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MOLLUSKS ON RECRUITMENT PANELS PLACED IN AN OFFSHORE HARBOR IN TROPICAL NORTHEASTERN BRAZIL

Moluscos associados a placas de recrutamento instaladas em um porto offshore no Nordeste Tropical Brasileiro

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ABSTRACT

In order to contribute to knowledge of marine fouling communities, the present study analyzed the temporal variation in molluscan communities found on quarterly and annual recruitment panels placed in a seaport area of northeastern Brazil. A set of 30 artificial panels was submerged among pier pillars to a depth of approximately 6 m. Every three months, one subset of 15 panels was removed to examine the biota present. The second subset of 15 panels was left submerged for one year, and then removed for analysis. On the same day that the panels were removed, they were replaced with new panels. Twelve removals/replacements of panels were performed from October 2009 to November 2012. Two classes of Mollusca were found in the recruitment panels: Gastropoda and Bivalvia. Thirty taxa were found in the quarterly panels, and 23 taxa in the annual panels. Two non-native species of the Brazilian coast were found: *Isognomon bicolor* and *Eualetes tulipa*. In the quarterly panels, the most abundant and common species found was the oyster *Crassostrea brasiliana* and the most abundant species found in the annual panels was *Musculus lateralis*.

Keywords: artificial substrates; Bivalvia; Gastropoda; seaport area; temporal changes.

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RESUMO

Como o objetivo de contribuir para o conhecimento das comunidades marinhas incrustantes, o presente estudo analisou a variação temporal em comunidades de moluscos encontradas em placas de recrutamento trimestrais e anuais instaladas em uma região portuária no nordeste do Brasil. Um conjunto de 30 placas artificiais foi submerso entre os pilares do píer a uma profundidade aproximada de 6 m. A cada três meses, um subconjunto de 15 placas era removido para o exame da biota presente. O segundo subconjunto de 15 placas foi deixado submerso por um ano, e depois removido para análise. No mesmo dia em que as placas eram removidas, elas eram substituídas por novas placas. Doze remoções/reposições de placas foram realizadas de outubro de 2009 a novembro de 2012. Duas classes de Mollusca foram encontradas nos painéis de recrutamento: Gastropoda e Bivalvia. Trinta táxons foram encontrados nas placas trimestrais e 23 táxons nas placas anuais. Duas espécies não-nativas da costa brasileira foram encontradas: Isognomon bicolor *e* Eualetes tulipa. *Nas placas trimestrais, a espécie mais comum e abundante foi a ostra* Crassostrea brasiliana *e a espécie mais abundante nas placas anuais foi o bivalve* Musculus lateralis.

Palavras-chaves*: substratos artificiais; Bivalvia; Gastropoda; área portuária; variações temporais.*

INTRODUCTION

The structure and dynamic of a biological community cannot be understood without extensive knowledge of the ecology of the species belonging to the particular area of study. The structure of marine communities can be controlled by the supply of larvae and by the success of larval settlement, both of which are important factors in explaining species fluctuations in space and time (Lewis, 1964; Underwood, 1979; Moore & Seed, 1986).

Pelagic larval life consists of three stages: the first is the developmental period where dispersion and feed may or may not occur; the second is the stage in which the substrate can be tested for possible settlement; and the third is the stage in which recruitment occurs (Underwood, 1979; Pechenik, 1999). A considerable variety of stimuli can be involved in the selection of the substrate on which the animal will settle. Responses to physical, chemical, and biochemical features, which attract the larvae to a particular habitat, are the factors that cause spatial variations in the number of larval settlements. Responses to physical, chemical, and biochemical stimuli from adults of their own species or related species result in a settlement of larvae in occupied or previously occupied areas (Underwood, 1978; 1986; Anderson & Underwood, 1994).

