

Isognomon bicolor (C. B. Adams, 1845) (Mollusca: Bivalvia): First record of this invasive species for the States of Paraíba and Alagoas and new records for other localities of Northeastern Brazil

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ABSTRACT: This study provides the first record of the exotic invasive bivalve *Isognomon bicolor* for the State of Paraíba, Northeastern Brazil. It has been found to occur in at least twelve coastal reefs along the coast. We also present its first record for the State of Alagoas and new record localities for the States of Rio Grande do Norte and Pernambuco, including its occurrence in hypersaline estuaries. From these records the distribution range of *I. bicolor* has been expanded to the littoral region of Northeast Brazil, where this invasive species seems well established.

Isognomon bicolor (C. B. Adams, 1845) is an exotic invader bivalve mollusc belonging to the family Pteriidae (Huber 2012), being originally distributed in the Caribbean region. It is believed that this species first reached Brazil between the 1970s and 1980s, probably by means of petroleum platforms (Domaneschi and Martins 2002, Breves-Ramos *et al.* 2010). Yet the first record from the Brazilian littoral was only published much later (Domaneschi and Martins 2002).

A series of studies has since recorded the species from beaches with consolidated substrates, which were revised by Teixeira *et al.* (2010), and Silva and Barros (2011). Matthews-Cascon and Rocha-Barreira (2006), Rocha-Barreira *et al.* (2010), and Loebmann *et al.* (2010) recorded *Isognomon bicolor* for the States of Ceará and Piauí, respectively. Recent research evaluated the spatial distribution and density of *I. bicolor* in rocky beaches in Southeastern and Southern Brazil (e.g. Zamprogno *et al.* 2010; Breves-Ramos *et al.* 2010; Martinez 2012).

According to Lopes and Villac (2009), *I. bicolor* is considered an exotic invader, because it is already established along the Brazilian coast, is abundant, and has a dispersal capacity sufficient to interfere with the survival capacity of native species, as demonstrated by Breves-Ramos *et al.* (2010) and Martinez (2012). It becomes necessary to know the distribution of these invasive species in order to promote environmental management. Our study provides the first record of *I. bicolor* for the

littoral of the State of Paraíba, and extends the known distribution of the species to new localities in the States of Alagoas, Pernambuco and Rio Grande do Norte (Figure 1).

The studied specimens of *I. bicolor* are deposited in Coleção de Invertebrados Paulo Young, Universidade Federal da Paraíba (CIPY-UFPB), having been collected during Project Biota Paraíba, which was conducted from 2007 to 2010 in 14 reef areas along the coast of the State of Paraíba (IBAMA/SISBIO License Nr 14220-1). Individuals were captured manually during intensive searches in the studied areas for about four hours at each locality. Additional specimens were observed from the States of Alagoas, Pernambuco and Rio Grande do Norte (Table 1). All specimens are preserved in alcohol at 70%. The identities of specimens from all localities were confirmed taxonomically with the literature (e.g. Domaneschi and Martins 2002, Mikkelsen and Bieler 2008). To facilitate further identification of species in future studies, we provide a brief diagnosis with illustrations based on the specimens studied.

Class Bivalvia Linnaeus, 1758
Order Pterioidea Newell, 1965
Family Pteriidae Gray, 1847
Isognomon bicolor (C.B. Adams, 1845)
(Figures 2 and 3)

Material Examined – State of Paraíba: UFPB.

