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The first finding of *Ostrea* cf. *puelchana* (Bivalvia) living as epibiont on *Callinectes exasperates* (Decapoda)

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ABSTRACT. This paper describes the epibiosis of *Ostrea* cf. *puelchana* on *Callinectes exasperatus* (Gerstaecker, 1856), both collected from the estuary of the Paraíba River, in the state of Paraíba, northeastern Brazil. The basibiont crab was captured using a trap installed in mangrove area at a depth of about 2 meters. The oyster was closely attached to the left side of dorsal carapace covering most of the epibranchial, mesobranchial and metabranchial regions. Possible advantages and disadvantages for both the epibiont and the basibiont are discussed. We believe that young *O.* cf. *puelchana* may avoid a variety of potential predators due to the considerable movement capacity of *C. exasperatus* and may also serve as a small protective shield for the basibiont. However, the oyster, which is a bivalve with an epifaunal lifestyle, is likely to be negatively affected, mainly due to burrowing activity of the crab. This is the first record of epibiosis between bivalves of the genus *Ostrea* Linnaeus, 1758 and crabs of the genus *Callinectes* Stimpson, 1860.

Keywords: Brachyura, mangrove, marine invertebrates, Mollusca, Pteriomorphia, South America.

Primeiro registro de *Ostrea* cf. *puelchana* (Bivalvia) vivendo como epibionte sobre *Callinectes exasperates* (Decapoda)

RESUMO. O presente estudo descreve a epibiose de *Ostrea* cf. *puelchana* sobre *Callinectes exasperatus* (Gerstaecker, 1856), ambos coletados no estuário do Rio Paraíba, no estado da Paraíba, nordeste do Brasil. O caranguejo basibionte foi capturado usando uma armadilha instalada em área de mangue em cerca de 2 metros de profundidade. A ostra estava fixada sobre o lado esquerdo da carapaça dorsal cobrindo grande parte das regiões epibranquial, mesobranquial e metabranquial. Possíveis vantagens e desvantagens para ambos epibionte e basibionte são discutidas. O espécime jovem de *O.* cf. *puelchana* pode evitar uma variedade de predadores potenciais devido à considerável capacidade de deslocamento de *C. exasperatus*, ao mesmo tempo, essa espécie pode atuar como um escudo protetor para o basibionte. Entretanto, o ostreídeo possui um estilo de vida epifaunal, podendo ser afetado de forma negativa, principalmente devido à atividade de escavação do caranguejo. Este é o primeiro registro de epibiose entre bivalves do gênero *Ostrea* Linnaeus, 1758 e caranguejos do gênero *Callinectes* Stimpson, 1860.

Palavras-chave: Brachyura, manguezal, invertebrados marinhos, Mollusca, Pteriomorphia, América do Sul.

Introduction

Epibiosis is a spatially close, facultative association between two living organisms in which the epibiont lives attached to the surface of a basibiont used as a substrate for support during the sessile period of the life cycle (Harder, 2009; Fernandez-Leborans, 2010; Romero, Brezina, Hernández, Casadío, & Bremec, 2013; Azevedo, Brandão, Abdallah, & Silva, 2014). This non-symbiotic relationship can provide a variety of potential benefits or negative impacts for the epibiont and/or basibiont (Wahl, 1989; Wahl & Mark, 1999; Fernandez-Leborans, 2010; Machado, Sanches, Fortuna, & Costa, 2013). Unlike what occurs with symbiosis, species-specific, obligate epibionts are rare and the majority of epibiotic associations are therefore classified as facultative (Wahl & Mark, 1999).

Many groups of marine invertebrates (e.g., annelids, bryozoans, cnidarians, crustaceans, mollusks, polychaetes, poriferans etc.) are recognized as epizoans on a wide variety of other mobile and

sessile invertebrates, mainly crustaceans, xiphosurans and mollusks (see Mori & Manconi, 1990; Gili, Abello, & Villanueva, 1993; Key, Jeffries, Voris, & Yang, 1996; Villegas, Stotz, & Laudien, 2005; Fernandez-Leborans, 2010; Farrapeira & Calado, 2010; Lima, Queiroz, Bravo de Laguna, & Mioso, 2014; Lima, Queiroz, Oliveira, Christoffersen, & Guimarães, 2016; Machado et al., 2013; Romero et al., 2013).