The assemblage of invertebrate species comprising marine fouling communities occurs on artificial and natural substrates and is typically widespread (Karlson & Osman, 2012). These communities are composed primarily of sessile, filter-feeding invertebrates and mobile epifauna such as ascidians, bryozoans, hydroids, sponges, crustaceans, and mollusks (Nydam & Stachowicz, 2007). Artificial substrates, such as recruitment panels, are widely used to monitor marine fouling communities, describe spatial and temporal patterns and predator effects to determine the composition of the fouling community, and detect the presence of non-native species (*e.g.* Nydam & Stachowicz, 2007; Broitman *et al.*, 2008; Bumbeer & Rocha, 2012; Fernandez *et al.*, 2014; García-Sanz *et al.*, 2014).

In order to contribute to knowledge of marine fouling communities, the present study analyzed the temporal variation in molluscan communities found on the quarterly and annual recruitment panels placed in a seaport area of northeastern Brazil.

MATERIALS AND METHODS

Terminal Portuário do Pecém (3°30′ S, 39°50′ W) is an offshore seaport, located on the west coast of Ceará in northeastern Brazil. A set of 30 sampling units (panels) was submerged among pillars of the pier at an approximately 6 m depth, consisting of two 10 x 10 cm polyethylene plates arranged in parallel with a 2 cm gap between them.

Every three months, one subset of 15 panels was removed in order to examine the biota present. The second subset of 15 panels was left submerged for one year and then removed for analysis after that period. All removed panels were replaced by new ones on the same day as the removal of the old ones. Twelve removals/replacements of the panels were performed (twelve collections of the quarterly panels equaling 180 samples; three collections of the annual plates equaling 45 samples) from October 2009 to November 2012.

The samples were stored in labeled plastic bags and conserved in 70% ethanol. The mollusks were separated under a compound microscope and preserved in 70% ethanol. They were identified to the lowest possible taxonomic level using the appropriate references. It should be noted that empty shells were not considered in the analysis of this study.

All collected material was incorporated into the Malacological Collection "Prof. Henry Ramos Matthews" - series B of the Universidade Federal do Ceará (CMPHRM-B/UFC).

Geographical distribution, natural habitats, and feeding habits of the collected species were determined from a secondary database (*e.g.* Rios, 1994; 2009; Rosenberg *et al.*, 2009).

RESULTS

Species composition, abundance, and temporal frequency

Two classes of Mollusca were found in the recruitment panels: Gastropoda (22 taxa) and Bivalvia (12 taxa). Fourteen taxa (2 bivalves and 12 gastropods) could not be identified at the species level due to their small size, as a result of being newly metamorphosed or very young individuals (Table I). Among the 20 species identified at specific levels, two are non-native species of the Brazilian coast - *Isognomon bicolor* (C. B. Adams, 1845) and *Eualetes tulipa* (Rousseau in Chenu, 1843).

Thirty taxa were found in the quarterly panels (eight with temporal frequency above 50%) and 23 taxa in the annual panels (11 with temporal frequency above 50%) (Table I). Of 34 taxa found, 19 (55.88%) occurred in both the quarterly and the annual samples, 11 (32.35%) were only recorded in the quarterly panels, and four (11.77%) were exclusive to the annual plates (Table I).

In the quarterly panels, the most abundant and common species was the oyster *Crassostrea brasiliana* (Lamarck, 1819) (1,700 specimens; 100% temporal frequency). However, this species was only the fifth most abundant species in the annual plates (54 individuals; 100% temporal frequency). The second most abundant species in the quarterly plates was the bivalve *Musculus lateralis* (Say, 1822) (1,482 specimens; 100% temporal frequency). *Musculus lateralis* was also the most abundant species in the annual panels (1,237 specimens; 100% temporal frequency). Gastropods of the family Columbellidae

[*Anachis veleda* (Duclos, 1846), *Anachis isabellei* (d'Orbigny, 1839), and *Mitrella pusilla* (Sowerby, 1844)] were also common species in the quarterly and annual plates (Table I).

Regarding the non-native species, six specimens of *I. bicolor* occurred in the recruitment panels (five in the quarterly plates and one in the annual plates), and five specimens of *Eualetes tulipa* were found in the annual plates (Table I).