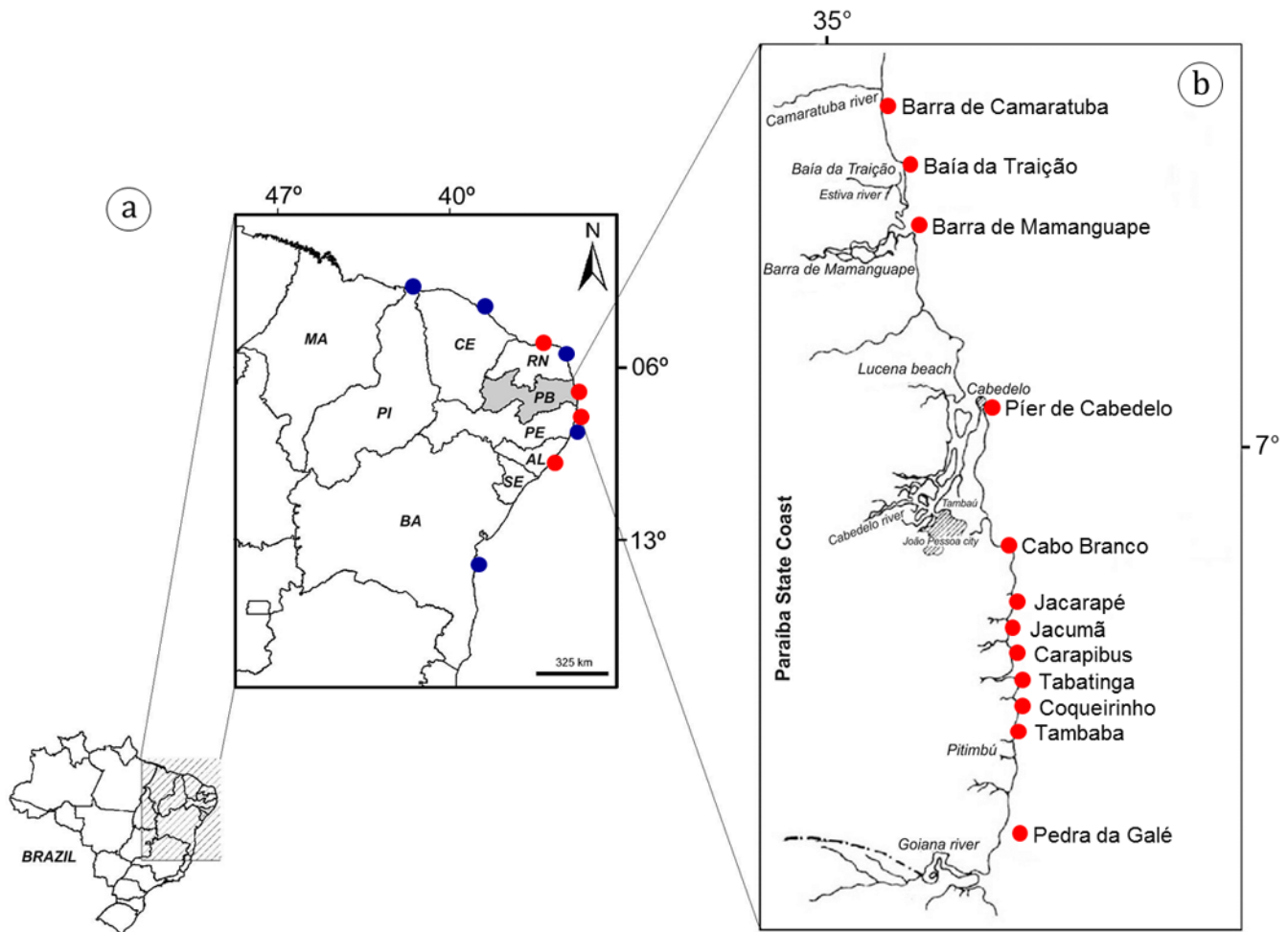


FIGURE 1. Map of the present distribution of *Isognomon bicolor* along northeastern Brazil (blue dots), and with new records along the coasts Rio Grande do Norte, Paraíba, Pernambuco and Alagoas (red dots).

