

## A STUDY ON THE OCCURRENCE OF THE BROWN MUSSEL *Perna perna* ON THE SAMBAQUIS OF THE BRAZILIAN COAST

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**RESUMO:** *Perna perna* é um molusco bivalve encontrado nas regiões tropicais e subtropicais dos oceanos Atlântico e Índico e também se estende pelo Mediterrâneo. O objetivo deste trabalho é investigar a hipótese de que a distribuição da espécie *Perna perna* no Brasil pode ser o resultado de eventos de bioinvasão. Para tal, verificou-se a ocorrência desta espécie nos sambaquis do litoral brasileiro. Não foram encontradas conchas desta espécie em nenhum dos sambaquis analisados. Naqueles em que a espécie é citada, o registro é dúbio. *Perna perna* talvez seja uma espécie exótica, podendo ter sido introduzida no Brasil há muitos anos atrás, possivelmente com o incremento do comércio marítimo, à época do tráfico de escravos.

**UNITERMOS:** *Perna perna* – Sambaqui – Bioinvasão – Espécie exótica.

### Introduction

A good part of the Brazilian seashore started to be colonized by human groups around 6,500 B.P.,<sup>1</sup> which began to exploit the marine environment, living mainly of fishing and mollusc harvesting, although they also hunted and gathered various plant products (Gaspar 2000a). These fishers,

hunters and gatherers left as the main testimony of their existence a type of archaeological site known as *sambaqui* (shellmound) (Gaspar 2000b).

The word *sambaqui* is thought to be derived from the tupi words *tamba* (shell) and *ki* (piling) (Prous 1991). A *sambaqui* is thus an artificial mound of mollusc shells which constitutes vestiges of human group habitation sites, where they buried their

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(1) “B.P.” stands for “years before the present”, the present being defined by convention as 1950, a reference to the discovery of Carbon 14 dating, which happened in 1952. The event referred to thus took place 6,500 years before 1950.

dead and gathered food and craftsmanship remains.

Formations of the sambaqui type are not endemic to Brazil. They receive different names depending on where they occur: in different parts of the Brazilian territory, *concheiros*, *berbigueiros*, *ostreiras* and *sernambis* (Kneip 1987); in Hispanic America, *conchales* or *basurales* (Duarte 1968). The Danish call them *kjökkenmødding*, and the English *kitchen-midden* or *shellmound*. Such formations are distributed throughout the Americas, Africa, Europe etc.. It was only after 1845 that they started to be viewed with interest and that the historical, archaeological and anthropological value of these “kitchen remains” was recognized (Gikovate 1933).

According to Mendonça de Souza (1981), sambaquis are thanocenoses *par excellence*, i.e., ensembles of dead organisms representative of the fauna existing in the area at the time in which they were formed. There are two possibilities of deposition of the remains that constitute them: the first has to do, predominantly, with microscopic fauna and young mollusc forms, subjected to random deposition, together with possible vacancy of the sites, and carried by river or sea water, or else, associated with the collection of species of economic interest to the sambaqui populations; the second, more specific to the macrofauna, conditions the accumulation to the habits, cultural traditions, occupation patterns and ways of group subsistence.

Built on plains as well as on hill sides, sambaquis occur along most of the Brazilian coast, from Rio Grande do Sul state to Todos os Santos bay in Bahia state. On the northeastern coast they disappear, to reappear in the states of Maranhão and Pará in the Northern Region (Lima 2000). However, the studies done in the North and Northeastern Regions are localized, and do not allow for safe correlations with the ones done in the South Region; systematic studies exist only for the north of Rio de Janeiro state (Gaspar 2000a).

The leftovers of prehistoric human populations gathering activity that inhabited the Rio de Janeiro state shores frequently show, in different archaeological sites, the presence of mollusc species belonging to classes Gastropoda and Bivalvia. Collection of these animals, their utilization in the diet of prehistoric man – as calcium and protein sources –, as well as the use of their shells in the manufacture of artifacts – knives, scrapers, hooks, drills and adornment objects – or as funereal accompaniment, has been

documented by records in archaeological sites, especially in sambaquis. It is worth noting that the remains of molluscs preserved in archaeological sites enable the reconstitution of the paleoenvironment (Beltrão *et al.* 1978).

Molluscs played a fundamental role for the fisher-gatherers, but they surely did not constitute their diet's staple, which was mainly made of fish. Nevertheless, everything seems to indicate that molluscs were their favorite food, their main object of desire, such was the intensity with which they searched for them, so that these groups came to be primarily viewed as mollusc gatherers (Lima 1991; Bandeira 1992; Figuti 1993; Lima 2000).

Curiously, in the majority of archaeological vestiges left by hunters and mollusc gatherers who lived on the shores of Rio de Janeiro state, no shells of *Perna perna*, the most abundant bivalve mollusc on the adjacent rocky shores, as well as the organism most consumed by the local population, were found. In those sites where *Perna* was cited, the records are dubious, since the records refer to triturated shells, which are difficult to identify (Beltrão *et al.* 1978). At the same time most of the sites were partially destroyed when they were studied, indicating that contamination of the archaeological record may have occurred (Mendonça de Souza 1981).

In principle, it seems that *Perna* was cited in an attempt to correlate the archaeological fauna with the surrounding environment. Both the historical records, which would define the species as exotic, and the archaeological record, which would characterize the species as cryptogenic or native, are faulty, thus casting a great doubt on the origin of this species in the present-day ecological community.

On the other hand, *Pinctada imbricata*, a species that is rare in today's rocky shores, due to its competition for space with *Perna perna*, is abundant in the sambaquis of Ribeira Bay at Angra dos Reis, in Santana island at Macaé (Lima 1991), and in Cabo Frio island at Arraial do Cabo (Tenório 2001, pers. com.). The *Pinctada imbricata* records, in the sites where its shells were found, are undeniable. In spite of the fragility of this mollusc's valves, its shells are found in good condition, which seems to indicate that this organism was collected frequently for feeding purposes (Lima 1988).

In 1990, two biological invasions by populations

of the genus *Perna*, of unknown origin, were reported from the Caribbean and from the Gulf of Mexico. Hicks & Tunnell (1993) identified the mussels collected in the Gulf of Mexico as *Perna perna*, while Agard *et al.* (1993) identified the species found in the Caribbean as *Perna viridis*. Biological invasion is defined as the arrival, establishment and subsequent diffusion of species in natural communities where they did not previously occur. There are two kinds of invasions: expansions and introductions. Expansions consist in the dispersal of species by natural mechanisms. These natural expansions of organisms extend over a vast geological time. Species are considered native if they include prehistoric invasions. Species are considered exotic when they performed historical invasions through natural expansion or through introduction by human activity (Carlton 1996). There is little information on the invasion of marine organisms, which implies that many introductions may have taken place without having been identified as such (Borrero & Díaz 1998).

Thus, the absence of consistent fossil records that attest to the existence of *Perna perna* in prehistoric times in Brazil, and the existence of recent cases of the invasive behavior of this genus, lead us to raise the possibility that the mussel *Perna perna* may be an exotic species, possibly introduced in Brazil several years ago. It is also possible that *Pinctada imbricata*, which is rare today on rocky shores but was abundant in prehistoric times, as indicated by its undisputed occurrence in many sambaquis, may have been replaced by the invading *Perna perna*. In order to investigate this hypothesis, the occurrence of *Perna perna* in sambaquis near the rocky shores where this species occurs today was verified, and the current populations of *Perna perna* and of *Pinctada imbricata* in the rocky shores and in the archaeological sites of Cabo Frio island, at Arraial do Cabo, Rio de Janeiro state, was characterized through the abundance and distribution of size frequencies.

## Material and methods

### *Sambaqui analysis*

A survey of the registered archaeological sites registered in the 6th Regional Superintendence of the IPHAN (National Institute of Historical and

Artistic Patrimony) was performed so as to identify, quantify and locate the sambaqui-type sites in the state of Rio de Janeiro. An analysis of bibliographical data referring to this state's sambaquis made it possible to verify in how many of them *Perna perna* was mentioned, and in which.