Table I - Molluscan species recorded on recruitment panels placed in the offshore harbor at Terminal Portuário do Pecém (NE Brazil) from October 2009 to November 2012; their respective abundance and temporal frequencies on 3-month and 1-year samples.

	Quarterly panels		Annual panels	
Class/Species	**Total abundance**	**Temporal frequency (n= 12)**	**Total abundance**	**Temporal frequency (n= 3)**
Bivalvia	**3,427**	**100%**	**1,511**	**100%**
Crassostrea brasiliana (Lamarck, 1819)	1,700	100%	54	100%
Musculus lateralis (Say, 1822)	1,482	100%	1,237	100%
Sphenia fragilis (H. Adams & A. Adams, 1854)	112	67%	150	100%
Chlamys sp.	41	58%	35	67%
Diplodonta nucleiformis (W. Wagner, 1840)	39	17%	3	67%
Diplodonta punctata (Say, 1822)[a]	17	25%		
Arca imbricata Bruguière, 1789	17	25%	16	67%
Entodesma brasiliense (Gould, 1850)	8	8%	10	33%
Isognomon bicolor (C. B. Adams, 1845)	5	17%	1	33%
Pinctada imbricata Röding, 1798	3	25%	4	33%
Pteria hirundo (Linnaeus, 1758)[a]	3	17%		
Chama sp.[a]			1	33%
Gastropoda	**716**	**100%**	**339**	**100%**
Mitrella pusilla (Sowerby, 1844)	342	83%	63	67%
Anachis isabellei (d'Orbigny, 1839)	127	58%	17	33%
Anachis veleda (Duclos, 1846)	122	83%	36	100%
Caecum sp.	61	75%	123	100%
Marionia limceana Silva, Meirelles & Matthews-Cascon, 2013	16	42%	5	33%
Turbonilla sp.	9	33%	6	67%
Lamellaria sp.[a]	8	33%		
Vitreolina arcuata (C. B. Adams, 1850)	6	8%	1	33%
Fissurella sp.	4	8%	3	33%
Cyclostremiscus sp.	3	8%	40	67%
Aeolidiidae species 1[a]	3	8%		
Astraea sp.[a]	2	8%		
Cymatium sp.[a]	2	8%		
Bittiolum varium (Pfeiffer, 1840)[a]	2	8%		
Crepidula sp.[a]	2	8%		
Luria cinerea (Gmelin, 1791)[a]	1	8%		
Stramonita brasiliensis Claremont & D. G. Reid, 2011[a]	1	8%		
Facelinidae species 1[a]	1	8%		
Haminoea elegans (Gray, 1825)	1	8%	13	33%
Doto sp.[a]			21	33%
Diodora sp.[a]			4	33%
Eualetes tulipa (Rousseau in Chenu, 1843)[a]			5	33%

[a]Exclusive species of the quarterly or the annual panels.

Ecological and geographical data of species

Among gastropods, the most representative feeding habit was carnivore (10 species), followed by grazer (5), herbivore (3), parasitic (2), and suspension feeder (2) (Table II). All bivalves found are filter feeders.

All individuals identified at the species level were previously reported on the coast of Ceará (Table III).

Table II - Gastropod species recorded from October 2009 to November 2012 at Terminal Portuário do Pecém (NE Brazil) and their respective feeding habits.

Species	Feeding habits
Anachis veleda, *Anachis isabellei*, *Mitrella pusilla*, *Lamellaria* sp., *Cymatium* sp., *Stramonita brasiliensis*, *Marionia limceana*, *Doto* sp., Aeolidiidae species 1, Facelinidae species 1	Carnivore
Luria cinerea, *Bittiolum varium*, *Caecum* sp., *Cyclostremiscus* sp., *Haminoea elegans*	Grazer
Diodora sp., *Fissurella* sp., *Astraea* sp.	Herbivore
Turbonilla sp., *Vitreolina arcuata*	Parasitic
Eualetes tulipa, *Crepidula* sp.	Suspension feeder

Table III - Geographical distribution and natural habitats of molluscan species recorded on recruitment panels placed in the offshore harbor at Terminal Portuário do Pecém (NE Brazil) from October 2009 to November 2012. Legend: *Non-native species.