MOL.3020, 37 specimens, Barra de Camaratuba, Mataraca, 6°36'06"S, 34°57'57"W; UFPB.MOL. 2846, 6 specimens, Baía da Traição, 6°41'19"S, 34°55'60"W; UFPB.MOL.3521, 15 specimens, Mamanguape River estuary, Rio Tinto, 6°46'11"S, 34°55'10"W; UFPB.MOL.3148, 2 specimens, Pier de Cabedelo, Cabedelo, 6°57'44"S, 34°50'35"W; UFPB.MOL.3041, 2 empty shells, Cabo Branco beach, João Pessoa, 7°08'50"S, 34°47'51"W; UFPB.MOL.3534, 5 specimens, Jacarapé beach, Conde, 7°11'38"S, 34°47'39"W; UFPB.MOL.3527, 3 specimens, Maceiozinho beach, Jacumã, Conde, 7°15'32"S, 34°48'18"W; UFPB.MOL.3535, 2 specimens, Tabatinga beach, Conde, 7°19'07"S, 34°48'01"W; UFPB.MOL.3384, 24 specimens, Coqueirinho beach, Conde, 7°19'14"S, 34°47'40"W; UFPB.MOL.2970, 3 specimens, Carapibus beach, Conde, 7°17'59"S, 34°47'54"W; UFPB.MOL.3361, 4 empty shells, Tambaba beach, Conde, 7°21'52"S, 34°47'50"W; UFPB.MOL.3329, 3 specimens, Pedra da Galé, Pitimbú, 7°28'01"S, 34°47'35"W. *State of Rio Grande do Norte:* UFPB.MOL.3536, 1 specimen, Casqueira River estuary, Macau, 5°06'20"S, 36°32'01"W; UFPB.MOL.3519, 4 specimens, Tubarão River estuary, Macau, 5°05'00"S, 36°27'28"W; UFPB.MOL.3520, 1 specimen, Bacopari beach, Baía Formosa, 6°22'20"S, 34°59'34"W; UFPB.MOL.3541, 2 specimens, Upanema beach, Areia Branca, 04°55'48.16"S, 37°07'01.19"W; UFPB.MOL. 3542, 3 specimens, Baixa Grande beach, Areia Branca, 04°55'36.2"S, 37°08'55.4"W; UFPB.MOL. 3543, 3 specimens, Ponta do Mel beach, Areia

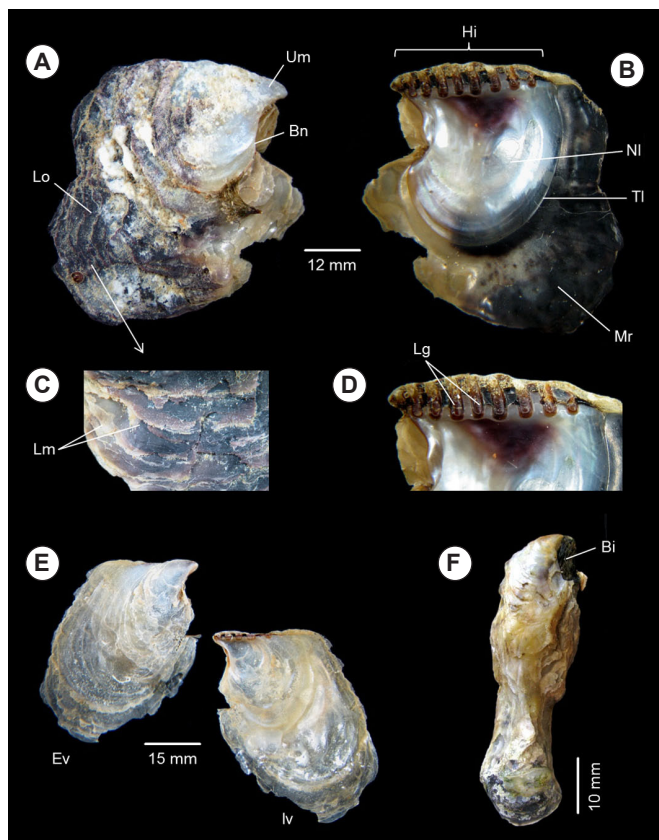
Branca, 04°56'44.3"S, 37°06'27.7"W. *State of Pernambuco:* UFPB.MOL.3544, 1 specimen, Suape Harbor bay, Ipojuca, 8°21'17"S, 34°57'13"W. *State of Alagoas:* UFPB.MOL.3534, 2 specimens, Japaratinga beach, Japaratinga, 9°05'35"S, 35°15'18"W.