Bivalves are known to have a multitude of lifestyles: free-living (Morton, 1973; Lützen & Nielsen, 2005), commensal (Goto, Hamamura, & Kato, 2007), mutualist (Mokady, Loya, & Lazar, 1998), epizoic (Villegas et al., 2005) or parasitic (Malard, 1903). Members of the family Ostreidae Rafinesque, 1815 are among the sessile marine invertebrates that live on a variety of abiogenic and biogenic substrates (Slack-Smith, 1998; Fernandez-Leborans, 2010). These bivalves have been reported specifically as epizoans on mangrove roots, gorgonians, corals (Slack-Smith, 1998), decapod crustaceans (Fernandez-Leborans, 2010) and other mollusks (Cope, 1968; Eschweile & Buschbaum, 2011; Zell, Beckmann, & Stinnesbeck, 2014).

In February 2016, a specimen of *Ostrea* cf. *puelchana* (*in vivo*) was found cemented to the carapace of a crab of the species *Callinectes exasperatus* (Gerstaecker, 1856). The brachyuran was captured during a study on molluscan and crustacean fauna in the estuary of the Paraiba River, in the state of Paraíba (northeastern Brazil). *Ostrea* cf. *puelchana* inhabits subtidal waters attached to a variety of hard substrates (Rios, 2009). *Callinectes exasperatus* is a euryhaline crab that inhabits intertidal and shallow subtidal zones to dephts of about 8 m, including estuaries near river mouths and mangroves (Melo, 1996; Carvalho & Couto, 2011), as a deposit feeder or preying on other invertebrates (Carvalho & Couto, 2011). Both have widespread distribution throughout the Atlantic coast of South America. However, there is no previous mention of epibiosis between the two species in the literature. Thus, the epibiosis of the oyster *Ostrea* cf. *puelchana* on the crab *C. exasperates* is recorded for the first time herein and the probable consequences of this relationship are discussed.

Material and methods

Study site

This study was conducted in February 16th to 18th, 2016 on a beach located on the property denominated Treze de Maio and Costinha de Santo Antônio (06°58'17.59"S, 34°51'47.19"W), which is within the area of influence of the estuary of the Paraíba River in the municipality of Lucena, state of Paraíba, northeastern Brazil. The surrounding coastal environment is characterized by the presence of mangrove forests (Sassi, 1991) in non-urbanized areas and a large sand bank, which is exposed at low tide. The area is under the influence of the Atlantic Ocean (Medeiros, Hepp, Patrício, & Molozzi, 2016) and main tributaries on the right (Sanhauá, Tambiá and Mandacaru Rivers) and left (Paroeira, Tiririm, Ribeira and Guia Rivers) margins of the estuary, which transport sediment and nutrients as well as domestic and industrial sewage (Sassi, 1991; Marcelino, Sassi, Cordeiro, & Costa, 2005). The area is not under the direct influence of the impact of the waves and has a beach with flat to slightly steep areas, with predominantly sandy-muddy and detritic bottoms (Sassi, 1991) (Figure 1).

Sampling and treatment of samples

A total of 21 crabs were captured using traps known locally as "manzuá" [see Carvalho and Couto (2011)]. Five traps were linearly installed on the bed of a small affluent at a depth of approximately 2 m in the mangrove area at low tide. Each trap contained 100 g of bait consisting of a mixture of beef (90%) and fish (10%). The traps were examined every 24 hours for three days and captured specimens were removed. An oyster found cemented to the carapace of a crab was photographed immediately after collection (Figure 2). All specimens, including the basibiont were placed in plastic recipients with sea water, stored in a cold container and then fixed in 70% ethanol for subsequent identification. In the laboratory, the oyster was removed from the crab carapace. Crab is housed in the Paulo Young Invertebrate Collection, Department of Systematics and Ecology of the *Universidade Federal da Paraíba* (UFPB CRUSTACEA 6165 ♀), João Pessoa, Paraíba, Brazil and oyster is deposited in the mollusc collection, *Museu de Zoologia, Universidade de São Paulo* (MZSP 131977), São Paulo, Brazil.