Malacological citations relating to the sambaquis of the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo and Rio de Janeiro were used. In relation to Espírito Santo state, no bibliography pertaining to its archaeological sites was found. As mentioned in the introduction, research on sambaquis is not highly developed in the states to the north of Rio de Janeiro.

So as to verify *in situ* the state of site conservation and the presence of the brown mussel in the malacological vestiges, visits were made to archaeological sites I and II of Cabo Frio island, located in Arraial do Cabo municipality, to the Fort and the Boca da Barra sambaquis, in Cabo Frio municipality, to the Beirada and the Manitiba I sambaquis, in Saquarema municipality, and to the Tarioba sambaqui, in Rio das Ostras municipality.

The Beirada and the Manitiba I sambaquis were visited on 29 May 2001. Under the supervision of Lina Kneip, archaeologist at Museu Nacional/UFRJ, a sample of each of the 7 stratigraphic levels of Manitiba I was taken. With the help of a trowel, about one kilogram of material was collected from each level. The samples were placed in plastic bags, labeled and taken for posterior identification to the Paulo Moreira Marine Studies Institute (IEAPM).

On 9 June 2001, under the guidance of Maria Cristina Tenório, archaeologist at the Museu Nacional/UFRJ, the Cabo Frio I and II sites at Cabo Frio island were visited, in Arraial do Cabo, Rio de Janeiro state. Since these sites have not yet been studied, it was only possible to survey those species of molluscs whose shells were exposed.

The Tarioba sambaqui museum in Rio das Ostras, Rio de Janeiro state, the Beirada sambaqui museum, in Saquarema, also in Rio de Janeiro state, and the Archaeological Museum of the Sambaqui in Joinville, Santa Catarina state were visited so as to verify whether in the exposed material there were *Perna perna* shells collected on archaeological sites that could attest to the presence of the species in these sites' prehistory.

Researchers at the National Museum/UFRJ, the Archaeology and Ethnology Museum/USP, Zoology Museum/USP, Joinville Archaeological

Museum of the Sambaqui, Brazilian Archaeology Institute, Brazilian Society of Archaeology, 6th Regional Superintendence of the IPHAN, Anchietao Research Institute and University of Stellenbosch, South Africa were contacted with the purpose of clarifying the malacological material found and the conservation state of the archaeological sites studied.

*Comparison of the distribution of Perna perna and Pinctada imbricata on the rocky shores and archaeological sites of Cabo Frio Island, Arraial do Cabo, Rio de Janeiro state*

On 13 June 2001, a random sampling of *Perna perna* and *Pinctada imbricata* was done on the rocky shores of Cabo Frio island, at Arraial do Cabo, Rio de Janeiro state, at 23° 00 S 42° 00 W (Fig. 1).

This sampling was done trying to reproduce the natural harvesting procedure, i.e., the molluscs were visually located and then collected with simple tools. Samples were placed in plastic bags, labeled and taken to the laboratory at IEAPM. In the lab, length and width measures of 258 *Perna perna* shells and

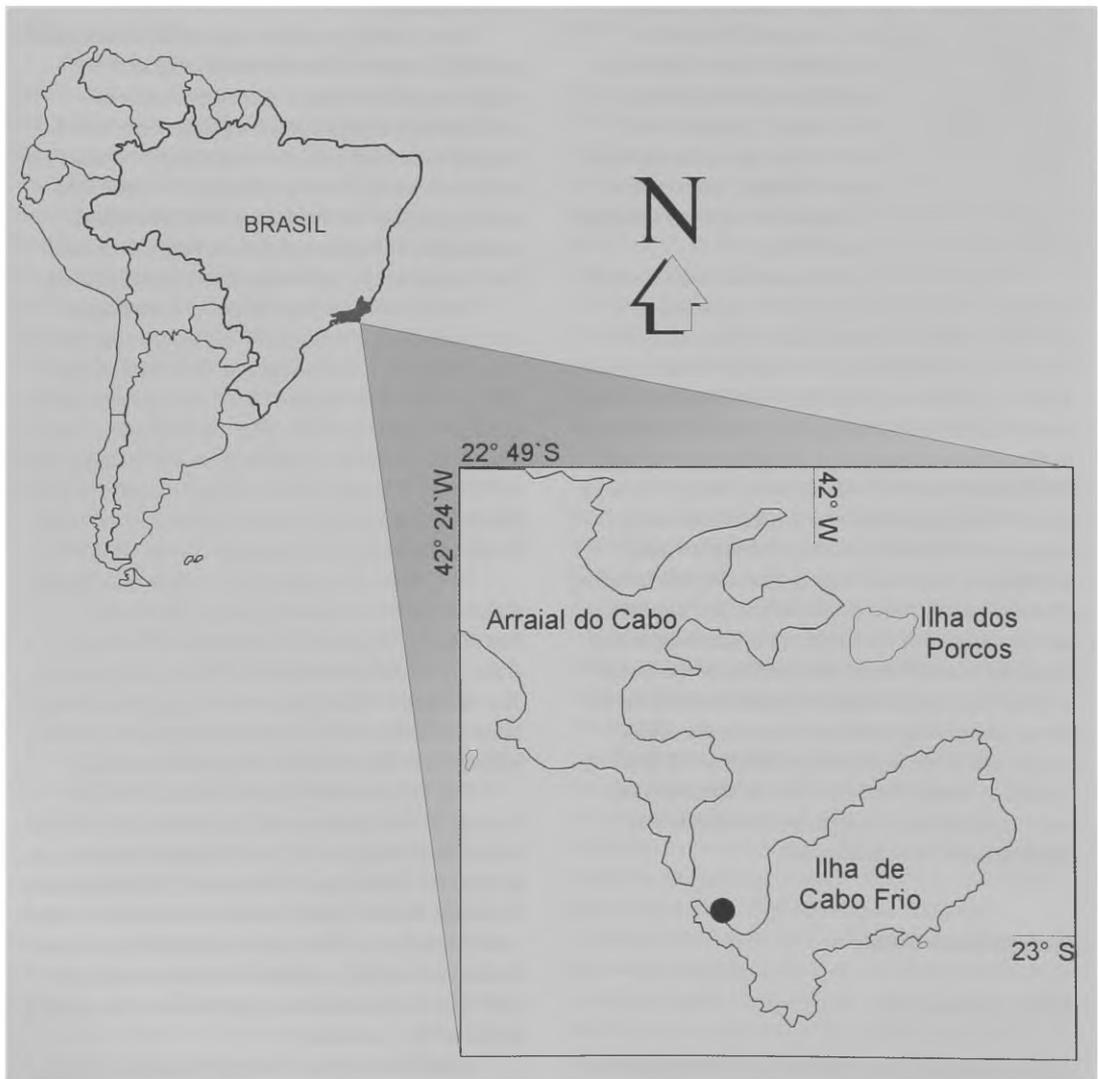


Figure 1 – Study area. The dot indicates the location of the archaeological site on the dunes on Cabo Frio island, Arraial do Cabo – Rio de Janeiro state.

86 *Pinctada imbricata* shells were taken with a caliper ruler.

Length and width measures of 150 *Pinctada imbricata* shells found over the dunes in the archaeological site were also taken. These shells could not be collected since, according to Brazilian legislation on prehistoric sites, it would be tantamount to destruction of patrimony. It was not possible to take *Perna perna* measurements, since this species was not found in the archaeological records, even though its valves are easily seen on the beach sand.

A size frequency distribution was made for shell length and width data for *Pinctada imbricata* and for *Perna perna*. The following size classes were determined: class 1 – from 0 a 0.99 cm; class 2 – from 1 to 1.99 cm; classe 3 – from 2 to 2.99 cm; classe 4 – from 3 to 3.99 cm; class 5 – from 4 to 4.99 cm, and class 6 – from 5 to 5.99 cm.

The Kolmogorov-Smirnov method was used to test if there was a significant difference between the *Pinctada imbricata* size distribution curves on the rocky shore and on the archaeological site. For *Perna perna* a histogram was made with length and width distribution, since this species was found only in the rocky shore.