Diagnosis – The shell shape is irregular, usually variable according to habitat (Figure 2a,f). More regular individuals somewhat quadrangular as adults (Figure 2a–b). Shell higher than long, slightly inflated, with hinge straight. Ligament multivincular, hinge ornamented with perpendicular grooves (Figure 2b, d). External ornamentation strongly lamellar, giving a flaky appearance to the outer surface of the shell. Outer surface decorated with concentric, irregular, easily fractured, marginal lamellae (Figure 2a,c). Color varies from tones of yellow to blackish-brown, becoming lighter towards the umbo. Valves usually opaque, translucent, when very thin (Figure 2e). Internally, the shell is moderately concave, being covered with a bright, nacreous layer, in which the anterior and posterior abductor muscle scars are located (Figure 2b). This nacreous layer is abruptly delimited by a slightly concave, non-nacorous, transitional line at the shell margin or border (Figure 2b).

Remarks – Records of *Isognomon bicolor* are common along the coastline of the State of Paraíba (Figure 1), including beach rocks from the intertidal region, coral/coralline algal reefs from the shallow infralittoral (up to 7 m in depth) and artificial concrete barriers (Table 1). In

TABLE 1. New record localities for *Isognomon bicolor* from the States of Paraíba, Rio Grande do Norte, Pernambuco and Alagoas, including habitat characteristics and recorded year.

SITE	MUNICIPALITY/STATE	HABITAT CHARACTERISTICS	RECORDED YEAR
Barra de Camaratuba	Mataraca, Paraíba	Beach rocks, under rocks	2008
Baía da Traição	Baía da Traição, Paraíba	Sandstone barrier reef, on crevices and under rocks	2007
Barra de Mamanguape	Rio Tinto, Paraíba	Sandstone barrier reef, on crevices and under rocks	2009
Pier de Cabedelo	Cabedelo, Paraíba	Man-made rocky structure, in crevices	2008
Cabo Branco Beach	João Pessoa, Paraíba	Sandstone reef, under rocks	2007
Jacarapé Beach	João Pessoa, Paraíba	Beach rocks, under rocks and in crevices	2012
Tabatinga Beach	Conde, Paraíba	Sandstone reef, in crevices	2009
Coqueirinho Beach	Conde, Paraíba	Sandstone reef, in crevices	2008
Carapibus Beach	Conde, Paraíba	Sandstone reef, in crevices and under rocks	2008
Tambaba Beach	Conde, Paraíba	Sandstone reef, in crevices	2007
Galé reef	Pitimbu, Paraíba	Coral-algal reef, in crevices and under rocks	2008
Casqueira River estuary	Macau, Rio Grande do Norte	Hypersaline estuary, attached to a pier support	2009
Tubarão River estuary	Macau, Rio Grande do Norte	Hypersaline estuary, on oyster banks	2012
Bacopari Beach	Baía Formosa, Rio Grande do Norte	Sandstone reef, under rocks	2011
Upanema beach	Areia Branca, Rio Grande do Norte	Beach rocks, in crevices, tide pools and under rocks	2012
Baixa Grande beach	Areia Branca, Rio Grande do Norte	Beach rocks, in crevices, tide pools and under rocks	2012
Ponta do Mel beach	Areia Branca, Rio Grande do Norte	Beach rocks, in crevices, tide pools and under rocks	2012
Paraíso beach	Port of Suape bay, Cabo de Santo Agostinho, Pernambuco	In crevices of granitic rocks	2012
Japaratinga Beach	Japaratinga, Alagoas	Sandstone reef, under rocks	2011

**FIGURE 2.** Some characters of *Isognomon bicolor*: a) Outer view of right valve indicating the umbo (Um), bissal notch (Bn) and lamellar ornamentation (Lo). b) Inner view of right valve showing hinge (Hi), inner nacreous layer (NI) and transition line (TI) delimiting nacreous from non-nacreous regions (Mr). c) Detail of outer portion of outer right valve showing lamellar ornamentation (Lo). d) Detail of hinge showing lamellar grooves (Lg). e) Outer (Ev) and inner view (Iv) of right valve from a young specimen, with thin, translucent, shell. f) Outer view of right side of irregular, elongate, specimen, from oyster banks, with indication of byssus (Bi). Photos by Thelma Dias.

all studied areas in the State of Paraíba, individuals of *I. bicolor* were observed in crevices or under rocks (Figure 3a–b). Along the State of Paraíba, *I. bicolor* was visibly most common in reefs of Barra de Mamanguape, Coqueirinho beach and Jacarapé beach (Figure 3a–c).

