification of specimens in the field.

The collection of *A. dimorphus* from two different sites in Ceará, its abundance at the second site, and the presence of numerous ovigerous females (Fig. 3), leave no doubt that a viable population of this species is now established in northeastern Brazil. For the moment, it can be only speculated on how *A. dimorphus* got to northeastern Brazil in the first place. The description of the first zoeal stages of *A. dimorphus* (Gurney, 1927; Bhuti *et al.*, 1977) suggests that this species has an extended development. Therefore, its planktonic larvae would be able to survive for several months in ballast water of large vessels, which may be responsible for most

marine invasions (Gollasch, 2007; Hewitt *et al.*, 2009). In addition, adults of *A. dimorphus* are small enough to dwell in the smallest hull fissures or among hull fouling growth, another important vector of marine invasive species (Hewitt *et al.*, 2009). Alpheid shrimps have also been reported from epibiotic growth on marine turtles (Frick *et al.*, 2003).

In the immediate vicinity of the first collection site (Pedra Rachada beach, Paracuru), there is a Petrobras oil terminal with a long pier (Fig. 1a) and pipes supplying both fuel and drinking water, and with heavy traffic of tugboats and barges transporting workers and materials to/from 10 regional operating units (Viana *et al.*, 2005). As environmental monitoring of this area has never been done, the impact of the oil terminal on adjacent natural habitats and its possible involvement in the introduction of invasive species remain unknown. The second collection site (Meireles beach, Fortaleza) is facing Mucuripe port, with both cargo and oil terminals (Fig. 1d). At least one other invasive decapod species was collected at this site, the portunid crab *Charybdis helleri* (A. Milne-Edwards, 1867), also from the Indo-West Pacific (see also Tab. 1).

Four other alpheid shrimps are known as invasive species; all of them belong to the genus *Alpheus* Fabricius, 1798 and are Lessepsian migrants from the Red Sea to the Mediterranean Sea. *Alpheus* cf. *edwardsii* (Audouin, 1826), *A. inopinatus* Holthuis and Gottlieb, 1958, *A. cf. rapacida* De Man, 1909 and *A. migrans* Lewinsohn & Holthuis, 1978 have now established populations in the warmer eastern and southern parts of the Mediterranean Sea, from Egypt and Israel to Turkey and Tunisia, with first records dating back to the late 1950s (Forest and Guinot, 1958; Lewinsohn and Galil, 1982; Galil *et al.*, 2002; Galil, 2006; A. Anker, pers. obs.). In Turkey, *A. cf. rapacida* appears to establish a symbiotic partnership with a shrimp goby, *Vanderhorstia mertensi* Klausewitz, 1974, also a Lessepsian migrant (Özcan *et al.*, 2007; Bilecenoglu *et al.*, 2008). The impact of burrowing alpheid shrimps on soft-sediment

and sea-grass meadow communities in the eastern Mediterranean has yet to be investigated. The listing of *Salmonesus gracilipes* Miya, 1972 as a non-indigenous species in California by the United States Geological Survey (website: <http://nas.er.usgs.gov/>) is based on Cadien's (1986) unconfirmed, not formally published record.

Compared to the four invasive species of *Alpheus*, which are large, stout, aggressive snapping shrimps, *Athanas dimorphus* is a small, fragile, inconspicuous shrimp, unable to snap (chelipeds of *Athanas* do not possess a snapping mechanism, see above). Unlike *Alpheus*, *A. dimorphus* does not dig a burrow, but instead uses natural shelters, such as cavities under rocks and crevices in coral rubble (Banner and Banner, 1973; A. Anker, pers. obs.). Its diet is unknown, but most likely consists of microorganisms and organic detritus. Therefore, the ecological impact of this invasive species on the intertidal communities in Brazil is expected to be minimal. In Brazil, *A. dimorphus* seems to occupy an ecological niche that is similar to those of *Salmonesus* Holthuis, 1955 and *Automate* De Man, 1888, two non-snapping alpheid genera with shallow-water representatives on Brazilian coasts (Christoffersen, 1998; Anker, 2007).

The present record of *A. dimorphus* from Ceará brings the total number of non-native Decapoda recorded from Brazilian marine and fresh waters to 20. This number includes (1) accidental introductions (shipping, ballast water, flotsam, aquarium trade or experiment animal escapees, etc.) that resulted in established populations; (2) deliberate introductions for shrimp aquaculture (with or without escaped individuals leading to established populations); and (3) incidental introductions that did not result in established populations (see Table 1). Three invasive decapods currently absent from Brazil have established viable populations in Uruguay and Argentina, including the globally invasive green crab, *Carcinus maenas* (Linnaeus, 1758) (Vinuesa, 2007; Darling *et al.*, 2008; Tavares, 2011), and may eventually spread to suitable habitats in southern Brazil. With increasing international marine traffic

and global warming effects the number of alien decapods and other crustaceans in Brazil will certainly rise in the future.

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THE JOURNAL OF THE BRAZILIAN CRUSTACEAN SOCIETY

Summary Volume 19(1) – 2011
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- Túlio Paiva Chaves, Sébastien Lacau, Nicolas Rabet** 1-5
Illustrated key to the Brazilian *Dendrocephalus* (Crustacea: Anostraca: Thamnocephalidae)
- André R. Senna, Jesser F. Souza-Filho** 7-16
A new species of *Pseudharpinia* (Amphipoda: Haustorioidea: Phoxocephalidae) from Southeastern Brazilian continental shelf
- Giovanna M. Cardoso, Alessandra A. de P. Bueno, Rodrigo L. Ferreira** 17-26
A new troglolithic species of *Hyaella* (Crustacea, Amphipoda, Dogielinotidae) from Southeastern Brazil
- Ivanklin Soares Campos-Filho, Paula Beatriz Araujo** 28-39
Two new troglolithic species of Scleropactidae (Crustacea: Isopoda: Oniscidea) from Pará, Brazil
- Luciane Ayres-Peres, Cadidja Coutinho, Joele S. Baumart, Alberto S. Gonçalves, Paula B. Araujo, Sandro Santos** 41-54
Radio-telemetry techniques in the study of displacement of freshwater anomurans
- Tainá Stauffer, Maria Cristina Ostrovski, Tereza Cristina Gonçalves da Silva-Ferreira, Tarso Costa** 55-61
Biology of the crab *Leurocyclus tuberculatus* (H. Milne Edwards & Lucas, 1843) bycatch from pink shrimp trawl fishery in the coast of Rio de Janeiro, Brazil
- Vinicius Queiroz, Licia Sales, Elizabeth Neves, Rodrigo Johnsson** 63-70
Dissodactylus crinitichelis Moreira, 1901 and *Leodia sexiesperforata* (Leske, 1778): first record of this symbiosis in Brazil
- Débora de Azevedo Carvalho, Pablo Agustín Collins** 71-77
Ontogenetic predation capacity of *Macrobrachium borellii* (Caridea: Palaemonidae) on prey from littoral-benthic communities
- João Alberto Farinelli Pantaleão, Rafael Augusto Gregati, Fabiano Gazzi Taddei, Rogerio Caetano da Costa** 79-85
Morphology of the first larval stage of *Macrobrachium brasiliense* (Heller, 1868) (Caridea: Palaemonidae)
- Paulo P. G. Pachelle, Cecili Barrozo Mendes, Arthur Anker** 87-96
The Indo-West Pacific alpheid shrimp *Athanas dimorphus* Ortmann, 1894: first record for Brazil and the western Atlantic