Results

The caparace of *Callinectes exasperates* served as a favorable, sufficiently large, firm substrate for the opportunistic occupation of *Ostrea* cf. *puelchana*. The carapace is heavily armored, dorsoventrally flattened and relatively rough, composed of numerous small tubercles that offer favorable conditions as a biogenic surface for the settlement and growth of the oyster. The specimen of *O.* cf. *puelchana* had a wet weight of 0.81 g and a shell length of 27 mm, with the shell occupying an area of 4.3 mm^2. The specimen of *C. exasperates* had a wet weight of 53.5 g

and a carapace width of 104 mm. The epibiont covered about 20% of the dorsal surface of the carapace (Figure 2). The oyster was closely attached to the left side, covering 60 to 70% of the epibranchial surface and about 90% of the mesobranchial and metabranchial regions. The antero-ventral and postero-ventral parts of the left valve of the oyster were completely cemented to the carapace of the crab, while the antero-dorsal and postero-dorsal parts of the valve (except part of the submedian margins) were not cemented, and only loosely covered the carapace.

Discussion

Information on oysters as epibionts on recent mobile marine invertebrates is scarce (Winter & Masunari, 2006; Eschweile & Buschbaum, 2011). However, fossil records seem not to be uncommon (Cope, 1968; Bishop, 1981; Tshudy & Feldmann, 1988; Fernandez-Leborans, 2010; Paul & Simms, 2012; Zell et al., 2014). Such records include *Liostrea roemeri* (Quenstedt, 1843) attached to the shells of ammonites in the Jurassic to Cretaceous periods in northeastern Mexico (Zell et al., 2014) and *Pycnodonta vesiculosa* (Sowerby, 1823) living on the lobster *Hoploparia stokesi* (Weller, 1903) in the Cretaceous period in Antarctica (Tshudy & Feldmann, 1988). This is the first record of epibiosis between bivalves of the genus *Ostrea* Linnaeus, 1758 and crabs of the genus *Callinectes* Stimpson, 1860.

The case of epibiosis found here in the current stage of the species is obviously favorable to the epibiont and also seems to be advantageous to the basibiont. The considerable capacity for movement of the basibiont may be advantageous to the epibiont with regard to the avoidance of predators and the obtainment of nutrients. Oysters are predated by a number of marine invertebrates, such as platyhelminthes (Littlewood & Marsbe, 1990; O'connor & Newman, 2001), crustaceans (Elner & Lavoie, 1983; Eggleston, 1990), polychaetes (Sabry & Magalhães, 2005; Radashevsky, Lana, & Nalesso, 2006) and other mollusks (Carriker, 1955; Herbert, Dietl, Fortunato, Simone, & Sliko, 2009). Studies suggest that an epizoitic lifestyle is beneficial by hindering the approach of sedentary predators due to the movements or defensive shield of certain basibionts (Wahl, 1989; Abelló, Villanueva, & Gili, 1990). Epibiont invertebrates (e.g., hydroids, polychaetes and barnacles) on decapods may also benefit from resuspended debris (Williams & Moyse, 1988) or the diet of the host (Bowers, 1968; Abelló et al., 1990).