For the State of Pernambuco, the species was also recorded for the Suape Harbor bay attached to consolidated substrates. For the State of Rio Grande do Norte, the species was recorded in six sites, four of which are beaches with consolidated substrates and two are hypersaline rivers (Table 1). The two specimens from Japaratinga beach, are the first record for this species in the State of Alagoas.

Individuals recorded from the State of Rio Grande do Norte occurred mainly in intertidal beach rocks and in hypersaline estuaries. Salinity of Casqueira River varied from 38 to 50, where *Isognomon bicolor* was observed on a wooden pier. In Tubarão river, located on the outskirts of the Ponta do Tubarão Sustainable Development Reserve, *I. bicolor* was visibly abundant in oyster banks, even though they tended to be mimetically confounded in shape with the oysters themselves. Specimens from these banks presented a distinct size, shape, and color (Figure 2f). These features may be related to the structure of the oyster habitat, in which dense banks normally have narrow and irregular crevices. According to Domaneschi and Martins (2002), specimens are numerous within crevices and cavities, where they show a pronounced elongation of the valves. Along the beaches of the State of Rio Grande do Norte, and at Japaratinga Beach, State of Alagoas, *I. bicolor* was observed under rocks and in crevices of intertidal arenitic beach rocks.

The records of *Isognomon bicolor* in the littoral of the States of Paraíba and Alagoas fill a gap in our knowledge of its distribution along beaches with hard substrates

in Northeastern Brazil. Its presence in other marine ecosystems, such as hypersaline estuaries, reinforces the notion that *I. bicolor* is a broadly distributed and well established species along the Brazilian littoral. Invasive species are considered a threat to the local and global biodiversity, because their high population densities may cause native species to disappear (Breves-Ramos et al. 2010). These authors record alarming densities in Rio de Janeiro, above 1000 individuals per 100cm². Still according to those authors, larger specimens of *I. bicolor* are associated with a high degree of eutrophication of the environment.

In the present study, *Isognomon bicolor* was registered in at least twelve rocky beaches along the littoral of the State of Paraíba, and in six rocky beaches in the States of Alagoas and Rio Grande do Norte, corroborating a preference for rocky intertidal and shallow infralittoral substrates (e.g. Domaneschi and Martins 2002, Oliveira and Creed 2008, Breves-Ramos et al. 2010, Loebmann et al. 2010, López et al. 2010, Zamprogno et al. 2010, Martinez 2012). Yet it should be noted that other biological substrates, such as the fronds of macroalgae may also be colonized by this species (López and Coutinho, 2010). According to these authors, macroalgae of the genus *Sargassum* occurring in areas with *I. bicolor* may facilitate larval settlement or enhance recruitment survival of this bivalve, due to protection against predators. Furthermore, physical conditions prevailing in this microhabitat may diminish thermal stress and desiccation, favoring the survival of individuals. López and Coutinho (2010) suggest that the association of *I. bicolor* with other native species may facilitate the expansion of this species into other habitats.

