

An erroneous record of *Perna viridis* (Linnaeus, 1758) (Bivalvia, Mytilidae) for the northeastern coast of Brazil, Southwestern Atlantic

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ABSTRACT

The introduction of species beyond their natural distribution area as a result of human activities is one of the main threats to marine biodiversity. In 2019, *Perna viridis*, an Indo-Pacific mytilid, was recorded for the first time in the coast of Brazil in Guanabara Bay (Rio de Janeiro State). In 2021, this species was recorded in the Northeast region of Brazil (Fortaleza, Ceará State). This record was subsequently replicated in studies from 2022, 2023, and 2024. The specimens from Ceará State were deposited in the malacological collection “Prof. Henry Ramos Matthews - Série B” of the Universidade Federal do Ceará. During a curation activity of this collection, these specimens were reanalyzed and their identification questioned. Therefore, this study aimed to confirm the record of *P. viridis* for the Northeast region of Brazil. According to the analyses, the individuals collected on the coast of Ceará are not *P. viridis*, but belong to *Mytella strigata*, a native species of the coast of South America. Thus, the occurrence of *P. viridis* in the Southwestern Atlantic remains restricted to the southeast region of Brazil.

Keywords: Non-native species, Invasive species, Exotic species, *Mytella*, Marine biodiversity

The introduction, intentional or not, of species beyond their natural distribution area as a result of human activities (called non-native species) is one of the main threats to marine biodiversity, along with overfishing, pollution, and climate-induced drivers (e.g., increase in seawater temperature

and ocean acidification) (Costello et al., 2010; Wesselmann et al., 2024).

Recent studies (Darrigran et al., 2020; Teixeira and Creed, 2020) compiled records of non-indigenous molluscan species in the Southwestern Atlantic, among which is the bivalve *Perna viridis* (Linnaeus, 1758). This species is an Indo-Pacific mytilid already well established in the Caribbean region and North America (Florida State), where it is considered invasive (Baker et al., 2007; Gobin et al., 2013; Dias et al., 2018). In 2019, *Perna viridis* was recorded for the first time in Brazil in

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Guanabara Bay (Rio de Janeiro State, Southeast coast) (de Messano et al., 2019). In 2021, it had its distribution on the Brazilian coast expanded, being recorded in the Northeast region of Brazil (Fortaleza, Ceará State) on recruitment plates placed in an area under port influence (Regis et al., 2021). This record was subsequently replicated in studies from 2022, 2023, and 2024 (Soares et al., 2022; dos Santos et al., 2023; Zenni et al., 2024). The study conducted by dos Santos et al. (2023) again recorded *P. viridis* in Rio de Janeiro, now in a Marine Extractive Reserve (Arraial do Cabo).

The specimens from Fortaleza (Ceará), analyzed by Regis et al. (2021), were deposited in the malacological collection “Prof. Henry Ramos Matthews - Série B” (CMPHRM-B) of the Universidade Federal do Ceará (UFC, Brazil) (voucher no. CMPHRM 7044B). During a curation activity in this collection, these specimens were reanalyzed, and their identification questioned. Therefore, this study aimed to confirm the record of *P. viridis* for the Northeast region of Brazil.

The specimens initially analyzed at UFC were sent to the Universidade Federal de São Carlos (Brazil), where they were measured, photographed, and compared with specimens of *Perna viridis*, *Mytella strigata* (Hanley, 1843), and *Mytella guyanensis* (Lamarck, 1819) deposited at the Museu de Zoologia da Universidade de São Paulo (MZSP, Brazil) and Museu da Diversidade Biológica da Universidade Estadual de Campinas (ZUEC, Brazil). The specimens analyzed were: *P. viridis* (voucher numbers: MZSP 119408, Manila, Philippines; MZSP 037151, Puket, Indonesia; MZSP 055588, Chantaburi, Thailand), *M. strigata* (ZUEC-BIV 501, 514, 519, 1512, 1715, 1716, 2168, 2169, 2946, 3509, and 3511, northern coast of the state of São Paulo, Brazil) and *M. guyanensis* (ZUEC-BIV 6196 São Sebastião, northern coast of the state of São Paulo, Brazil).