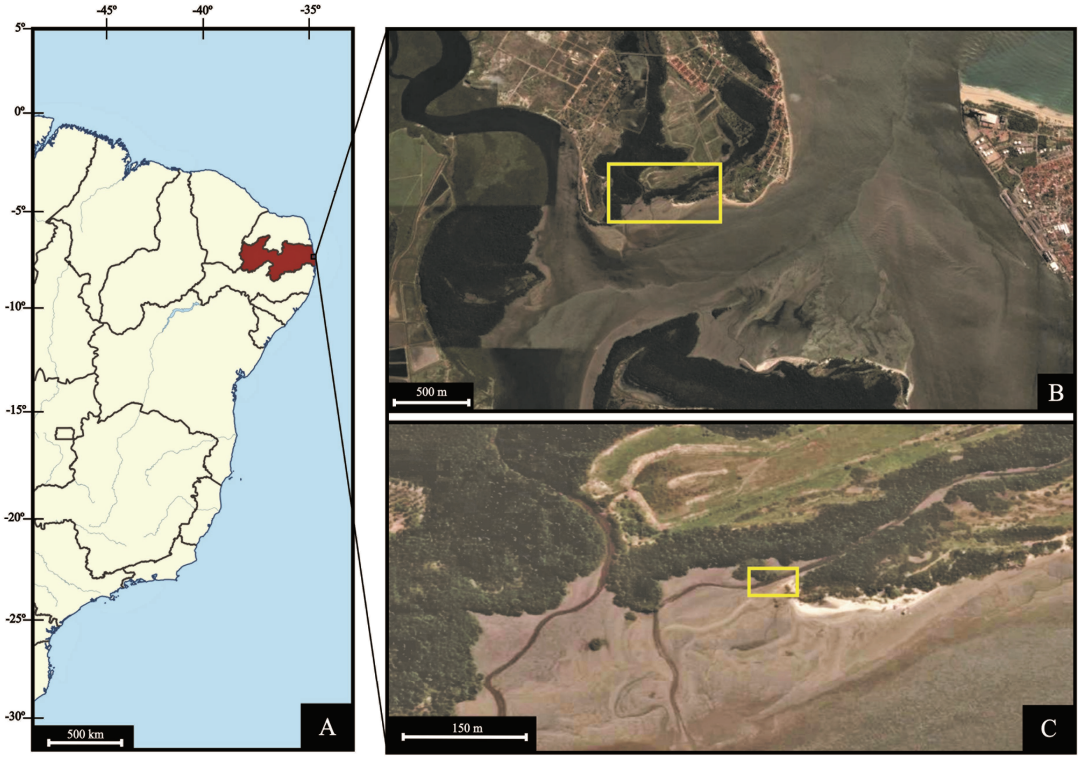

Figure 1. (A) Map of coast of Brazil and state of Paraíba (red); (B) Photo of estuary of Paraíba River indicating sampling location (upper region of property denominated Treze de Maio and Costinha de Santo Antônio) (Google Earth); (C) Photo of stretch of beach showing affluent in which traps were installed (yellow lozenge) (Google Earth).

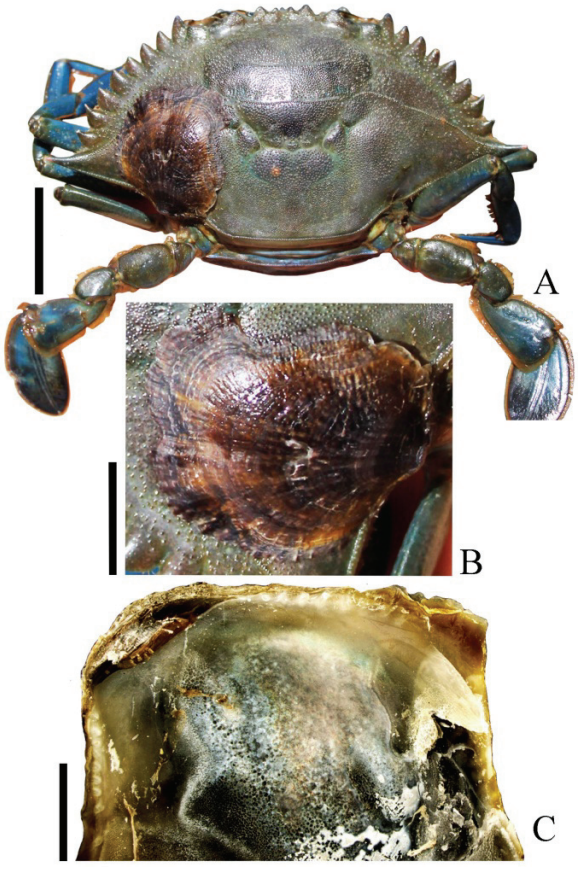

Figure 2. (A) Specimen of *Ostrea* cf. *puelchana* cemented to carapace of *Callinectes exasperates*; (B) Detail of right valve of *O.* cf. *puelchana*; (C) Internal view of right valve of *O.* cf. *puelchana* showing denticles on hinge. Scale bars: A. 2 cm, B. 1 cm, C. 5 mm.