Class/Species	Geographical distribution	Natural habitats
Bivalvia		
Crassostrea brasiliana (Lamarck, 1819)	Brazil (Ceará to Santa Catarina)[a]	rocky coasts and mangroves[a]
Musculus lateralis (Say, 1822)	N. Carolina to Florida, Texas, Mexico, Caribbean to Brazil (Ceará, Pernambuco to Santa Catarina; Trindade Is.)[b,c]	host of ascidians[b,d]
Sphenia fragilis (H. Adams & A. Adams, 1854)	Texas, Puerto Rico, Surinam, Brazil (Ceará to Santa Catarina)[b]	worn burrows, oyster and mussel colonies[b]
Diplodonta nucleiformis (W. Wagner, 1840)	N. Carolina to Florida, Caribbean, Brazil[b]	sandy and coral substrates[b]
Diplodonta punctata (Say, 1822)	Bermuda, N. Carolina to Florida, Caribbean, Brazil (Amapá to São Paulo, Fernando de Noronha) to Magellanic Region and Chiloé Is. (Chile)[b,e]	sandy and mud-sandy bottoms[e]
Arca imbricata Bruguière, 1789	N. Carolina to Florida, Texas, Caribbean, Venezuela, Surinam, Brazil (Pará to Santa Catarina, Fernando de Noronha)[b]	rocks and corals[b]
Entodesma brasiliense (Gould, 1850)	Bermuda, N. Carolina to Florida, Caribbean, Brazil (Amapá to Rio de Janeiro)[b]	sponges and tunicates[b]
Pinctada imbricata Röding, 1798	Bermuda, N. Carolina to Florida, Texas, Caribbean, Venezuela, Brazil (Pará to Santa Catarina)[2]	rocks, corals, and mangrove roots[2]
Pteria hirundo (Linnaeus, 1758)	Bermuda, N. Carolina to Florida, Texas, Caribbean, Venezuela, all Brazilian coast[b]	gorgonians, buoys and dead shells[b]
Isognomon bicolor (C. B. Adams, 1845)*	Bermuda, Florida to Texas, Caribbean, Venezuela, Brazil (Piauí to Santa Catarina; Atol das Rocas)[b,f,g,h,i]	rocks, corals, calcareous algae and magrove roots[b,f,g,h,i]
Gastropoda		
Mitrella pusilla (Sowerby, 1844)	Bermuda, N. Carolina to Florida, Texas, Caribbean, Brazil (Ceará to Santa Catarina, Abrolhos Is., Vitória Seamount)[b]	sand, *Sargassum* weeds[b]
Anachis isabellei (d'Orbigny, 1839)	Brazil (NE Brazil and Rio Grande do Sul) to Argentina (Golfo S. Matias)[b]	sandy bottoms[b]
Anachis veleda (Duclos, 1846)	Costa Rica to Panamá, Cuba, Central America to Brazil (Ceará to Santa Catarina)[b]	under rocks near algae[b]
Marionia limceana Silva, Meirelles & Matthews-Cascon, 2013	Ceará to Rio Grande do Norte (northeast Brazil)[j]	octocorals[j]

(continuation of Table III)