Table 1 provides a comparative analysis of the principal diagnostic characteristics among the specimens under consideration. While all specimens examined display the typical morphology associated with the family Mytilidae, a distinction arises: *P. viridis* exhibits a ventrally oriented face (Figure 1A–E), whereas the other specimens present a forward-facing

orientation. Additionally, the umbo is terminal in *P. viridis* but subterminal in the Fortaleza specimens (Figure 1 F–J), as well as in *M. strigata* (Figure 1 K–O) and *M. guyanensis* (Figure 1 P–T). Moreover, the absence of the scar from the anterior adductor muscle in *P. viridis* sets it apart from the other specimens, in which this feature is present (Figure 2). These observed discrepancies lead to the inference that the mussels collected from Fortaleza are taxonomically aligned not with the genus *Perna*, but rather with the genus *Mytella*.

Considering that the specimens collected in Fortaleza exhibit two teeth in the hinge (Figure 1 J), and *M. guyanensis* lacks cardinal teeth (Figure 1 T), these specimens are morphologically more similar to *M. strigata*. According to Lim et al. (2018), *M. strigata* typically possesses three to four teeth, although up to seven teeth may be observed in some specimens. The species also exhibits significant color variation, ranging from uniformly black or green to brown with irregular green spots or lines, which may form concentric or zigzag patterns. The specimens analyzed from Fortaleza and *M. strigata* deposited in the ZUEC are brown with irregular green spots.

Other distinguishing characteristics between the specimens from Fortaleza and *M. guyanensis*, which also align them more closely with *M. strigata*, include: in Fortaleza’s specimens, the posterior margin is rounded but subtly inclined towards the ventral region, whereas, in *M. guyanensis*, it is broadly rounded; mussels from Fortaleza exhibit a slightly prominent umbonal region, in contrast to the distinctly conspicuous umbonal area of *M. guyanensis*. Moreover, the specimens from Fortaleza feature a keel extending from the umbo to the ventral posterior margin, defining a flat ventral area, whereas the valve surface of *M. guyanensis* tends to be more rounded.

According to the analyses, the individuals collected on the coast of Ceará are not of *P. viridis* but belong to the species *Mytella strigata*. In the Atlantic, *M. strigata* is distributed from Venezuela to Argentina (Rios, 2009). On the Brazilian coast, it is a quite abundant mytilid found in the intertidal zone, buried in mud or sandy-muddy banks and shallow lagoons, or can occur anchored to submerged

plant remains, being used as food in Northeast and Southeast Brazil (Narchi and Galvão-Bueno, 1983; Nishida et al., 2006; Rios, 2009). Currently, *M. strigata* is also found in several locations in the Indo-Pacific, expanding its geographic distribution probably via ballast water and/or biofouling (Lim et al., 2018; Huang et al., 2021).

Thus, the occurrence of *P. viridis* in the Southwestern Atlantic remains restricted to the Southeast region of Brazil (Guanabara

Bay and Arraial do Cabo, Rio de Janeiro State) (de Messano et al., 2019; dos Santos et al., 2023). Moreover, this study highlights important points in studies on biodiversity. Firstly, the fundamental role of a precise taxonomic analysis for a correct record of the biota. Secondly, the importance of scientific collections and the deposit of studied specimens in these collections since this practice allows fresh analyses and further studies across various fields of knowledge.

Table 1. Comparison of the morphological characters of the analyzed species of Mytilidae. PAMS= posterior adductor muscle scar; MBRMS= middle byssal retractor muscle scar.