Conversely, settling on a crustacean could be a poor option. The carapace of *Callinectes exasperates* is an available hard substrate for the attachment of *Ostrea* cf. *puelchana* mainly in a predominantly soft sediment environment. However, some aspects of the biology of crustaceans and the ecology of *C. exasperates* may negatively affect an epibiont. Ecdisys (molting) makes the carapace of crustaceans only a semi-permanent substrate for epizoans (Ross, 1983; Wahl, 1989; Gili et al., 1993). As a result, there are few reports of epibiosis between bivalves and crustaceans (Gili et al., 1993; Villegas et al., 2005). *Ostrea* cf. *puelchana* may also be negatively affected by stressful environmental conditions due to the burrowing activity of *C. exasperates* (Abelló et al., 1990; Fernandez-Leborans, 2010).

According to Wahl and Mark (1999), epibiosis may negatively affect basibionts by increasing weight and friction, decreasing flexibility, shading basibionts from light and access to dissolved nutrients or inflicting 'shared doom'. On the other hand, basibionts may benefit from the presence of epibionts due to effects such as optical and chemical camouflage, reduced friction, protection against desiccation and harmful irradiation or associational defense. The continued growth of an epibiont oyster to adulthood on the carapace of *Callinectes exasperates* could adversely affect the buoyancy and locomotion of the latter, making the crab more vulnerable to predation. A similar harmful pattern has been seen involving the oyster *Crassostrea gigas* (Thunberg, 1793), which impaired the mobility of the gastropod *Littorina littorea* (Linnaeus, 1758). Villegas et al. (2005) report that the epibiont mussel *Semimytilus algosus* (Gould, 1850) is apparently unfavorable to the basibiont *Emerita analoga* (Stimpson, 1857) by increasing its mass and damaging the surface of the carapace as well as reducing the growth and buoyancy of this sand crab. However, the specimen of *Ostrea* cf. *puelchana* in the juvenile stage described in the present study likely did not have a negative effect on the basibiont *C. exasperates* as the oyster (weight: 0.81 g) was attached to only about 20% of the dorsal carapace and did not overlap any appendage or other articulated structure on the carapace and therefore probably did not impair movement, flexibility or the function of organs in the basibiont. The same pattern has been reported in other cases of epibiosis among marine invertebrates (Overstreet, 1983; Wahl, 1989; Cadée, 1991;Wahl & Mark, 1999; Fernandez-Leborans, 2010). Furthermore, no injuries were found on the carapace of the crab after the removal of the oyster. Another important point is that the shell of this ostreid may offer additional protection from potential predators of the crab. There are many examples of epibionts that may discourage predation on basibionts (Feifarek, 1987; Laudien & Wahl, 1999; Marin & Belluga, 2005).

The specimen of *Ostrea* cf. *puelchana* was able to grow on the carapace of *Callinectes exasperates* enough to reach about half its adult size (27 mm in shell length) without being affected by the process of ecdysis. Thus, the oyster may has been between three and four months of age (based on growth rate of other ostreids, such as *Crassostrea gigas*) (Acosta Ruíz & Gutiérrez Wing, 1996) and the basibiont was an adult crab in terminal an ecdysis, thereby providing a rather stable substrate for the epibiont. The carapace width of the crab studied herein was within the estimated size (61 to 160 mm) for first gonadal maturation, based on data from congeners (Tagatz, 1968; Branco & Masunari, 1992; Branco & Lunardon-Branco, 1993; Severino-Rodrigues, Musiello-Fernandes, Moura, Branco, & Caneo, 2013; Sumer, Teksam, Karatas, Beyhan, & Aydin, 2013), which live between 2.3 and 4 years (Tagatz, 1968; Williams, 1974; Ferreira & D'incao, 2008;

Keunecke, D'Incao, Moreira, Silva, & Verani, 2008). However, biological data on *C. exasperates* are practically non existent, likely due to low abundance of the species. Furthermore, oysters are filter feeding bivalves adapted to a sessile epifaunal lifestyle in marine or brackish waters and are dependent on hard substrates (Amaral & Simone, 2014).

Conclusion

This study expands knowledge on the diversity of epibiosis among marine invertebrates through the record of the bivalve *Ostrea* cf. *puelchana* attached to the crab *Callinectes exasperates* on the coast of Brazil. The case epibiosis found apparently not adversely affected both epibiont and basibiont. However, future studies on the biology and life cycle of the crab and oyster will be decisive to the determination of factors that are either favorable or unfavorable.

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