## Results and discussion

### *Sambaqui analysis*

At IPHAN, an official list called “Archaeological sites registered in Rio de Janeiro state”, dated from 17 February 2000, was consulted. This was IPHAN’s latest document at the time. It lists 575 sites, including prehistoric and historic ones.

The IPHAN archives are of unquestionable richness, containing registers dating back to 1963, but during this survey the absence of certain data was noted, as well as a lack of accuracy in the data on the site registration cards. Flaws on the archaeological sites data from the time of their registration also became evident.

According to Rosana Pinhel Mendes Najjar (archaeologist of the 6th CR/IPHAN, pers. comm.), in some cases the sites registered at IPHAN are doubly registered, under different names; in other cases, they have not even been registered. Others were registered, but the site type was not defined, while yet others are impossible to locate, since the reference points no

longer exist (e.g., “near the tree at the top of the hill, in Mr João’s yard near the railway, ...”), or they simply were not indicated. In addition, most sites were destroyed without having ever been studied.

At INEPAC we were able to find the catalogue cards originating from a systematic registration of the archaeological sites in Rio de Janeiro state, initiated in 1979 and published in 1981 by Alfredo A. C. Mendonça de Souza. It features 339 examined sites, organized in 14 microregions (Itaperuna, Miracema, Campos, Cantagalo, Três Rios, Cordeiro, Vale do Paraíba Fluminense, Serrana Fluminense, Vassouras and Barra do Piraí, São João and Macacu basins, Fluminense do Grande Rio, Cabo Frio, Ilha Grande bay and Rio de Janeiro).

Mendonça de Souza (1981) verified that 60 to 80% of the sites were destroyed or severely damaged. Around 42.62% were destroyed by engineering works (plot delimitation and urbanization, opening of streets and roads, building and land removal), 30.74% by anthropogenic erosion and plundering, 12.5% by agriculture (horticulture), 7.09% by sand and gravel shell extraction for making lime and, lastly, 2.03% by natural causes (deforestation and wind, river or sea erosion).

According to the IPHAN and INEPAC records, a record of all Rio de Janeiro state sites of the *sambaqui*, *berbigueiro*, and *concheiro* type was put together. Sites that were not registered or were not of the sambaqui type but that featured any malacological reference in the bibliography used were also considered. In all, 206 sites distributed around 20 of the state municipalities were listed.

The most cited bivalve species were *Anomalocardia brasiliana* (42.2%), *Ostrea sp.* (40.2%) and *Lucina pectinata* (30%). *Pinctada imbricata* was cited for 25 sites, which corresponds to 12.1%. Bivalves from family Mytilidae cited were *Brachidontes sp.* (0.4%), *Mytilus perna* (0.9%), *Mytilus sp.* (0.9%), *Brachidontes exustus* (1.4%) and *Perna perna* (13.1%). Table I gives the list of sites for which *Pinctada imbricata* and the species of family Mytilidae were cited.

*Perna perna*, *Mytilus perna* or *Mytilus sp.* were cited in 2 sites in Arraial do Cabo, 3 sites em Cabo Frio, 1 site in Casimiro de Abreu, 1 site in Macaé, 8 sites in Magé, 12 sites in Parati, 1 site in Rio das Ostras, 1 site in São Pedro D’Aldeia and 3 sites in Saquarema, totalling 32 sites.

TABLE I

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
1.	Angra dos Reis	Sambaqui da Caieira	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i>	IPHAN (2000); Lima, T.A (1991); Mendonça de Souza, AAC (1981)
2.	Angra dos Reis	Sambaqui do Peri	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Abra seminuda</i> , <i>Trachycardium muticatum</i>	IPHAN (2000); Beltrão, MC (1978)
3.	Angra dos Reis	Sítio Cunhambebe (rebatizado como Caieira II)	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i>	IPHAN (2000); Lima, T.A (1991); Mendonça de Souza, AAC (1981)
4.	Angra dos Reis	Sítio do Alexandre	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Arca imbricata</i> , <i>Anadara notabilis</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Lima, T.A (1991)
5.	Angra dos Reis	Sítio do Bigode I	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Lima, T.A (1991)
6.	Angra dos Reis	Sítio do Bigode II	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i> , <i>Ostrea sp.</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Lima, T.A (1991)
7.	Angra dos Reis	Sítio do Joaquim	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Lima, T.A (1991)
8.	Angra dos Reis	Sítio do Major	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Arca imbricata</i>	IPHAN (2000); Lima, T.A (1991)
9.	Armação dos Búzios	Sambaqui da Ponta do Geribá	<u><i>Pinctada imbricata</i></u> , <i>Lucina pectinata</i> , <i>Astrea latispina</i> , <i>Arca imbricata</i> , <i>Ostrea sp.</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
10.	Arraial do Cabo	Sítio da Ilha de Cabo Frio	<u><i>Pinctada imbricata</i></u>	IPHAN (2000); Tenório, MC (2001)- Com. Pessoal - Museu Nacional
11.	Arraial do Cabo	Sítio da Ponta da Cabeça	<i>Perna perna</i> , <u><i>Pinctada imbricata</i></u> , <i>Astrea sp.</i> , <i>Olivancillaria sp.</i> Destruído/1978. Obras de engenharia (remoção de aterro) e erosão antropogênica	PHAN (2000); Tenório, MC (1995); Gaspar, MD (1991)

TABLE I (cont.)

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
12.	Arraial do Cabo	Sítio da Prainha	<i>Mytilus perna</i> , <u><i>Pinctada imbricata</i></u> , <i>Cassostrea ryzophorae</i> , <i>Callista macullata</i> Destruído/1978. Obras de engenharia (construções e aterros)	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
13.	Arraial do Cabo	Sítio Dunas da Praia Seca	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
14.	Cabo Frio	Boca da Barra	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> , <i>Trachycardium muricatum</i> , <i>Ostrea sp.</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Barbosa, DR (1999)
15.	Cabo Frio	Sambaqui da Ilha do Vigia	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
16.	Cabo Frio	Sambaqui da Salina Peroano	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> , <i>Ostreidae</i>	IPHAN (2000);
17.	Cabo Frio	Sambaqui de Campos Novos	<i>Mytilus sp.</i> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> , <i>Phacoides pectinatus</i> . Ruim/1961. Obras de engenharia (retirada de aterro para construção de estrada)	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
18.	Cabo Frio	Sambaqui do Forte	<u><i>Pinctada imbricata</i></u> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anomalocardia brasiliana</i> , <i>Anadara notabilis</i>	IPHAN (2000); Kneip, L (1975); Gaspar, MD (1991); Tenório (1996)
19.	Cabo Frio	Sambaqui do Morro do Índio	<i>Mytilus sp.</i> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> Destruído/1973. Obras de engenharia	IPHAN (2000); Mendonça de Souza, AAC (1981)
20.	Cabo Frio	Sítio Cemitério Cabo Frio	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> , <i>Callista macullata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
21.	Cabo Frio	Sítio do Meio	<i>Perna perna</i> , <u><i>Pinctada imbricata</i></u> , <i>Ostreidae</i> , <i>Lucina pectinata</i> , <i>Trachycardium muticatum</i>	IPHAN (2000); Gaspar, MD (1991); Tenório (1996)

TABLE I (cont.)