Characters	<i>Perna viridis</i>	Mytilidae*	<i>Mytella strigata</i>	<i>Mytella guyanensis</i>
Outline	Mytiliform, with anterior side pointed and down turned	Mytiliform, with anterior side pointed and facing forward	Mytiliform, with anterior side pointed and facing forward	Mytiliform, with anterior side rounded and facing forward
Umbo	Terminal	Subterminal	Subterminal	Subterminal
Hinge	Thick hinge plate with one large tooth in each valve	Thin hinge plate with two pointed teeth in each valve	Thin hinge plate with two or three pointed teeth in each valve	Thin hinge plate without teeth
Resilial ridge	Large, highly pitted	Large, weakly pitted	Large, highly pitted	Large, highly pitted
Anterior margin	Short, sharply rounded	Short, rounded	Short, rounded	Broadly rounded
Dorsal margin	Long, broadly rounded, forming an angle in its median portion	Long, almost straight, dorsally inclined at its greatest extent, rounded and confluent with the posterior margin in its final portion	Long, almost straight, dorsally inclined at its greatest extent, rounded and confluent with the posterior margin in its final portion	Long, straight, and dorsally inclined
Posterior margin	Long, broadly rounded	Broadly round, pointing towards the ventral region	Broadly round, pointing towards the ventral region	Broadly rounded
Ventral margin	Straight	Straight	Arched in the middle part	Straight
Valve surface	Round keel present from the umbo to the mid-region of the valve, delimiting a flat anterior-ventral area	Round keel present from the umbo to the ventral margin, delimiting a flat ventral area	Round keel present from the umbo to the ventral margin, delimiting a flat ventral area	Keel absent; valve surface rounded
Anterior adductor muscle scar	Absent	Elongated, very close to the ventral margin	Elongated, very close to the ventral margin	Very elongated, very close to the ventral margin
Posterior retractor byssal muscle scar	Elongated with its widest portion confluent with the PAMS, and the thinnest above the MBRMS	Elongated with its widest portion confluent with the PAMS, and the thinnest confluent with MBRMS	Elongated with its widest portion confluent with the PAMS, and the thinnest confluent with MBRMS	Elongated with its widest portion confluent with the PAMS, and the thinnest confluent with MBRMS
Middle retractor byssal muscle scar	Round	Narrow and elongated	Narrow and elongated	Narrow and elongated
Anterior retractor byssal muscle scar	Elongated oval, close to the dorsal margin	Round, close to the dorsal margin	Round, close to the dorsal margin	Round, close to the dorsal margin

*Specimens from the Northeast region of Brazil (Fortaleza, Ceará State) found on recruitment plates placed in an area under port influence.

