Malacopedia

São Paulo, SP, Brazil
Volume 5(2): 11-16

ISSN 2595-9913
May/2022

Islands: an important source of mollusk endemicity

Luiz Ricardo L. Simone

Museu de Zoologia da Universidade de São Paulo
lrsimone@usp.br; lrlsimone@gmail.com
ORCID: 0000-0002-1397-9823

Abstract

Islands are isolated areas important for studies on speciation because of the isolation. Preliminary results of a project on insular mollusk life in the middle Atlantic, mainly Brazil, is presented, showing that islands located relatively close to the coast already have endemic land snails, but have the same continental marine malacofauna. Oceanic islands, on the other hand, maintain the endemicity of the non-marine snails, but the marine mollusks have ~50% of endemicity. The survey includes all Brazilian oceanic islands (Fernando de Noronha, Trindade, Martin Vaz, Rocas, São Pedro e São Paulo) and some British ones (Ascension and Santa Helena). The mollusk diversity is also proportional to the size of the island.

DOI:

Keywords: insular life, endemicity, faunal survey, evolution.

Introduction

Surrounded by water, islands are isolated geographic bodies. They are covered by life forms, usually called “insular life”, which can suffer some degree of isolation from other populations, and, consequently, endure speciation. Although there are also freshwater islands, this paper deals mainly with marine islands.

Related to mollusks, as the isolation is fundamental for the speciation, the islands can be classified in 3 categories:

1) Islands very close to the coast

They are islands in such distance to the coast that can be measured in meters. Because of the proximity, there is a gene flow between the island and the mainland, precluding the establishment of local variants and, consequently, the specialization. Both, marine and non-marine mollusk

populations, constantly receive visitors from the mainland, which contribute with genetic matter and the uniformity of both populations. This kind of island is not covered by this paper.

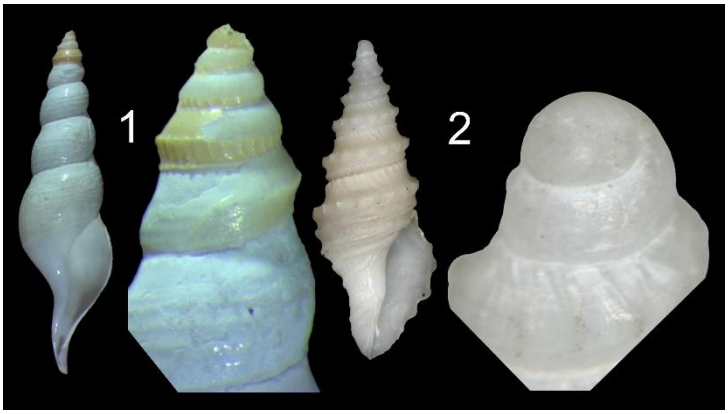
2) Coastal islands far removed from the coast

In this category, the islands are away from the coast in distances measured in kilometers. The subaquatic environment is practically the same as the coastal one, and rarely some insular marine species is different from the continental ones. On the other hand, the non-marine, i.e., land, freshwater and estuarine, malacofauna has not a constant flow of visitors from the adjacent mainland. In this case, the non-marine species tend to specialize, and to be different from those from the mainland.

3) Oceanic islands

Oceanic islands are usually separated from the mainland coast by distances measured in hundreds of kilometers. Great depths are found between the coast and the island, breaking the subaquatic ecosystem continuity. Thus, both marine and nonmarine mollusks are greatly isolated from the coastal populations. The gene flow is practically absent, and only viable in groups with long-term pelagic larvae, as well as in exceptional accidental transportation, like rafts, hurricanes, etc. In oceanic islands, the endemicity of mollusk species is much more common. It is found even in marine taxa, and reaches almost 100% in non-marine species.

Of course, there is not an absolute separation amongst these categories of islands. As well as the surrounding environment, like type and intensity of currents and winds, temperature, depth, avian flow and migrations, etc., can greatly influence the degree of isolations of insular mollusks. Here only an average approach is applied and explored, but it is recognized that lots of exceptions exist. Additionally, this paper is mostly based on an ongoing project on insular malacofauna focusing the south-western Atlantic. It is not concluded, but some preliminary information is already available, and can be disclosed. However, no absolute numerical and statistical framework is presented here. They are reserved to the final report of that project.