Vitreolina arcuata (C. B. Adams, 1850)	N. Carolina to Florida, Texas, Jamaica, Brazil (Ceará, São Paulo to Rio Grande do Sul)[b,c]	ectoparasitic on echinoderms[b]
Bittiolum varium (Pfeiffer, 1840)	N. Carolina to Florida, Texas, Caribbean, all Brazilian coast[b]	algae, marine grass[b]
Luria cinerea (Gmelin, 1791)	Bermuda, N. Carolina to Florida, Caribbean, Northern South America, Brazil (Amapá to Cabo Frio - RJ, Atol das Rocas, Fernando de Noronha Is., Abrolhos, Trindade Is. and seamounts), Ascension Is.[b]	sand, rocks and coral reefs[b]
Stramonita brasiliensis Claremont & D. G. Reid, 2011	Lesser Antilles (Trinidad, Tobago, Dominica, St. Thomas), Venezuela to Uruguay, Fernando de Noronha and Trindade Is.[k]	rocky shores[k]
Haminoea elegans (Gray, 1825)	Mediterranean Sea, Portugal, Marocco, Sta. Helena Is., N. Bermuda, Florida, Texas, Caribbean, Brazilian coast (Ceará, Alagoas to Santa Catarina)[b,l]	muddy bottoms[b]
Eualetes tulipa (Rousseau in Chenu, 1843) *	Florida, Costa Rica, Panama, Hawaii, Venezuelan Caribbean, Brazil (Ceará, Rio Grande do Norte, and Rio de Janeiro); India[m]	artificial (monobuoys, breakwaters, pillars, and offshore port) or natural (rocky reefs) substrates[m]

References: [a]Amaral & Simone (2014); [b]Rios (1994; 2009); [c]Veras *et al*. (2013); [d]Cañete & Rocha (2013); [e]Domaneschi (1979); [f]Domaneschi & Martins (2002); [g]Franklin-Jr. *et al.* (2005); [h]Loebmann *et al.* (2010); [i]Dias *et al.* (2013); [j]Silva *et al.* (2013); [k]Claremont *et al.* (2011); [l]Galvão-Filho *et al.* (2015); [m]Spotorno-Oliveira *et al.* (2017).

DISCUSSION

The richness of mollusks, the number of newly metamorphosed or very young individuals, and the variety of feeding habits found in this study show that the recruitment panels provide a microhabitat able to support different trophic guilds. Research using these same recruitment panels, conducted by Paiva (2013) and Fernandez *et al*. (2015), reinforce the evident richness of this habitat. Paiva (2013) found great coverage percentages of ascidians and bryozoans, as well as other groups, such as polychaete worms, sponges, hydroids, bivalves, octocorals, barnacles, and anemones. Also, Fernandez *et al*. (2015) studied the temporal patterns in richness and composition of benthic cnidarian assemblage.

The majority of gastropods found are mobile or semi-sessile organisms, and their presences are due to the availability of food in the recruitment panels. Columbellidae is a very diverse family and contains species that are either herbivorous or carnivorous (Marcus & Marcus, 1962; Bandeira *et al*., 2014). The representative abundance of Columbellidae, as well as the considerable number of carnivorous species, found in the recruitment panels maybe due to the presence of sessile animals such as tunicates and sponges that are their prey. The parasitic gastropod *Turbonilla* sp. belongs to the Pyramidelloidea, comprising the ectoparasites of bivalves and polychaetes (Rios, 1994), while *Vitreolina arcuata* belongs to Eulimidae, a family of very small parasitic sea snails in echinoderms and other marine animals (Warén, 1992; Rios, 1994).

On the other hand, the great number of bivalve taxa found is related to the different strategies allowing them to inhabit the recruitment panels. *Isognomon bicolor*, *Pinctada imbricata*, *Pteria hirundo*, *Chlamys* sp., and *Arca imbricata* have a byssus (a bundle of proteinaceous filaments secreted by a gland on the foot), which allows them to colonize hard surfaces. The remaining species of bivalves directly settled on the recruitment panels

(e.g., *Crassostrea brasiliana*) or drilled into the fouling animals (mainly ascidians) to settle (e.g., *Musculus lateralis*, *Diplodonta nucleiformis*, *Diplodonta punctata*, *Sphenia fragilis*, and *Entodesma brasiliense*).

The great abundance of *Musculus lateralis*, found in this study, can be explained by the high coverage percentage of its hosts (ascidians) on the recruitment panels. Cañete & Rocha (2013) also reported this interaction between *M. lateralis* and ascidians. Another species commonly found in tunicates as well as sponges, *Entodesma brasiliense*, was also found in this study (Rios, 1994).

