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The terrestrial microgastropods of Trindade Island, Brazil

(Gastropoda, Pulmonata)

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Trindade is an oceanic island 1140 km off Vitória, Brazil. The Marion Dufresne Expedition (1987) recovered there many land snail shells, all stylommatophoran pulmonates. Here, four microgastropod species found in this material are recorded for the first time on Trindade Island: *Lilloiconcha gordurasensis* (Charopidae), *Pupisoma macneilli* (Valloniidae), *Gastrocopta barbadensis* (Gastrocoptidae) and *Vertigo* sp. (Vertiginidae). The last one could be a non-native, introduced species. Unfortunately, none of these species can be currently found alive on the island, which can be indicative of extinction.

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Introduction

Trindade Island lies about 1140 km from the Brazilian coast (20°30'S 29°20'W), off the city of Vitória, Espírito Santo state (Fig. 1). The island is the top of a volcanic cone and, together with the Martin Vaz Island lying 48 km to the east, is the single emergent peak of the Vitória-Trindade seamount chain. The island was discovered in 1501 by a Portuguese expedition and, throughout its history, ships from many military and scientific expeditions have visited it (from Europe, the USA and Brazil), carrying people, food (including livestock) and supplies. In 1957, the Brazilian navy established an oceanographic station on Trindade. The latest large campaign to pass by the island was the Marion Dufresne Expedition (MD-55), in 1987, a joint endeavour of the Muséum National d'Histoire Naturelle (Paris, France) and the Universidade Santa Úrsula (Rio de Janeiro, Brazil) that recovered many land snails.

Here we report four microgastropod species (shells only) found in this material and discuss their presence in the island. Presently, Trindade Island has only a handful of recorded native land snail species (Salvador et al. 2013, 2014): *Bulimulus brunoi* (Ihering, 1917), *Happia* sp., *Naesiotus arnaldoi* (Lanzieri & Rezende, 1971), *Oxyloma beckeri* Lanzieri, 1966, *Succinea lopesi* Lanzieri, 1966 and *Vegrandinia trindadensis* (Breure & Coelho, 1976), being the later genus endemic to the island. Moreover, there is also a single non-native species reported for Trindade (Alves 2008): *Bradybaena similaris* (Férussac, 1821).

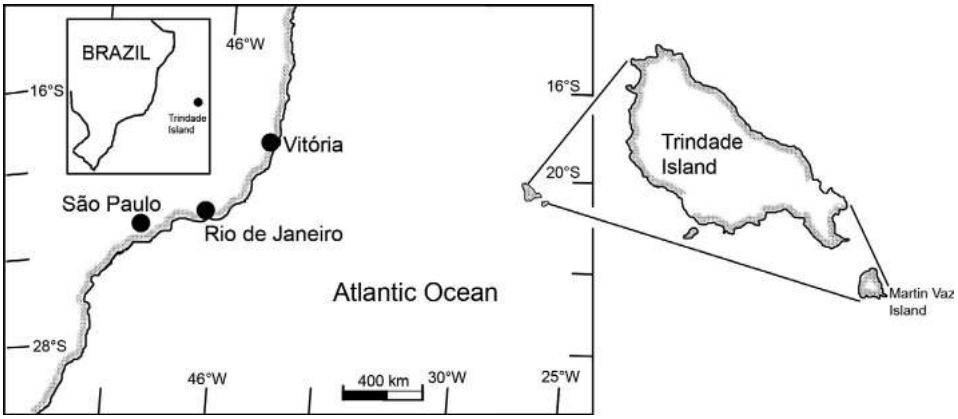

Fig. 1. Map showing the location of Trindade Island, off Vitória (20°30'S 29°20'W).

Material and methods

The material herein analysed comes from the R/V Marion Dufresne Expedition, as well as subsequently collected material. All collected specimens are stylommatophoran pulmonates and consist only of empty shells, mostly in a good state of preservation. The material is housed in the collections of the Muséum National d'Histoire Naturelle (MNHN, Paris, France) and the Museu de Zoologia da Universidade de São Paulo (MZSP, São Paulo, Brazil). For complementary examination, samples were mounted on stubs, coated with a gold-palladium alloy and observed under a Zeiss DSM 940 scanning electron microscope at the MZSP.