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
22.	Cabo Frio	Sítio Peró III	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Ostreidae</i> , <i>Arca imbricata</i> , <i>Cypraea zebra</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Gaspar, MD (1991)
23.	Casimiro de Abreu	Sambaqui da Vila Nova	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> Ruim/1969	IPHAN (2000); Mendonça de Souza, AAC (1981)
24.	Macaé	Sítio do Ury	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i>	IPHAN (2000); Mendonça de Souza, AAC (1981)
25.	Macaé	Sítio da Ilha de Santana	<u><i>Pinctada imbricata</i></u> , <i>Chama sp.</i> , <i>Arca imbricata</i> , <i>Ostrea sp.</i>	IPHAN (2000); Lima, TA (1991)
26.	Magé	Sambaqui de Sernambetiba	<b><i>Mytilidae</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Trachycardium mutricatum</i> . Ruim/1981. Obras de engenharia (abertura de estrada, construções)	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978)
27.	Magé	Sambaqui do Arapuan	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> . Regular/1981. Obras de engenharia (loteamento) e agricultura	IPHAN (2000); Mendonça de Souza, AAC (1981)
28.	Magé	Sambaqui do Fernando	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> . Destruído/1973. Obras de engenharia (loteamento e terraplanagem)	IPHAN (2000); Mendonça de Souza, AAC (1981)
29.	Magé	Sambaqui do Guapi	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> . Ruim/1973. Erosão antropogênica (torres de transmissão da Light)	IPHAN (2000); Mendonça de Souza, AAC (1981)
30.	Magé	Sambaqui do Imenezes	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> , <i>Phacoide pectinatus</i> . Destruído/1977. Mineração (de areia)	IPHAN (2000); Mendonça de Souza, AAC (1981)

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Nº	Municipality	Name	Bivalve molluscs cited and observations	References
31.	Magé	Sambaqui do Rio das Pedrinhas	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> , <i>Phacoide pectinatus</i> . Ruim/1981. Obras de engenharia (loteamento) e erosão pluvial	IPHAN (2000); Mendonça de Souza, AAC (1981)
32.	Magé	Sambaqui do Cordovil	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Cassostrea rizophorae</i> , <i>Phacoide pectinatus</i> . Destruído/1973. Obras de engenharia (loteamento) e agricultura	Mendonça de Souza, AAC (1981)
33.	Magé	Sítio Saracuruna	<b><i>Perna perna</i></b> , <i>Ostrea sp.</i> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Cassostrea sp.</i> Destruído/1973. Obras de engenharia (loteamento e construções) erosão pluvial	IPHAN (2000); Mendonça de Souza, AAC (1981)
34.	Niterói	Sítio de Camboinhas	<i>Brachidontes sp.</i> ; <u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Cassostrea rhyzophorae</i> , <i>Lucina pectinata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978); Mello, EMB & Coelho, ACS (1989)
35.	Parati	Abrigo da Ponta do Leste II	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Arca imbricata</i> , <i>Lucina pectinata</i> , <i>Trachycardium mutricatum</i> . Regular/1977. Depredação	IPHAN (2000); Mendonça de Souza, AAC (1981)
36.	Parati	Abrigo de Paratimirim I	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Arca imbricata</i> , <i>Lucina pectinata</i> , <i>Trachycardium mutricatum</i> , <i>Ostrea sp.</i> Regular/1977. Erosão antropogênica	IPHAN (2000); Mendonça de Souza, AAC (1981)
37.	Parati	Sambaqui do Forte	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> <i>Arca imbricata</i> , <i>Trachycardium muricatum</i> , <i>Lucina pectinata</i> . Regular/1980. Erosão antropogênica	IPHAN (2000); Mendonça de Souza, AAC (1981)

TABLE I (cont.)

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
38.	Parati	Sambaqui Mamanguá	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> , <i>Lucina pectinata</i> . Ruim/1977. Erosão antropogênica	IPHAN (2000); Mendonça de Souza, AAC (1981)
39.	Parati	Sambaqui Pouso	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> , <i>Lucina pectinata</i> . Ruim/1977. Erosão antropogênica	IPHAN (2000); Mendonça de Souza, AAC (1981)
40.	Parati	Sítio Ilha Comprida II	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> , <i>Lucina pectinata</i> . Ruim/1977. Depredação	IPHAN (2000); Mendonça de Souza, AAC (1981)
41.	Parati	Sítio Ilha da Cotia	<b><i>Perna perna</i></b> , <i>Ostrea sp.</i> , <i>Anomalocardia brasiliiana</i> , <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> . Destruído/1977. Depredação	IPHAN (2000); Mendonça de Souza, AAC (1981)
42.	Parati	Toca do Cassununga	<b><i>Perna perna</i></b> , <i>Ostrea sp.</i> , <i>Anomalocardia brasiliiana</i> , <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> . Regular/1981. Depredação	Mendonça de Souza, AAC (1981)
43.	Parati	Toca dos Caboclos	<b><i>Perna perna</i></b> , <i>Ostrea sp.</i> , <i>Anomalocardia brasiliiana</i> , <u><i>Arca imbricata</i></u> , <i>Trachycardium muricatum</i> . Bom/1977. Erosão antropogênica	IPHAN (2000); Mendonça de Souza, AAC (1981)
44.	Parati	Trindade I (Sambaqui do Severo)	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anadara notabilis</i> . Destruído/1979. Obras de engenharia (loteamento)	IPHAN (2000); Mendonça de Souza, AAC (1981)
45.	Parati	Trindade II	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anadara notabilis</i> . Destruído/1979. Obras de engenharia (loteamento)	IPHAN (2000); Mendonça de Souza, AAC (1981)

TABLE I (cont.)

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
46.	Parati	Trindade III	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anadara notabilis</i> . Destruído/1979. Obras de engenharia (loteamento)	IPHAN (2000); Museu do Sambaqui da Tarioba (2001); Mendonça de Souza, AAC (1981)
47.	Rio das Ostras	Sambaqui da Tarioba	<b><i>Perna perna</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anadara notabilis</i> . Destruído/1969. Obras de engenharia (construções)	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978)
48.	Rio de Janeiro	Capão da Benta	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Trachycardium muricatum</i> , <i>Lucina pectinata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978)
49.	Rio de Janeiro	Sambaqui Casqueiro de Araçatiba	<b><i>sp. de Mytilidae</i></b> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978)
50.	Rio de Janeiro	Sambaqui do Telles	<b><i>sp. de Mytilidae</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i>	IPHAN (2000); Beltrão, MC (1978); Salles Cunha, (1965)
51.	Rio de Janeiro	Sambaqui do Capão do Gentio	<b><i>sp. de Mytilidae</i></b> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Phacoides pectinatus</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978);
52.	Rio de Janeiro	Sambaqui do Piracão	<u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Trachycardium muricatum</i> , <i>Arca imbricata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Beltrão, MC (1978); Salles Cunha, E (1965)
53.	Rio de Janeiro	Sambaqui do Poço das Pedras	<b><i>sp. de Mytilidae</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Trachycardium muricatum</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Salles Cunha, E (1965)
54.	Rio de Janeiro	Sambaqui do Vaso	<b><i>sp. de Mytilidae</i></b> , <i>Anomalocardia brasiliiana</i> , <i>Lucina pectinata</i> , <i>Ostrea sp.</i> , <i>Trachycardium muricatum</i>	IPHAN (2000); Carvalho, ET (1984); Mendonça de Souza, AAC (1981)

TABLE I (cont.)

List of Rio de Janeiro state archaeological sites that cite species from the Mytilidae family (in bold) and *Pinctada imbricata* (underlined), elaborated out of the IPHAN, INEPAC records and from publications

Nº	Municipality	Name	Bivalve molluscs cited and observations	References
55.	São Pedro D'Aldeia	Sítio Botafogo (Corondó)	<i>Mytilus perna</i> , <u><i>Pinctada imbricata</i></u> , <i>Anomalocardia brasiliana</i> , <i>Macrocalista maculata</i> , <i>Lucina pectinata</i> Ruim/ 1978. Erosão antropogênica (arado, pastagem, agricultura)	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
56.	Saquarema	Sambaqui da Beirada	<i>Brachidontes exustus</i> , <i>Anomalocardia brasiliana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Trachycardium muricatum</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
57.	Saquarema	Sambaqui da Madresilva	<i>Brachidontes exustus</i> , <i>Anomalocardia brasiliana</i> , <i>Ostrea cristata</i> , <i>Lucina pectinata</i> , <i>Donax hanleyanus</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
58.	Saquarema	Sambaqui da Pontinha	<i>Brachidontes exustus</i> , <i>Anomalocardia brasiliana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Anadara notabilis</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
59.	Saquarema	Sambaqui de Manitiba I	<i>Perna perna</i> , <i>Brachidontes exustus</i> , <i>Anomalocardia brasiliana</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
60.	Saquarema	Sambaqui de Saquarema	<i>Perna perna</i> , <i>Anomalocardia brasiliana</i> , <i>Lucina pectinata</i> , <i>Ostrea sp.</i> , <i>Donax hanleyanus</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)
61.	Saquarema	Sambaqui do Moa	<i>Perna perna</i> , <i>Brachidontes exustus</i> , <i>Ostrea sp.</i> , <i>Lucina pectinata</i> , <i>Trachycardium muricatum</i>	IPHAN (2000); Mendonça de Souza, AAC (1981); Kneip, L (2001)

According to Mendonça de Souza (1981), the Ponta da Cabeça and Prainha sites, in Arraial do Cabo municipality, were in a ravaged state in 1978 due to construction work, land fill removal and other types of anthropogenic erosion. This suggests a possible contamination of the malacological records obtained by Gaspar (1991a) and Tenório (1995), since the inhabitants of that region use to

discard the shells in the place where they collect the mussels.