The presence of *Isognomon bicolor* in hypersaline estuaries in Rio Grande do Norte may be related to the dispersion of larvae by marine currents, but may also have been facilitated by the accumulation of algae torn from their substrates or even by the keels of boats navigating between the sea and the estuary. According to Lenz et al. (2011), exotic marine invertebrates are more tolerant to environmental stresses than taxonomically related native species. When submitted to extreme environmental conditions, the invasive bivalve *I. bicolor* presented higher survival rates than the bivalve *Perna perna* (Lenz et al. 2011). We are unable to infer physiological mechanisms used by *I. bicolor* to adapt to the hypersaline conditions of the Tubarão and Casqueira rivers, but the presence of oyster banks in these areas most likely function as a facilitator for the permanence of *I. bicolor* in the estuarine ecosystem. Oyster banks provide a consolidated substrate necessary for the fixation of individuals. As suggested by Lenz et al. (2011), a broad tolerance for stress is one of the factors that may favor the establishment of exotic species, but not the only one. An interaction of several factors is necessary, including dispersal capacity, larval survival rate, and tolerance to other abiotic factors. The exotic invasive bivalve *Isognomon bicolor* represents one of the most important introductions in the Brazilian marine realm (Ferreira et al. 2009). Studies of its population ecology, biology and of its interactions with other native benthic organisms will be the next important step aiming at the control or eradication of this species.

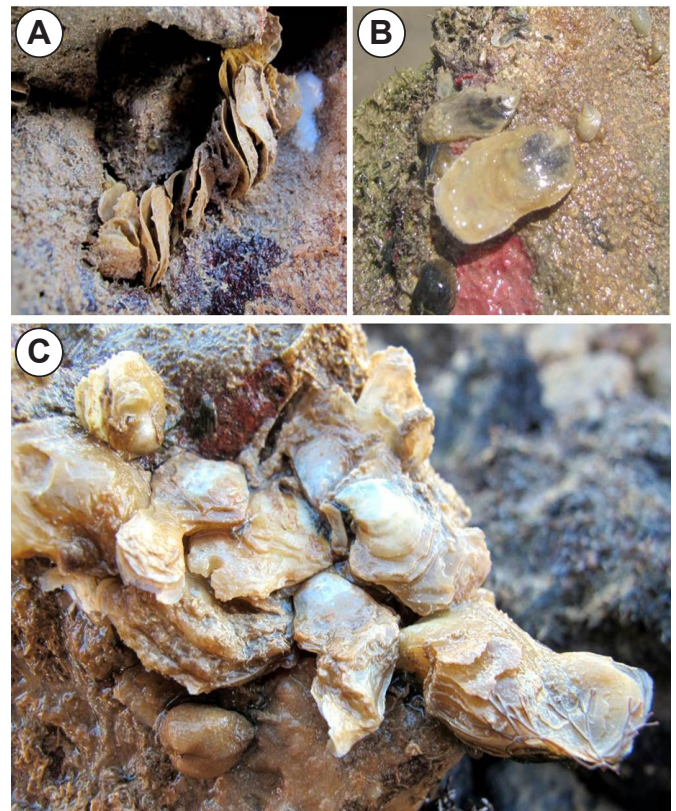


FIGURE 3. Live individuals of *Isognomon bicolor* in natural habitats in the State of Paraíba. a) On crevices in sandstone reefs of Barra de Mamanguape, Rio Tinto, b) Juveniles under a removed rock at Baía da Traição reef, and c) Several individuals attached to rocks at Jacarapé beach. Photos by Thelma Dias.

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Literature Cited

- Breves-Ramos, A., A.O.R. Junqueira, H.P. Lavrado, S.H.G. Silva and M.A.G. Ferreira-Silva. 2010. Population structure of the invasive bivalve on rocky shores of Rio de Janeiro State (Brazil). *Journal of the Marine Biological Association of the United Kingdom* 90(3): 453-459.
- Domaneschi, O. and C.M. Martins. 2002. *Isognomon bicolor* (C. B. Adams) (Bivalvia, Isognomonidae): primeiro registro para o Brasil, redescricao da espécie e considerações sobre a ocorrência e distribuição de *Isognomon* na costa brasileira. *Revista Brasileira de Zoologia* 19(2): 611-627.
- Ferreira, C.E.L., A.O.R. Junqueira, M.C. Villac and R.M. Lopes. 2009. Marine bioinvasions in the Brazilian Coast: brief report on history of events, vectors, ecology, impacts and management of non-indigenous species; p. 459-478 In G. Rilov and J.A. Crooks. (ed.). *Biological Invasions in Marine Ecosystems*. Berlin: Springer-Verlag.
- Huber, M. 2012. *Isognomon bicolor* (C.B. Adams, 1845). Accessed through: World Register of Marine Species at <http://www.marinespecies.org/aphia.php?p=taxdetails&id=420737> on 2012-11-08.
- Lenz, M., Gama, B.A.P., Gerner, N.V., Gobin, J., Gröner, F., Harry, A., Jenkins, S.R., Kraufvelin, P., Mummelthei, C., Sareyka, J., Xavier, E.A. and Wahl, M. 2011. Non-native marine invertebrates are more tolerant towards environmental stress than taxonomically related native species: results from a globally replicated study. *Environmental Research* 111(7): 943-952.