Systematics

Family Charopidae
Genus *Lilloiconcha* Weyrauch, 1965

Lilloiconcha gordurasensis (Thiele, 1927)
Figs 2A–C

Main distinctive features: Shell diminutive (mean width: 2 mm), discoidal with slightly elevated spire; ~4½ whorls. Apical region flattened; body whorl rounded. Suture well-marked. Protoconch (~1¼ whorl) sculptured by spiral striae; transition to teleoconch clear. Teleoconch sculptured by numerous closely-set strong prosocline axial ribs, with delicate reticulate pattern between ribs. Aperture circular. Peristome simple, sharp. Umbilicus wide, funnel-shaped. Colour light brown, alternated with darker reddish brown axial bands.

Material examined: BRAZIL. Southwest Trindade Island, 10–30 m altitude, P. Bouchet coll., 22/v/1987: MNHN, 41 shells; MZSP 104738, 7 shells; MZSP 104739, 2 shells (coated for SEM).

Remarks: The overall shell shape and colour, alongside the proto- and teleoconch sculpture (Fig. 2C), compare remarkably well to *Lilloiconcha gordurasensis*, a species widespread in South America, known from the Northeast of Brazil to Paraguay and Argentina (Miquel et al. 2004, Simone 2006). There are also some records from Colombia and Peru (Hausdorf 2005), but they should be re-checked. The type locality of *L. gordurasensis* is Gorduras, near the city of Belo Horizonte, Minas Gerais state, Brazil (Thiele 1927). The species also has a dubious fossil record from the Middle Miocene of Patagonia, Argentina (Miquel & Bellosi 2007).

Family Gastrocoptidae
Genus *Gastrocopta* Wollaston, 1878

Gastrocopta barbadensis (Pfeiffer, 1853)
Fig. 2D

Main distinctive features: Shell diminutive (mean height: 2 mm), oval to pupiform; ~4.5 whorls. Greatest width on body whorl. Spire apex rounded. Protoconch rounded (~1½ whorl), smooth; transition to teleoconch not clear. Teleoconch smooth. Whorls profile convex. Suture weakly marked. Aperture rounded, orthocline. Peristome reflexed (except upper palatal region). Aperture with five teeth: one large and bifid angulo-parietal, two columellar (upper one larger) and two palatal (lower one larger). Colour light brown.

Material analysed: BRAZIL. Southwest Trindade Island, 10–30 m altitude, P. Bouchet coll., 22/v/1987, MNHN, 50+ shells; MZSP 104735, 8 shells; MZSP 104736, 2 shells (coated for SEM).