Throughout the study, it was observed that the oyster *C. brasiliana* settled in the recruitment panels, and over time, was covered by other fouling organisms, especially ascidians. This recoating caused the death of these bivalves. Several covered shells were found in the annual plates, but they were not counted due to they were no longer alive at the time of collection (only shells existed with no soft tissue). This may explain the greater abundance of *C. brasiliana* in the quarterly plates than in the annual ones.

The presence of *I. bicolor*, one of the non-native species found in this study, is well documented in Brazil (Breves-Ramos *et al*., 2010; Dias *et al*., 2013). This is an invasive species found in hard substrates all along the Brazilian coast; it was originally distributed in the Caribbean (Domaneschi & Martins, 2002; Dias *et al*., 2013). Domaneschi & Martins (2002) believe that the arrival of this species in Brazil occurred between 1970 and 1980 because previous malacological surveys did not record the presence of *I. bicolor* on the Brazilian coast. The first records of *I. bicolor* in the intertidal rocky shore of the coast of Ceará were made by Franklin-Jr. *et al.* (2005) on eight beaches, including Pecém Beach, where Terminal Portuário do Pecém is located.

Spotorno-Oliveira *et al*. (2017) just recently confirmed the presence of *Eualetes tulipa* in the Brazilian coast. These authors discuss the first documented occurrence of this species in Brazil, which was in 2005 at Ceará State (NE), and its register in the Rio de Janeiro (SE) four years later. The impact on the native benthic community of Brazilian coast is still unknown, but Spotorno-Oliveira *et al.* (2017) found *E. tulipa* growing on artificial substrates and also on sandstone fringing reefs and rocky reefs, coexisting with the native species *Petaloconchus varians* (d'Orbigny, 1839).

The record of only two species of non-native molluscs in this study may be related to the offshore location of the Terminal Portuário do Pecém. Wasson *et al.* (2005) carried out a marine invasion investigation of central California, and their results revealed that the absolute number of exotic species in the estuary was an order of magnitude higher than that along the open coast. According to them, possible reasons for this were differential transport processes between the two types of marine habitats, numbers of propagules (introduction rates), retention rates, and resistance due to the markedly greater species richness of open coast versus estuaries. Bumbeer & Rocha (2012) reported the presence of nine introduced species out of a total of 40 in an area on the inner continental shelf under the influence of the large estuarine complex. Among explanations given by the authors for their detection were the influence of the nearby estuary with an international port where most of the introduced species had been reported and the proximity of the study area to the route of ships entering the port.

The placement of recruitment panels was shown to be an efficient methodology for the study of mollusk species recruitment. This reinforces their role in the monitoring of port areas.

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REFERENCES

Amaral, V.S. & Simone, L.R.L. Revision of genus *Crassostrea* (Bivalvia: Ostreidae) of Brazil. *J. Mar. Biol. Assoc. UK*, Londres, v.94, p.811–836, 2014.

Anderson, M.J. & Underwood, A.J. Effects of substratum on the recruitment and development of an intertidal estuarine fouling assemblage. *J. Exp. Mar. Biol. Ecol.*, Amsterdam, v.184, p.217–236, 1994.

Bandeira, E.V.P.; Rabay, S.G. & Matthews-Cascon, H. Sexually dimorphic radular morphology in *Columbella mercatoria* (Mollusca: Gastropoda: Columbellidae). *Arq. Ciênc. Mar*, Fortaleza, v.47, p.78–82, 2014.

Breves-Ramos, A.; Junqueira, A.O.R; Lavrado, H.P.; Silva, S.H.G. & Ferreira-Silva, M.A.G. Popopulation structure of the invasive bivalve *Isognomon bicolor* on rocks shores of Rio de Janeiro State (Brazil). *J. Mar. Biol. Assoc. UK*, Londres, v.90, p.453–459, 2010.