In Cabo Frio municipality, the Campos Novos sambaqui was examined in 1961 and its conservation status was deemed poor, due to land removal for road construction. The Morro do Índio sambaqui, when examined in 1973, was considered destroyed by construction work.

Sítio do Meio site is located between the Boca da Barra and Salinas Peroano sites, on a 7-meter rise, with an approximate area of 240 m<sup>2</sup> and a depth of 70 cm (Tenório 1996). Although Gaspar (1991b) recorded the presence of *Perna perna* in this site, it would be well to consider that although this site is currently located in an environmental protection area, it is still subject to anthropogenic influence, since both tourists and local residents frequently go to that area for picnics. *Perna* was not found in neighboring sites.

Botafogo (Corondó) site, in São Pedro D'Aldeia municipality, was in a poor state of conservation, since land had been prepared for agriculture and cattle grazing, having been revolved to a depth of 60 cm (Carvalho 1984).

Likewise, the Vila Nova site, in Casimiro de Abreu municipality, Barra de São João district, had been ravaged by construction work by the time it was examined in 1969 (Mendonça de Souza 1981).

The Tarioba site, in Rio das Ostras municipality, was discovered by a team of researchers from the Brazilian Archaeological Institute in 1967, but excavation only began in 1998, when more than two thirds of the site had been ravaged as a result of the real estate boom (Dias Jr. *et al.* 2001).

In Macaé municipality, the Ury sambaqui was also undergoing anthropogenic erosion in 1969, being already considered in poor condition (Mendonça de Souza 1981). At the Santana island site, located in the same municipality, Mytilids were not present in the archaeological records, not even in the form of crumbs, even though they are quite abundant and intensely exploited at present. This fact struck the Museu Nacional/UFRJ researcher Tania Andrade Lima, who considered the possibility that the mussels were not present at the time of the prehistoric occupation, since it was unlikely that their food value would be ignored (Lima 1984, 1991).

The Sernambetiba, Arapuã, Cordovil, Fernando, Guapi and Imenezes sambaquis, and the Saracuruna site, in Magé municipality, were in an extremely bad state of conservation in 1973, due to agriculture, road construction, earth leveling, plot delimitation, sand extraction, electric power plant installation and powerline construction (Mendonça de Souza 1981). Likewise, according to Mendonça de Souza & Mendonça de Souza (1983), the Rio das Pedrinhas sambaqui should originally measure approximately 2000 m<sup>3</sup>, having been partially destroyed when streets for plot delimitation were

opened up. Valves of *Perna perna* found in this site were “decomposed or quite fragmented, forming brilliant lenses” This remark suggests a difficulty of identification, coupled with a possible attempt to associate past conditions with the present surrounding environment.

The Parati sites, where the occurrence of *Perna perna* was mentioned, also presented some type of anthropogenic erosion, such as construction, land filling, plundering, plot delimitation etc.. Abrigo Ponta do Leste II site was plundered even by treasure hunters, who are common in the area of Ilha Grande bay, due to its numerous islands which were once a haven for the pirates who preyed on Rio de Janeiro in the past (Mendonça de Souza 1981).

Kneip (2001) published the relation of the malacological fauna found in the Saquarema sites, *Perna perna* having been cited in the Moa, Saquarema and Manitiba I sites.

Although Magalhães *et al.* (2001) affirm that *Perna perna* was one of the most consumed molluscs in the Beirada and Manitiba I sambaquis, this species does not feature in the malacological listings of the Beirada sambaqui published in Kneip (1994 and 2001). The citations mention “mussels” and the family Mytilidae, emphasizing the fragility of their valves, admitting the difficulty of species recognition and associating the iridescent aspect of the soil with the presence of *Perna perna* on the site. Once again there are signs of an attempt to establish a correlation of the past fauna with the current one.

With the aim of confirming the evidence of existing records, so as to confirm and date the occurrence of shells, we solicited from Lina Kneip the samples of this species collected at the Manitiba I site. According to Kneip, confirmation and dating of the two samples is impossible, since the shells were sent for identification and then discarded. The Museu Nacional/UFRJ malacologist Elisa Maria Botelho de Mello informed (pers. comm.) that the Manitiba I site samples did include *Perna perna* shells that were discarded after identification.

Kneip then suggested that a sample be taken from the Manitiba I site itself, where “an enormous quantity of *Perna perna* shells could be seen”. In March 2001, under Lina Kneip's guidance, approximately one kilogram of material was taken from each level of the Manitiba I site. The samples were taken to the IEAPM and analyzed by Dr. Flavio da Costa Fernandes.

About the sampling performed at this site the following can be considered: the first, more superficial level, of black coloration, was poor in malacological remains, with a preponderance of *Anomalocardia brasiliiana*; level II was grey and had a somewhat greater number of shells, also with a preponderance of *A. brasiliiana*. Level III was black and was nearly devoid of fauna remains. The lower levels IV, V, VI and VII displayed a yellowish tinge resulting from the enormous quantity of shells of the mussel *Brachidontes exustus*. Contrary to Kneip's statement, no valves of *Perna perna* were found in the sampling.

The Moa and Saquarema sites, situated in heavily populated urban areas, were already very altered when they were discovered. The Saquarema sambaqui researched in the 1930s by Simões da Silva was taken apart at that time to serve as filling material for paving the main town streets. Today its remains are buried under streets, buildings and squares. In 1993, cistern reform and construction work led to the discovery of funereal rites. Archaeological remains were disturbed in several places by recent addition of rubble (Kneip 1995), which lead us to believe that the occurrence of *Perna perna* in this site is the result of contamination of the record.

In the south coast of the state, in Angra dos Reis municipality, in a region of many islands, several prehistoric sites have been detected, where different sambaquis, in different states of preservation, were found: Sítio do Joaquim, on Caieira island; Sítio da Caieira I and II, on the same island; Sítios do Bigode I and II on an islet in the midst of a mangrove in Ribeira bay; Sítio Alexandre, on Algodão island; Sítio do Jorge on the island by the same name, in Bracuí sound; Peri and Major sambaquis (Lima 1991).

In all these sites, valves and dozens of pearls of *Pinctada imbricata* were found. This is the most exploited bivalve in all sites, after the oysters, which represent the majority of molluscs consumed. Strangely, no occurrence of *Perna perna* was recorded in the fauna records recovered from the studied sites. Out of the family Mytilidae, only *Brachidontes sp.* was cited. However, benthic fauna surveys on the surroundings of Ribeira bay, in Piraquara de Dentro e Piraquara de Fora sounds, from February 1980 to January 1981, mention the occurrence of both *P. imbricata* and *P. perna* (Quitete 1981).