1-2. Examples of different types of protoconchs. 1, multispiral, *Famelica* sp. (Raphitomidae – Brazil) (L 8.8 mm); **2**, paucispiral, *Gemmula mystica* (Turridae – Brazil) (L 20.8 mm) (Holotype MZSP 32766 by Simone, 2005).

Another important aspect that is important to be established is in respect to the degree of dispersion of larvae phase of the aquatic forms. There are mollusks in such the development is direct, i.e., all larva phases are intracapsular. The young specimen hatch as a miniature of the adult (e.g., marginellids). In these cases, theoretically, the dispersion is minimum and the protoconch usually is paucispiral, i.e., has a single whorl (Fig. 2). On the other hand, there are groups with long-term larvae, which live and eat on plankton for weeks and even months (e.g., tonnoideans). In these cases, a widespread dispersion is expected, and the protoconch is multispiral, i.e., has 3-4 whorls (Fig. 1), usually the protoconch has 2 regions, an early one – protoconch 1 – in which the animal hatched, and

a late one – protoconch 2 – in which the animal built in its planktonic phase before the metamorphose to the benthonic life – planktotrophic. Of course, there are all kinds of intermediary types between these two extremes, in groups that have planktonic phase, but not so long and sometimes not feeding (living from its yolk, i.e., lecithotrophic). Despite the examples here being gastropods, the same phenomenon occurs in other mollusk classes. The mollusks' larva characters will be subject of another Malacopedia issue.

Although the mollusks with long term larvae are usually more widespread and more frequent in remote islands, and those of direct development are more restricted, this is not absolute. The practice shows us that exceptions are usual.

Study of case: Brazilian coastal and oceanic islands

Coastal islands

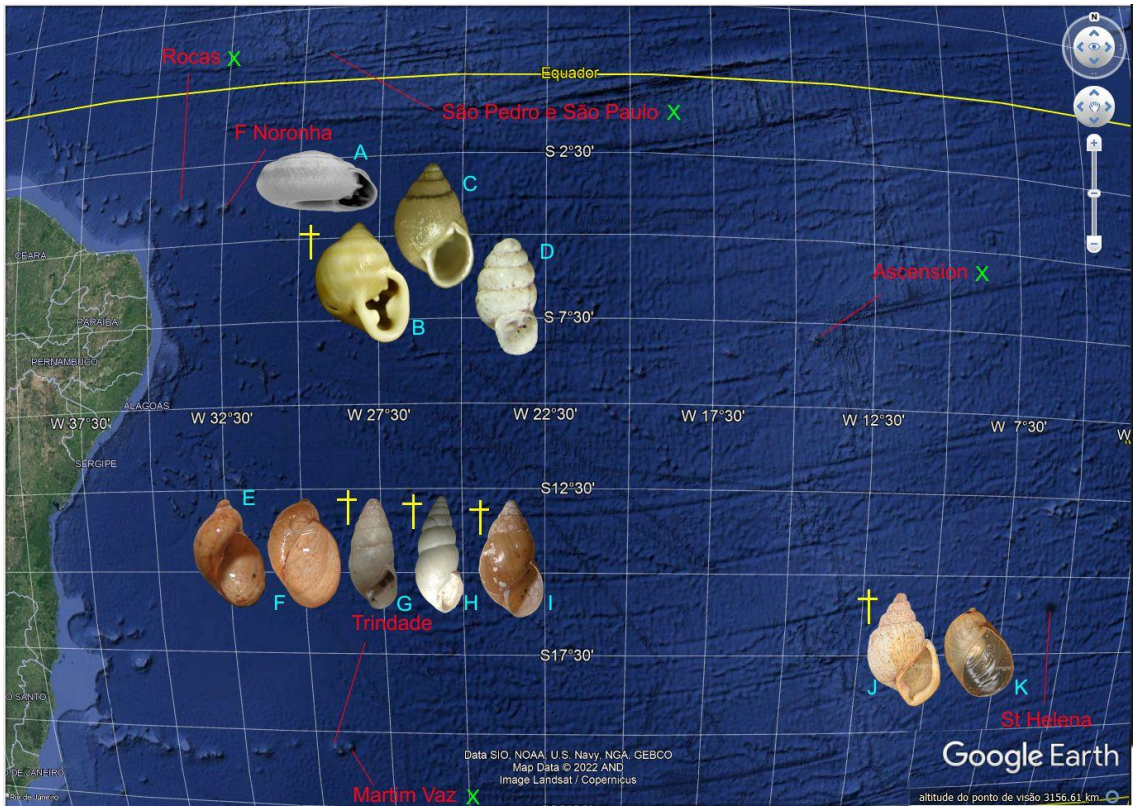
As referred above, a project dealing with a survey on marine and non-marine malacofauna has been developed for decades by the author and team. Several expeditions collecting samples from forests up to deep diving in coastal islands in SE Brazilian coast, Brazilian Oceanic islands, some British South Atlantic Islands – Ascension and Santa Helena, Azores, and some south Caribbean islands. The detailed results, statistics and lists are still being processed and will be published in some years. However, certain interesting preliminary information is possible to be informed.