Broitman, B.R.; Blanchette, C.A.; Menge, B.A.; Lubchenco, J.; Krenz, C.; Foley, M.; Raimondi, P.T.; Lohse, D. & Gaines, S.D. Spatial and temporal patterns of invertebrate recruitment along the west coast of the United States. *Ecol. Monogr.*, Washington DC, v.78, p.403–421, 2008.

Bumbeer, J.A. & Rocha, R.M. Detection of introduced sessile species on the near shore continental shelf in southern Brazil. *Zoologia*, Curitiba, v.29, n.2, p.126–134, 2012.

Cañete, J.I. & Rocha, R.M. *Modiolarca lateralis* (Pteryomorphia: Mytilidae): bivalve associated to six species of ascidians from Bocas del Toro, Panama. *Latin Am. J. Aquat. Res.*, Valparaíso, v.41, p.1030–1035, 2013.

Claremont, M.; Williams, S.T.; Barraclough, T.G. & Reid, D.G. The geographic scale of speciation in a marine snail with high dispersal potential. *J. Biogeogr.*, Medford, v.38, p.1016–1032, 2011.

Dias, T.L.P.; Mota, E.L.S.; Gondim, A.I.; Oliveira, J.M.; Rabelo, E.F.; Almeida, S.M. & Christoffersen, M.L. *Isognomon bicolor* (C.B. Adams, 1845) (Mollusca: Bivalvia): First record of this invasive species for the State of Paraíba and Alagoas and new records fot other localities of Northeastern Brazil. *Check List*, São Paulo, v.9, p.157–161, 2013.

Domaneschi, O. Aspectos da biologia de *Diplodonta punctata* (Say, 1822) (Bivalvia – Lucinacea – Ungulinidae). *Rev. Nord. Biol.*, João Pessoa, v.2, p.21–25, 1979.

Domaneschi, O. & Martins, C.M. *Isognomon bicolor* (C.B. Adams) (Bivalvia, Isognomonidae): primeiro registro para o Brasil, redescrição da espécie e considerações

sobre a ocorrência e distribuição de *Isognomon* na costa brasileira. *Rev. Bras. Zool.*, Curitiba, v.19, p.611–627, 2002.

Fernandez, M.O.; Navarrete, S.A. & Marques, A.C. Temporal variation in richness and composition of recruits in a diverse cnidarian assemblage of subtropical Brazil. *J. Exp. Mar. Biol. Ecol.*, Amsterdam, v.460, p.144–152, 2014.

Fernandez, M.O.; Navarrete, S.A. & Marques, A.C. A comparison of temporal turnover of species from benthic cnidarian assemblages in tropical and subtropical harbours. *Mar. Biol. Res.*, Norway, v.11, p.492–503, 2015.

Franklin-Jr., W.; Matthews-Cascon, H.; Bezerra, L.E.A.; Meirelles, C.A.O. & Soares, M.O. *Macrofauna bentônica de ambientes consolidados no Estado do Ceará - região entremarés de praias rochosas.* Relatório Científico do Projeto de Zoneamento Ecológico Econômico do Litoral do Ceará – ZEE, SEMACE/FCPC/LABOMAR-UFC, 111p., Fortaleza, 2005.

Galvão-Filho, H.C.; Araújo, A.K.; Silva, F.V.; Azevedo, V.M.D.; Meirelles, C.A.O. & Matthews-Cascon, H. Sea slugs (Gastropoda: Heterobranchia) from a poorly known area in North-east Brazil: filling gaps in Atlantic distributions. *Mar. Biodiv. Rec.*, Londres, v.8, p.e115, 2015.

García-Sanz, S.; Navarro, P.G. & Tuya, F. Colonization of prosobranch gastropods onto artificial substrates: seasonal patterns between habitat patches. *Am. Malacol. Bull.*, Washington DC, v.32, p.94–103, 2014.

