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, Alpheidae, 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 Alpheidae (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.
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 Zoolo gia, 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).
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.

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>Natural distribution</th>
<th>First records in Brazil</th>
<th>Population established in the wild</th>
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<tr>
<td>1. Atlas aestuarinus (Ortmann)*</td>
<td>Alpheidae</td>
<td>IWP</td>
<td>2011 (CE)</td>
<td>Yes</td>
<td>CE</td>
<td>Present study</td>
</tr>
<tr>
<td>3. Cancer pagurus L.*</td>
<td>Cancridae</td>
<td>NEA</td>
<td>2004 (SP)</td>
<td>No</td>
<td>---</td>
<td>Tavares, 2011 (and references)</td>
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<td>5. Charybdis belleri (A. M-Edwards)*</td>
<td>Portunidae</td>
<td>IWP</td>
<td>1996 (RJ, SP)</td>
<td>Yes</td>
<td>CE, RJ, SP, SC, RS</td>
<td>Tavares and Mendonça, 1996; Negreiros-Franzoso, 1996; Mantelatto and Dias, 1999; Ferreira et al., 2001; Bezerra and Almeida, 2005; Tavares, 2011 (and references); present study</td>
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<tr>
<td>8. Liocarcinus navigator (Herbst)*</td>
<td>Portunidae</td>
<td>NEA</td>
<td>2002 (RJ)</td>
<td>No</td>
<td>---</td>
<td>Tavares, 2011 (and references)</td>
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<td>9. Liopenaeus stylirostris (Stimpson)*</td>
<td>Penaeidae</td>
<td>EP, Mexico to Peru</td>
<td>1983 (RN)</td>
<td>No</td>
<td>---</td>
<td>Tavares, 2011 (and references)</td>
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<td>10. Liopenaeus vannamei (Boone)*</td>
<td>Penaeidae</td>
<td>EP, Mexico to Colombia</td>
<td>deliberate introduction to NE Brazil in the early 1990s</td>
<td>Yes? (isolated captures, wild populations yet to be confirmed)</td>
<td>CE, RN, PE, BA</td>
<td>Santos and Coelho, 2002; Luvesuto et al., 2007; Tavares, 2011</td>
</tr>
<tr>
<td>11. Macrobrachium rosenbergii (De Man)*</td>
<td>Palaemonidae</td>
<td>S. Asia: India to W. Indonesia</td>
<td>deliberate introduction to SP in 1977 (from Hawaii)</td>
<td>Yes? (isolated captures)</td>
<td>SP</td>
<td>Magalhães et al., 2005 (and references); see also Wowor and Ng, 2007, 2008, for nomenclature of M. rosenbergii</td>
</tr>
<tr>
<td>12. Macrobrachium japonicus (Bate)*</td>
<td>Penaeidae</td>
<td>IWP</td>
<td>deliberate introduction to RN in 1978</td>
<td>Yes? (isolated captures)</td>
<td>RN?</td>
<td>Tavares, 2011 (and references)</td>
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<tr>
<td>14. Penaeus monodon (Fabricius)*</td>
<td>Penaeidae</td>
<td>IWP</td>
<td>deliberate introduction to RN and BA in 1982-1985</td>
<td>Yes</td>
<td>MA, PE, SE, AL, SP</td>
<td>Santos and Coelho, 2002; Tavares, 2011 (and references)</td>
</tr>
<tr>
<td>15. Pilumnusidae pelatus (Pfeppig)*</td>
<td>Pilumnoidae</td>
<td>EP, Peru, Chile</td>
<td>2000 (SP)</td>
<td>No</td>
<td>---</td>
<td>Tavares, 2011 (and reference)</td>
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<tr>
<td>16. Procambalurus clarkei (Caradja)*</td>
<td>Cambaridae</td>
<td>S USA, N Mexico</td>
<td>around 1986 (SP)</td>
<td>Yes</td>
<td>SP</td>
<td>Magalhães et al., 2005; Melo da Silva and Siquiera Bueno, 2005</td>
</tr>
<tr>
<td>17. Pseudocarcinus tuberculatus (Lockington)*</td>
<td>Inachidae</td>
<td>EP, Mexico to Colombia</td>
<td>around 1985 (PA)</td>
<td>Yes</td>
<td>PA, SP, RJ, SC, RS</td>
<td>Tavares, 2011 (and references)</td>
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<tr>
<td>18. Rhiobrachyura bresi (Gould)*</td>
<td>Panopoidae</td>
<td>NWA</td>
<td>around 1982</td>
<td>Yes</td>
<td>RS</td>
<td>Tavares, 2011 (and references)</td>
</tr>
<tr>
<td>19. Scylla serrata (Forster)*</td>
<td>Portunidae</td>
<td>IWP</td>
<td>1983 (SP)</td>
<td>No? (isolated captures)</td>
<td>---</td>
<td>Tavares, 2011 (and references)</td>
</tr>
</tbody>
</table>

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 pereiopod with five carpal articles, first longest. Third pereiopod 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 Krausewitz, 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 Salmoneus gracipes 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 Salmoneus 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...
Acknowledgments

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(Penaeus monodon Fabricius, 1798 e Litopenaeus vannamei Boone, 1931) nos ambientes estuarino e marinho do Nordeste do Brasil. Boletim Técnico-Científico do CEPENE, 10: 207-222


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