2. Stretch from Brazilian coast from São Paulo and Paraná. (From Google Earth) Studied coastal islands that possess a dominant endemic land snail indicated by red arrow. Islands Vitória and Búzios: *Megalobulimus* sp (still undescribed, ~120 mm); Alcatrazes: *Bulimulus sula*; Queimada Pequena: *Drymaeus micropyrus*; Queimada Grande: *Helicina* sp (still undescribed, ~20 mm); Castilho: *D. castilhensis*; Currais: *D. currais*. Details in Simone & Amaral (2018); Simone et al. (2020).

By proximity, the insular bodies off São Paulo and Paraná coasts were the first studied. No endemic marine species was detected, as well several of them lack land snails. However, those islands shown in Fig. 2 are revealed to possess a large land snail, i.e., above 2 cm, called as "dominant species", mostly already studied and published, and some micro land snails that are still under analysis. These micro snails are found in soil and leaf litter, corresponding mostly to problematic families such as subulinids, diplommatinids and euconulids, which need much more time to be understood. The so-called dominant species revealed all endemic from the islands they were collected, and there is a single dominant species per island, all shown in Fig. 2 (Simone & Amaral, 2018; Simone et al, 2020; two species still under description).

The SE Brazilian coastal islands have a particularly interesting back history. The sea level in that coast was ~120 m lower than today's in the early Holocene (Vieira, 1981; Simone & Amaral, 2018), when the sea level started to rise up to today's level ~8,000 year ago, and has been stable since then. Thus, most of these coastal islands were connected to the mainland, since no area deeper than 120 m occurs between the present coast and those islands. Certainly, the luxuriant Atlantic Rainforest that occurs today in that coastal region covered entirely the area now submerged. Despite 8,000 years does not appear to be sufficient for a speciation, possibly those islands have any kind of previous isolation. This can explain the occurrence of the remaining endemic species mentioned above.

Oceanic islands



3. Map showing tropical and subtropical south Atlantic studied oceanic islands (red arrows) (from Google Earth), displaying found endemic land snails. Green "X" show islands lacking land snails. Yellow crosses indicating recently extinct species, possibly by anthropic action. **Fernando de Noronha**: **A**, *Ridleia quinquelirata* (W 6 mm); **B**, *Bonnarius ramagei* (L 22 mm); **C**, *Hyperaulax ridleyi* (L 10 mm); **D**, *Gastrocopta solitaria* (L 2 mm); **Trindade**: **E**, *Oxyloma beckeri* (L 10 mm); **F**, *Succinea lopesi* (L 10 mm); **G**, *Vegrandinia trindadensis* (L 8 mm); **H**, *Bulimulus brunoi* (L 20 mm); **I**, *Naesiotus arnaldoi* (L 10 mm); (all from Simone, 2006); **Santa Helena**: **J**, *Chilonopsis nonpareil* (L 42 mm); **K**, *Succinea sanctaehelenae* (L 16 mm) (both courtesy Femorale).