- Loebmann, D., A.C.G. Mai and J.T. Lee. 2010. The invasion of five alien species in the Delta do Parnaíba Environmental Protection Area, Northeastern Brazil. *Revista de Biología Tropical* 58(3): 909-923.
- Lopes, R.M. and M.C. Villac. 2009. Capítulo 2 – Métodos; p. 19-28 In Ministério do Meio Ambiente (ed.). Informe Sobre as Espécies Exóticas Invasoras Marinhas no Brasil. Brasília: Ministério do Meio Ambiente.
- López, M.S. and R. Coutinho. 2010. Positive interaction between the native macroalgae *Sargassum* sp. and the exotic bivalve *Isognomon bicolor*? *Brazilian Journal of Oceanography* 58(special issue II CCBM): 69-72.
- López, M.S., R. Coutinho, C.E.L. Ferreira and G. Rilov. 2010. Predator-prey interactions in a bioinvasion scenario: differential predation by native predators on two exotic rocky intertidal bivalves. *Marine Ecology Progress Series* 403: 101-112.
- Martinez, A.S. 2012. Spatial distribution of the invasive bivalve *Isognomon bicolor* on rocky shores of Arvoredo Island (Santa Catarina, Brazil). *Journal of the Marine Biological Association of the United Kingdom* 92(3): 495-503.
- Matthews-Cascon, H. and C.A. Rocha-Barreira. 2006. Mollusca; p. 113-144 In H. Matthews-Cascon and T.M.C. Lotufo (ed.). *Biota Marinha da Costa Oeste do Ceará*. Série Biodiversidade 24. Brasília: Ministério do Meio Ambiente.
- Mikkelsen, P.M. and R. Bieler. 2008. *Seashells of Southern Florida – Bivalves*. Princeton: Princeton University Press.
- Oliveira, A.E.S. and J.C. Creed. 2008. Mollusca, Bivalvia, *Isognomon bicolor* (C. B. Adams 1845): distribution extension. *Check List* 4(4): 386-388.
- Rocha-Barreira, C.A., H. Matthews-Cascon and A.C.G. Mai. 2010. Moluscos; p. 62-93 In A.C.G. Mai and D. Loebmann (ed.). *Guia Ilustrado: Biodiversidade do Litoral do Piauí*. Sorocaba: Paratodos.
- Silva, E.C. and F. Barros. 2011. Macrofauna bentônica introduzida no Brasil: lista de espécies marinhas e dulcícolas e distribuição atual. *Oecologia Australis* 15(2): 326-344.
- Teixeira, R.M., J.S.P. Barbosa, M.S. López, M.A.G. Ferreira-Silva, R. Coutinho and R.C. Villaça. 2010. Bioinvasão marinha: os bivalves exóticos de substrato consolidado e suas interações com a comunidade receptora. *Oecologia Australis* 14(2): 381-402.
- Zamprognio, G.C., L.F.L. Fernandes and F.C. Fernandes. 2010. Spatial variability in the population of *Isognomon bicolor* (C.B. Adams, 1845) (Mollusca, Bivalvia) on rocky shores in Espírito Santo, Brazil. *Brazilian Journal of Oceanography* 58(1): 23-29.

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