Karlson, R.H. & Osman, R.W. Species composition and geographic distribution of invertebrates in fouling communities along the east coast of the USA: a regional perspective. *Mar. Ecol. Prog. Ser.*, Amsterdam, v.458, p.255–268, 2012.

Lewis, J.R. *The ecology of rocky shores*. The English Universities Press LTD, XII + 323p., Londres, 1964.

Loebmann, D.; Mai, A.C. & Lee, J.T. The invasion of five alien species in the Delta do Parnaíba Environmental Protection Area, Northeastern Brazil. *Rev. Biol. Trop.*, San José, v.58, p.909–923, 2010.

Marcus, E. & Marcus, E. Studies on Columbellidae. *Bol. Univ. São Paulo.*, São Paulo, v.261, p.335–402, 1962.

Moore, P.G. & Seed, R. *The ecology of rocky coasts.* Columbia University Press, 467p., New York, 1986.

Nydam, M. & Stachowicz, J.J. Predator effects on fouling community development. *Mar. Ecol. Prog. Ser.*, Amsterdam, v.337, p.93–101, 2007.

Paiva, A.B. *Estudo comparativo das assembleias de ascídias em duas regiões portuárias da costa brasileira.* Dissertação de Mestrado, Programa de Pós-Graduação em Ciências marinhas Tropicais, Universidade Federal do Ceará, 87p., Fortaleza, 2013.

Pechenik, J.A. On the advantages and disadvantages of larval stages in benthic marine invertebrate life cycle. *Mar. Ecol. Prog. Ser.*, Amsterdam, v.177, p.269–297, 1999.

Rios, E.C. *Seashells of Brazil*, 2ª. ed., Fundação da Universidade do Rio Grande, 481p., Rio Grande, 1994.

Rios, E.C. *Compendium of Brazilian Sea Shells*. Editora Evangraf, 720p., Rio Grande, 2009.

Rosenberg, G.; Moretzsohn, F. & García, E.F. Gastropoda (Mollusca) of the Gulf of Mexico, p.579–700, *in:* Felder, D.L. & Camp, D.K. (eds.), *Gulf of Mexico: origin, waters, and biota* - vol. 1, Biodiversity. Texas A&M University Press, 393p., Texas, 2009.

Silva, F.V.; Meirelles, C.A.O. & Matthews-Cascon, H. A new species of *Marionia* (Opisthobranchia: Nudibranchia: Tritoniidae) from the tropical South Atlantic Ocean. *J. Mar. Biol. Assoc. UK*, Londres, v.93, p.1617–1624, 2013.

Spotorno-Oliveira, P.; Coutinho, R. & Tâmega, F.T.S. Recent introduction of non-indigenous vermetid species (Mollusca, Vermetidae) to the Brazilian coast. *Mar. Biodiv.*, Londres, doi:10.1007/s12526-017-0702-7, 2017.

Underwood, A.J. A refutation of critical tidal levels as determinants of the structure of intertidal communities on british shores. *J. Exp. Mar. Biol. Ecol.*, Amsterdam, v.33, p.261–276, 1978.

Underwood, A.J. The ecology of intertidal gastropods. *Adv. Mar. Biol.*, Flórida, v.16, p.11–210, 1979.

Underwood, A.J. Physical factors and biological interactions: the necessity and nature of ecological experiments, p.372–373, in Moore, P.G. & Seed, R. (eds.), *The Ecology of Rocky Coasts.* Columbia University Press, 467p., New York, 1986.

Veras, D.R.A.; Martins, I.X. & Matthews-Cascon, H. Mollusks: How are they arranged in the rocky intertidal zone? *Iheringia, Ser. Zool.*, Porto Alegre, v.103, p.97–103, 2013.

Warén, A. Comments on and descriptions of eulimid gastropods from Tropical West America. *The Veliger*, Berkeley, v.35, p.177–194, 1992.

Wasson, K.; Fenn, K. & Pearse, J.S. Habitat differences in marine invasions of central California. *Biol. Invasions*, Knoxville, v.7, p.935–948, 2005.