Related to the Brazilian Oceanic islands, a different result was provisionally obtained. No land snail was collected in Atol das Rocas, Martin Vaz and São Pedro e São Paulo. The land malacofauna is 100% endemic in remaining islands of Fernando de Noronha and Trindade (Fig. 3) (Salvador et al. 2013a, b, 2014). Related to marine species, about 50% are endemic species in all islands and no close relation to long-term larvae and no influence of the African fauna were found. Comparing these provisional results with British islands in the central-south Atlantic – Ascension and Santa Helena (Fig. 3), only in the latter was found land snails, and both are endemic species. However, related to the endemicity of the marine species, the higher influence of African species, and

the low knowledge on the African malacofauna preclude any detailed analysis. Apparently, the endemicity degree also orbits 50%. Azores, another studied oceanic island (not in Fig. 3), is closer to Africa. It, in the Project, represents those NW African Iberian fantastic islands (Canarias, Madeira, Cabo Verde, etc.), which apparently have a similar malacofauna history. All of them have a myriad of land malacofauna in which endemicity is high, but not totally established because of long anthropic local influence. The marine malacofauna, on the other hand, apparently has a low degree of endemicity, around 10%, with most species of long-term larvae.

The marine species of the Brazilian oceanic islands are still being studied and gradually being described. Fernando de Noronha is the largest set of Islands, with ~350 km^2. It has the largest number of marine mollusk species, over 400, with ~200 of them endemic. Unfortunately, no one has been described so far, as their description depends on a careful anatomical and molecular comparison with their continental counterparts. Trindade is the second largest Brazilian oceanic island, with ~10.2 km^2. It has about 200 mollusk species, with ~100 endemic. They are in the same level of study as those of Fernando de Noronha. The São Pedro e São Paulo Archipelago has only ~0.2 km^2 and has less than 40 known mollusk species. This regional malacofauna is the best studied, from the ~20 endemic species, several ones were already described (Simone, 2008a, b, 2009; Spotorno & Simone, 2013).

These data already show a direct correspondence between the size of the insular area and the number of species – the larger the area, the larger the number of species. This is somewhat intuitive, as large areas permit more diversity of habitats and ecosystems.

Another interesting phenomenon is the ephemeral occurrence of some species. This was detected at least in Fernando de Noronha in, e.g., two marine gastropods: *Cassis tuberosa* and *Thais nodosa*. *C. tuberosa* was reported as very common, even in high concentrations in shallow waters in that island in 1970's, eating sea-urchins (Matthews & Coelho, 1972), while *T. nodosa* were abundantly collected in 1980's in MORG (Museu Oceanográfico de Rio Grande) expeditions to that island, as that institution's collection demonstrates. In expeditions of the present Project, performed after 2000's, only fragments of *C. tuberosa* shells were found, and not even a piece of that of *T. nodosa*, despite all the efforts to find them, including the same places where they had been collected. Possibly, in so remote islands, the colonization of these species may be exceptional, resulting from an anomalous current containing larvae. A population may temporarily establish in that ecosystem, but it does not last long.

A different phenomenon happened in the same place, Fernando de Noronha, with its endemic limpet *Lottia noronhensis*. It was previously very abundant in lower supratidal and upper intertidal zones in all hard substrates in the entire coastal line. In the last expedition (2018) the species almost was not found! Less than 10 individuals were detected! (Simone et al., 2019). F. Noronha has been slightly modified in coastal areas for tourist purposes, and there is no idea how these modifications can threaten intertidal species. As far as we detected, no other intertidal or supratidal mollusk species was impacted, only *L. noronhensis* suffered drastic reduction of density. But, as far as known, in the 3 following years, no complementary observations were conducted. At least the warning was given.

Acknowledgments

I thank José & Marcus Coltro for permission of using the Femorale imagens in Fig. 3J-K

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