A similar fact occurs in the Lagoon Region of Rio de Janeiro state, where *P. imbricata* is recorded in archaeological sites in the municipalities of Armação dos Búzios, Arraial do Cabo, Cabo Frio and São Pedro D'Aldeia. This distribution was confirmed by Maria Cristina Tenório (Museu Nacional/UFRJ) who, when visiting the two sites of Ilha de Cabo Frio at Arraial do Cabo, could verify the abundance of *Pinctada imbricata* and the absence of *Perna perna* from the archaeological records, even though the latter is present today on the adjacent rocky shores. Tenório (2001, pers. comm.) stated she had never seen *Pinctada imbricata* shells as large as these before and considered that, if such a large shell were discarded at a site some one or two hundred years ago, it would become a part of the ensemble and might be incorporated into the prehistoric registers by researchers.

The presence of *Perna perna* on the sambaquis of other Brazilian states could not be established either.

In the fauna remains of the COSIPA sambaquis, located in Casqueirinho island in the region of Santos, São Paulo state, *Perna perna* was not found (Figuti 1993). Garcia (1972), studying the Piaçaguera and Tenório sites on the shores of São Paulo state, verified that at the time the sites were formed, species of family Mytilidae did not occur in the area, whereas today they are common on the nearby rocky shores.

Nishida (2001) believed that the scarcity of *Perna perna* among the fauna remains of Mar Virado site (~2640 B.P.) at Ubatuba, São Paulo state, was the result of a food taboo among the fisher-gatherers, since the species is currently very abundant on the island's rocky shores. However, Nishida (pers. comm.) explained that the site underwent intense occupation by fisher communities until the 1960's, which caused a great disturbance in the stratigraphy of the site; in other words, the surface levels were mixed with deeper ones, which great likelihood of contamination of the malacological record. She further noted that the valves of *Perna perna* found in the samples date from a recent period, since there was a housekeeper living on the island until a year ago, and the remains were found on the site surface.

According to Luiz Ricardo L. Simone (2002, pers. comm.) in the University of São Paulo (USP)'s Zoology Museum animal collection from several sambaquis, a good part of which is constituted

by the De Fiori collection from the 1960's, no *Perna perna* shells were found. He nevertheless found the presence of other Mytilids, such as *Mytella falcata* and *M. guyanensis*, although in low quantities, *Crassostrea* being the predominant genus in the samples. Although he did not conduct an exhaustive search, Simone did not find any material originating from sambaquis in this museum's *Perna perna* drawers.

Gikovate (1933) lists the bivalve species found in 15 sambaquis explored in Iguape, São Paulo state, and 19 sambaquis in Imbituba and Laguna, Santa Catarina state, and *Perna perna* is not on the list.

Bigarella (1949) after examining 150 sambaquis in Paraná and Santa Catarina states, verified the occurrence of 49 mollusc species, *Anomalocardia brasiliiana*, *Ostrea sp.* and *Lucina jamaicensi* being the more common ones. *Perna perna* was not mentioned. However, Gofferjé (1950), doing a survey of marine molluscs on the Paraná state shores, verified the occurrence of large beds of *Mytilus perna*.

Bandeira (1992) recorded the occurrence of *Perna perna* in the Enseada I archaeological site, but when contacted she considered that the shells were sometimes "minced", and that whoever analyzed the material may have tried to correlate it with the present environment, due to the difficulty in identifying it. In addition, Enseada I and II sambaquis, located in São Francisco do Sul municipality, Santa Catarina state, were less than 25% whole at the time they were registered at the IPHAN, having been destroyed by road work construction carried out by the municipality city hall after 1962 (IPHAN 2002).

Oliveira (2000) analyzed 42 sambaquis in Joinville, Santa Catarina state, among them the Ipiranga sambaqui and the Ilha do Mel I, II and III sambaquis, located in Ilha do Mel island. *Perna perna* was not found in any of the sambaquis analyzed.

Piazza (1966) mentions *Anomalocardia brasiliiana*, *Ostrea sp.*, *Tellina lineata*, *Cardium muricatum* and *Lucina lineata* as the bivalve species found in Ponta das Almas sambaqui, in Florianópolis municipality, Santa Catarina state. Nevertheless, when he analyzed the remains of the Espinheiros I sambaqui, in Joinville, he recorded the occurrence of family Mytilidae, but made no mention of *Perna perna*. Figuti & Klökler (1996) did not find the presence of this species in the zooarchaeological vestiges of Espinheiros II Sambaqui.

Farias & Magalhães (2002), analyzing the

molluscs of the Homem do Sambaqui – Colégio Catarinense and Museu Universitário Professor Osvaldo Rodrigues Cabral - Setor Arqueológico-UFSC collections, with material from the archaeological sites in Rio do Meio and Armação do Pântano do Sul, in Florianópolis, and of sites in Içara and Itajaí, Santa Catarina state, recorded the presence of *Perna perna*. In contrast, Rosa (1999) recorded the occurrence of *Perna perna* in the present malacological fauna in the vicinities of Sítio Içara, Içara, Santa Catarina state, but was unable to find vestiges of the species in remains dating back 1160 ± 50 B.P. He also noted that some marine species, relatively common in that area, were not found in the archaeological deposits.

According to Rohr (1977), among the bivalve species of Pântano do Sul site, Santa Catarina state, was *Mytilus perna*; nevertheless, Schmitz & Bitencourt (1996) could not find this species and could not discover why there is so little resemblance between their bivalve list and the one by Rohr. This might be explained by the constant anthropogenic disturbance suffered by the site, since its different levels lie under the fishers' village at Pântano do Sul, containing recent archaeological material.

The Cabeçudas archaeological site, localized at the beach by the same name, in Itajaí municipality, Santa Catarina state, was also suffered present-day cultural interference. A manioca mill was built over it, later being replaced by a yacht club (Schmitz & Verardi 1996).

Schmitz & Bitencourt (1996), studying Laranjeiras I site, located in Camboriú municipality, Santa Catarina state and dated at 3815 ± 145 B.P., did not record the presence of *Perna perna*.

The existence of *Perna perna* in the fauna remains of an archaeological site would evidence its native character, as long as specific dating was carried out and the possibility of record contamination discarded. For this reason, Farias & Magalhães' (2002) record is at odds with all the data presented in the present study.

In the Capão D' Areia sambaqui, located on the eastern Atlantic shore of the Laguna dos Patos Restinga, Rio Grande do Sul state, mollusc remains were identified and quantified (Silva *et al.* 2002). Among the bivalve species mentioned was *Perna perna*. According to Flavio Ricci Callipo (MAE/USP, pers. comm.), one of the text's authors, 24 shells of *Perna perna* were in the three top stratigraphic levels, down to 30 cm, and were

whole, many of them still with vestiges of the covering cuticle, an indication of recent age and of contamination of the record.

Rosa (1996) did not find vestiges of *Perna perna* in the fauna remains of Itapeva site at Torres, Rio Grande do Sul state.

In Bahia state, systematic studies started with the work of Valentin Calderón from UFBA (Bahia federal University) at Pedra Oca sambaqui (Periperi, a suburb of Salvador), where the first absolute chronology for precolonial populations was established: 2.830 ± 130 B.P. Among the mollusc species encountered, *Perna perna* was cited as a rare species.

When one analyzes all the citations made for *Perna perna* in the sambaquis of the Brazilian coast, it becomes clear that the records are flawed. In the majority of cases the sites were in a poor state of conservation and showed signs of contamination of the archaeological records, while in others identification was uncertain and the iridescent aspect of the soil was associated with the presence of *Perna perna*. Lastly, there was an attempt to correlate the species found with those currently existing in the surrounding area.

On account of the data presented, in association with the existence of recent cases that display the invasive behavior of the genus, the hypothesis that the brown mussel *Perna perna* be an exotic species in Brazil gains strength, since its presence in Brazilian prehistory cannot be established.

In contrast, according to Hilary John Deacon (2002, pers. comm.), researcher in the Archaeology Department of Stellenbosch University, South Africa, this species is found in the deepest levels of the shellmounds in the Klasies River area (34° 6' S, 24° 24' E), in deposits dating from 60,000 to 115,000 B.P., the oldest date obtained for this species. One hundred kilometers to the west, near Plettenberg Bay, another archaeological site was found, with 10,000 year-old records of this bivalve.