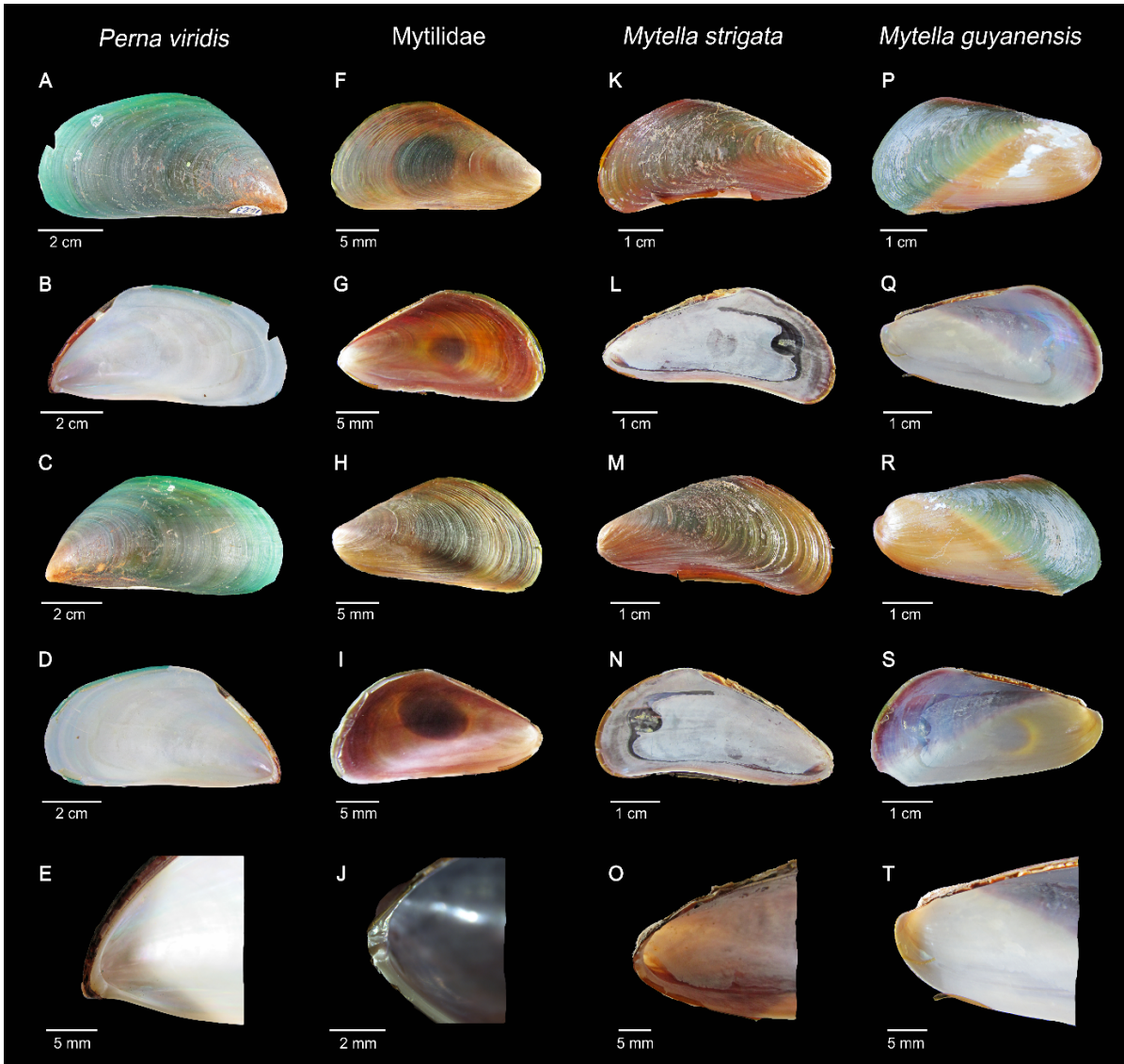


Figure 1. Representatives of the Mytilidae analyzed in this study. A–E) *Perna viridis* (Linnaeus, 1758), MZSP 119408. F–J) Mytilidae from Fortaleza, state of Ceará, Brazil, CMPHRM 7044B. K–O) *Mytella strigata* (Hanley, 1843), ZUEC-BIV 2169. P–T) *Mytella guyanensis* (Lamarck, 1819), ZUEC-BIV 6196. (A, F, K, P) external view of the right valve; (B, G, L, Q) internal view of the right valve; (C, H, M, R) external view of the left valve; (D, I, N, S) internal view of the right valve; (E, J, O, T) right valve hinge.

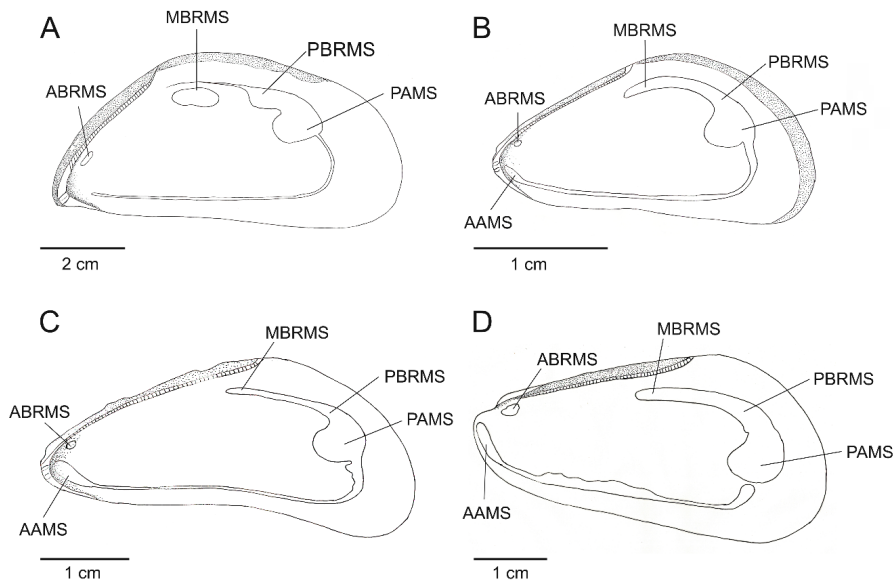


Figure 2. Schematic drawing representing the muscle scars of the analyzed specimens. (A) *Perna viridis* (Linnaeus, 1758), MZSP 119408. (B) Mytilidae from Fortaleza, state of Ceará, Brazil, CMPHRM 7044B. (C) *Mytella strigata* (Hanley, 1843), ZUEC-BIV 2169. (D) *Mytella guyanensis* (Lamarck, 1819), ZUEC-BIV 6196. Legends: AAMS= anterior adductor muscle scar; ABRMS= anterior byssal retractor muscle scar; MBRMS= middle byssal retractor muscle scar; PAMS= posterior adductor muscle scar. PBRMS= posterior byssal retractor muscle scar.

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AUTHOR CONTRIBUTIONS

E.P.A.: Conceptualization; Investigation; Methodology; Writing – original draft; Writing – review & editing.

L.B.R.; M.O.: Investigation; Writing – review & editing.

H.M.C.: Supervision; Resources; Funding Acquisition; Writing – review & editing.

C.X.B.: Conceptualization; Investigation; Writing – original draft; Writing – review & editing.

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