Given the absence of records of *Perna perna* in Brazilian prehistory which could confirm its native status, and the presence of this species in the current and archaeological African records dating back more than 100,000 years, it could be speculated that this species has its origin in Africa and that it came to Brazil at the time of the slave trade.

During the XVI century, Brazil emerged as the greatest destination for African slaves in the Americas, becoming the New World's largest slave importer, a status it maintained during most of the

duration of the slave trade to the Americas. From 1580, the number of Africans deported to the Americas exceeds the volume of the sea trade to European ports and to the Atlantic islands. From then on, slave trade ceases to be just another of the several activities initiated by the period of Western discoveries to become the mainstay of the Western Empire economy (Table II).

Fig. 2 illustrates the slave trade routes, emphasizing the trajectories of triangular commerce. It is in this sense that we appeal to geography as a support for a better understanding of history. In the XV, XVI and XVII centuries, slave ships left Senegal and Gambia and reached the Brazilian northeastern ports. Neither the

TABLE 2

Estimate of the number of Africans (in thousands) arriving in Brazil\*

Period	No. of Africans arriving in Brazil
1451-1475	—
1476-1500	—
1501-1525	—
1526-1550	—
1551-1575	10
1576-1600	40
1601-1625	150
1626-1650	50
1651-1675	185
1676-1700	175
1701-1720	292,7
1721-1740	312,4
1741-1760	354,5
1761-1780	325,9
1781-1790	181,2
1791-1800	233,6
1801-1810	241,3
1811-1820	327,7
1821-1830	431,4
1831-1840	334,3
1841-1850	378,4
1851-1860	6,4
1861-1870	0
<b>Overall total</b>	<b>4029,8</b>

\*Source: Alencastro (2000:69)

departure nor the arrival points coincide with the current distribution of *Perna perna*. Starting in the XVIII century, ships hailed from Congo, Angola, Mozambique and Tanzania, places where the existence of *Perna perna* has been recorded, to the states of Bahia and Rio de Janeiro. Although the northeastern region was a part of the slave trade ship routes, the most intense traffic was the one destined to Rio de Janeiro. In effect, the routes seen in these maps lends credence to the bioinvasion hypothesis.

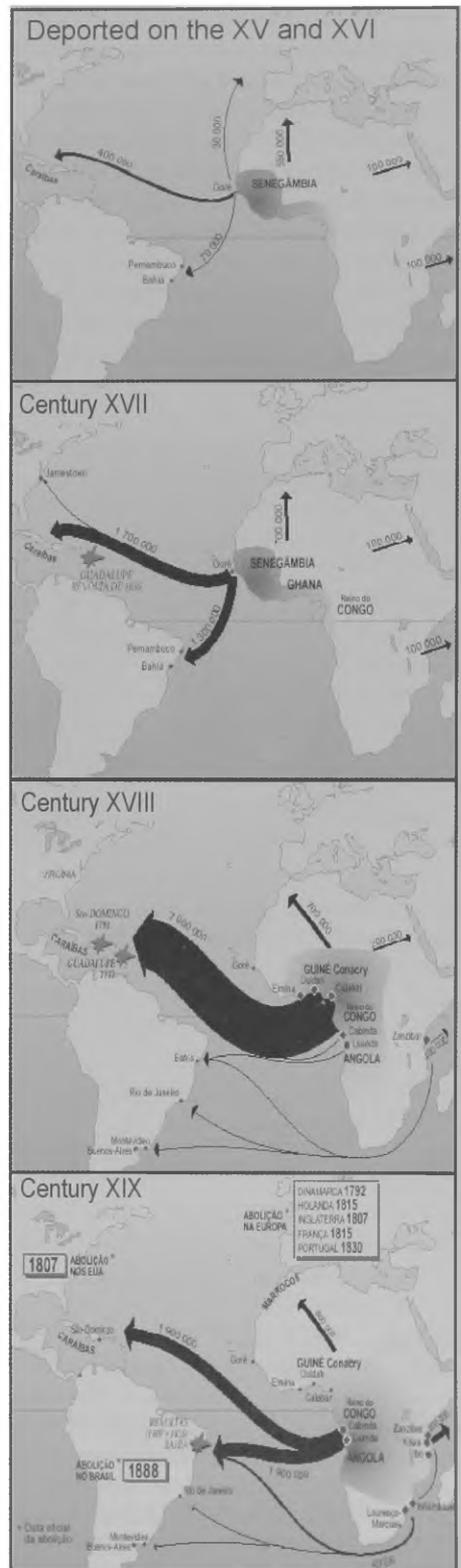
Gollasch (2002), evaluating the importance of ship hull fouling as a vector for the introduction of exotic species, carried out a comparative study between the water and the sediment transported in the ballast tanks and fouling on ship hulls. Non-native species were registered in 38% of all the ballast water sampled, in 57% of all the sediment and in 96% of all samples taken from the hulls, indicating that biofouling is an important vector of species introduction. Gollasch further noted that in some cases fouling attained a thickness of 30 cm, cirripeds and bivalves being the most frequently found organisms.

Eno *et al.* (1997) have suggested that biofouling on ship hulls may have been the most important vector for species introduction in the past. Currently there exist various records of marine benthic species introduction on the Brazilian coast, showing in most cases strong indication of introduction via biofouling.

According to Borrero & Díaz (1998), the problem of biological invasions is an old one, and many introductions may have happened without becoming known. It is for this reason that it is important that prehistoric records be studied, to try and make a survey of living organisms and of fossils, for it is only when the native organisms of a given continent are established that it will be possible to identify the exotic species (Furon 1969).

**Comparison of the distributions of *Perna perna* and *Pinctada imbricata* on the rocky shores and on the archaeological sites on Cabo Frio island, Arraial do Cabo, Rio de Janeiro state**

Figure 2 – Slave trade routes from the XV to the XIX centuries. Source: UNESCO.



The Cabo Frio island archaeological site, although included in the IPHAN registers, has not been described in any work published so far. This site was chosen by us for a more detailed comparison between the zooarchaeological registers and the surrounding fauna, with the aim of reinforcing the reasoning here expounded on the origin of the brown mussel *Perna perna* on the Brazilian coast.

*Pinctada imbricata* is the most abundant bivalve on the Cabo Frio island site, occurring on the neighboring rocky shores as well. On the other hand, *Perna perna*, although present on the rocky shores, was not to be found at this site.

Shell size of the bivalve *Pinctada imbricata* at the archaeological site varied from 2.4 to 5.8 cm in

length, and from 2.4 to 5.2 cm in width, with averages of 4.09 and 3.59 cm, respectively. On the rocky shore, length varied from 0.9 to 4.9 cm, and width from 0.7 to 4.7 cm, with an average of 3.7 and 3.3 cm, respectively. Fig. 3 shows the frequency distribution for length and width of *Pinctada imbricata* both for the archaeological site and the rocky shore. The application of the Komorogov-Smirnov test to this data set showed that there are no significant differences in shell size between the rocky shore and the archaeological site ( $p > 0,10$ ; Fig. 4).

These data are interesting in that one might intuitively expect a concentration of larger *Pinctada imbricata* individuals in the archaeological site as compared to the rocky shores. If the ecological conditions of these shores did not change over time,

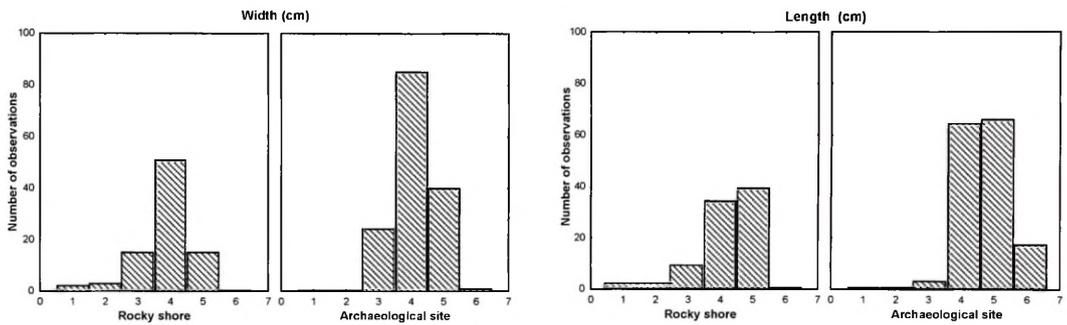
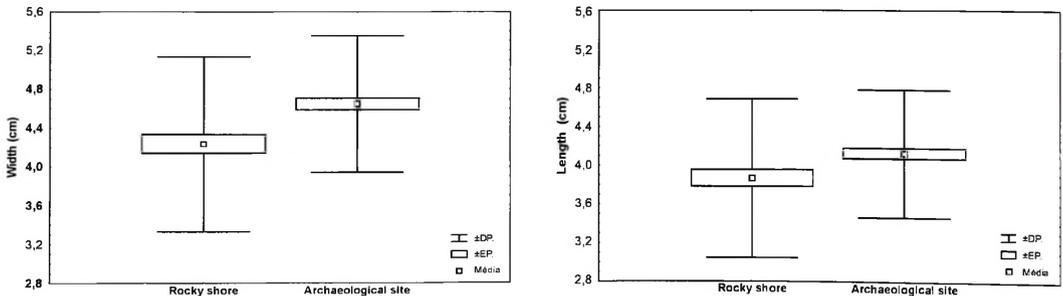


Figure 3 – *Pinctada imbricata* shell length and width frequency distribution on the rocky shore and on the archaeological site of Cabo Frio island, RJ.



Max. neg. diff.	Max. pos. diff.	p	Average	Average	SD	SD	N	N
			RS	ARS	RS	ARS	RS	ARS
-0.10	0	$p > 0,10$	3.86	4.12	0.83	0.66	86	150

Figure 4 – Results of the Kolmogorov-Smirnov test for *Pinctada imbricata* shell length and width from the rocky shore and from the archaeological site (RS=rocky shore, ARS=archaeological site, SD=standard deviation, SE= standard error, N=number of sampled organisms).

these data can be used as an indication of the low selectivity of the mollusc gatherers in the past.

*Perna perna* is the most abundant bivalve on the rocky shores of Cabo frio island today, being largely used as a food source by the present-day population. Fig. 5 presents a histogram of length and width distribution of the individuals collected on the rocky shore. Shell size presented a length range varying from 1.3 to 10.9 cm, and width from 0.8 to 4.7 cm, with averages equal to 6.3 and 2.87 cm, respectively.

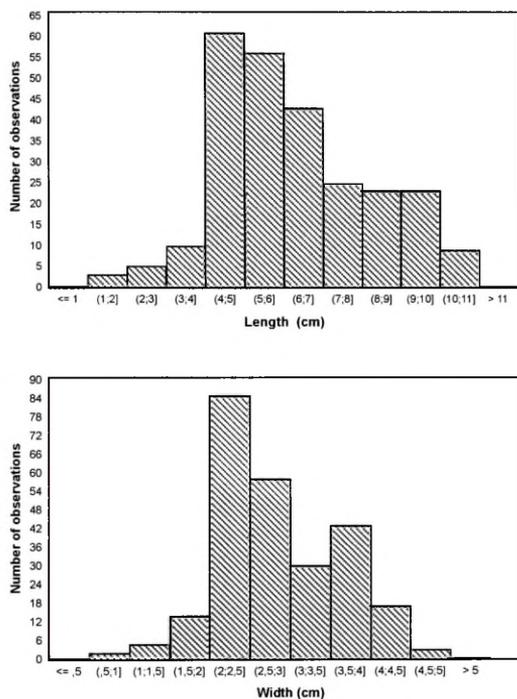


Figure 5 – Shell length and width distribution histogram for *Perna perna* collected on the rocky shore.

It is unlikely that, at the time this site was occupied, *Perna perna* was ignored as a food item, unless a taboo relating to this species had arisen. Lima (1991) had already considered the possibility that this species was not present at the time of occupation in the prehistory of Rio de Janeiro state, since it is currently abundant but is absent from the historical record. This fact was also noted by Nishida (2001) when she attempted to justify this mollusc’s absence from the fauna remains of the Mar Virado site in Ubatuba, São Paulo state.

For the collection undertaken on the rocky shore of Cabo frio island, an attempt was made to reproduce the behavior of prehistoric shell collectors, i.e., visual localization of the resource followed by extraction using simple tools, such as natural spatulas made from shells, wood, rocks, etc.

To collect 86 individuals of *Pinctada imbricata*, it was necessary to employ skin diving along more than 100 m of rocky shore for a period of approximately 2 hours. The collection of 258 individuals of *Perna perna* lasted for about 30 minutes, on a stretch of less than 5 m of rocky shore. Since *Perna perna* inhabits the intertidal zone, skin diving was not necessary for its collection. These observations indicate that the availability of *Perna perna* on the rocky shores, at least in the present, is several times larger than that of *Pinctada imbricata*.

Similarly, a comparison of the average sizes of these two species suggests that *Perna perna* should have been more attractive as a food item, had it been available to prehistoric gatherers. The present study does not have data on the paleoecological conditions of the Arraial do Cabo region, nor of the Brazilian coast as a whole, but the fact that no significant size difference in *Pinctada imbricata* between the rocky shore and the archaeological site in the island exists indicates that, at least for *P. imbricata*, size distribution has not changed very much. Nothing can be said, however, about the resource’s availability, since the abundance of *P. imbricata* at the site, quite different from the rocky shore, may be the result of thousands of years of shell accumulation.

The intriguing absence of the brown mussel *Perna perna* at the island site, as well as the impossibility to confirm its presence on the sambaquis of the Brazilian coast, may be explained by the following hypotheses:

1. The shells were destroyed by time due to their fragility of their valves. However, careful sifting is done on the material taken from sambaquis and no vestiges of shells of this species have been found, even in a crumbled state. In those cases in which the species was cited, it was seen that the record had suffered contamination of shells from historic times. In addition, it is common to make associations between the surrounding environment and the site itself to try to study the context to which it belongs, which may have led to infer that the mussels found in the sambaqui and those found in the surroundings belong to the same species.

2. The prehistoric gatherers had a food taboo in relation to *Perna perna*. However, it is unlikely that, given its abundance, this species was ignored as a food resource, or even as raw material for making adornments or artifacts.

3. *Perna perna* is an exotic species in Brazil. The absence of prehistoric records of its occurrence, coupled with this species' invasive behavior, lends credence to the hypothesis that the brown mussel *Perna perna* is an exotic species, having possibly been introduced in Brazil several years ago, possibly at the time of the slave trade.

## Conclusion

Given that species are considered cryptogenic, cosmopolitan or native if they have prehistoric records between 5,000 and 400 B.P, and exotic if they enter a given ecosystem 400 B.P, there are strong reasons to believe that *Perna perna* is an exotic species in Brazil, originating from South Africa and having been introduced to Brazilian shores many years ago, possibly with the development of sea trade and particularly with the slave trade, via bioincrustation on the hulls of slave ships.

SOUZA, R.C.C.L.; FERNANDES, F.C.; SILVA, E.P. A study on the occurrence of the brown mussel *Perna perna* on the sambaquis of the Brazilian coast. *Rev. do Museu de Arqueologia e Etnologia*, São Paulo, 13: 3-24, 2003.

**ABSTRACT:** *Perna perna* is a bivalve that occurs in the tropical and subtropical regions of the Atlantic and Indian Oceans, as well as in the Mediterranean Sea. The present work aims to investigate the hypothesis that the distribution of *Perna perna* in Brazil may be the result of bioinvasion events. For that purpose, occurrence of the species in shellmounds along the Brazilian coast was verified. In the majority of the shellmounds, in Brazil no shells of *Perna perna* were found. In those mounds for which occurrence of this species is cited, the citations are dubious. *Perna perna* may be an exotic species which may have been introduced in Brazil several years ago, possibly with the development of sea commerce all through the slave trade period.

**UNITERMS:** *Perna perna* – Shellmound – Bioinvasion – Exotic species.

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