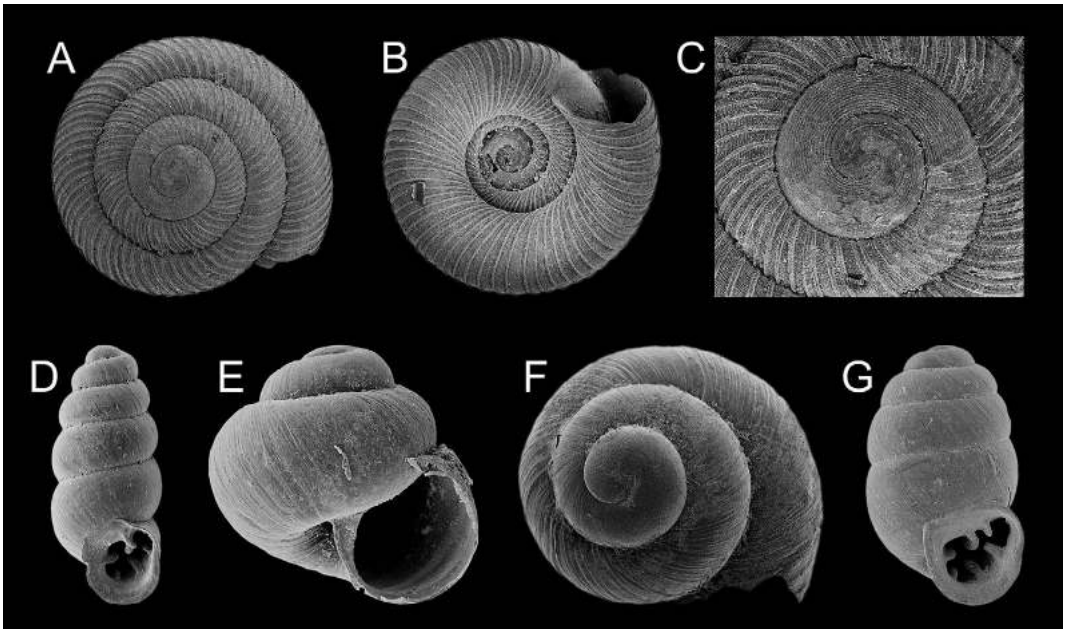

Fig. 2. A–C. *Lilloiconcha gordurasensis*. **A.** Apical view (MZSP 104739, spec #1, shell width 1.9 mm). **B.** Umbilical view (MZSP 104739, spec #2, shell width 1.8 mm). **C.** Protoconch detail. **D.** *Gastrocopta barbadensis*, apertural view (MZSP 104736, shell height 1.9 mm). **E–F.** *Pupisoma macneilli*. **E**. apertural view (MZSP 106069, shell height 1.2 mm). **F.** apical view. **G.** *Vertigo* sp., apertural view (MZSP 104734, shell height 1.5 mm).

Remarks: The specimens from Trindade compare well to *Gastrocopta barbadensis*, mainly by its distinctly bifid anguloparietal lamella (Pilsbry 1916–1918). This species is known from the Caribbean Islands (type locality: Barbados), Venezuela and Fernando de Noronha, another Brazilian oceanic island (Pilsbry 1916–1918; Richards & Hummelinck 1940). The present specimens are also somewhat reminiscent of *Gastrocopta servilis* (Gould, 1843), but this species has usually weaker teeth, with a straighter anguloparietal lamella and wider shell (Pilsbry, 1916–1918).

Family Valloniidae
Genus *Pupisoma* Stoliczka, 1873

***Pupisoma macneilli* (Clapp, 1918)**
Figs 2E–F

Main distinctive features: Shell diminutive (mean height: 1 mm), globose-conical; 2½ to 3 whorls. Suture well-marked. Whorls profile convex. Protoconch (~1 whorl) smooth; transition to teleoconch unclear. Teleoconch sculptured by fine prosocline ribs. Aperture circular. Peristome simple, not reflected except for columellar region largely reflected over umbilicus. Umbilicus wide. Colour yellowish brown, translucent.

Material examined: BRAZIL. Southwest Trindade Island, 10–30 m altitude, P. Bouchet coll., 22/v/1987, MNHN, 24 shells; MZSP 104737, 5 shells; MZSP 106069, 1 shell (coated for SEM).

Remarks: The present specimens compare reasonably well to *Pupisoma macneilli*, a species with a wide distribution, ranging from southern USA (type locality Alabama) to northern Argentina, but with a single record from Brazil, more specifically from Paraná state (Hausdorf 2007). Nevertheless, the present specimens are slightly smaller than what has been reported for the species (Hausdorf 2007).

Family Vertiginidae
Genus *Vertigo* Müller, 1774

***Vertigo* sp.**
Fig. 2G

Main distinctive features: Shell diminutive (mean height: 1.75 mm), oval to globose; ~4½ whorls. Greatest width on body whorl. Protoconch (~1 whorl) dome-shaped, smooth; transition to teleoconch not clear. Teleoconch smooth. Whorls profile convex. Suture weakly marked. Aperture rounded (except parietal region, straight), orthocline, with slight reen-

trance on palatal margin. Peristome reflected. Aperture with six teeth: two parietal (median tooth larger), two columellar, two palatal. Colour light brown.

Material analysed: BRAZIL. Southwest Trindade Island, 10–30 m altitude, P. Bouchet coll., 22/v/1987, MNHN, 41 shells; MZSP 104733, 6 shells; MZSP 104734, 2 shells (coated for SEM).

Remarks: Unfortunately, not knowing whether the present specimens are natural occurrences or not (see Discussion below), it is very hard to identify a *Vertigo* species based on its shell alone. Nevertheless, Trindade's specimens are reminiscent of *V. rugosula* Sterki, 1890, from southeastern USA (Nekola & Coles 2010), in overall shell shape, whorl profile and aperture dentition, despite not displaying the coarse sculpture of the latter.

Discussion

Since its discovery, many ships have visited Trindade, providing many opportunities for introducing alien species. Land snails can be easily unintentionally introduced, mainly associated with plants and soil (notably horticultural and agricultural products), but containers and cargo of any kind can carry snails (Cowie & Robinson 2003, Cowie 2011, Hayes et al. 2012). Eggs or juveniles may be especially readily transported, making detection even more difficult (Cowie & Robinson 2003, Cowie 2011). The same can be said of microgastropods such as the ones reported here.

Given such history, it is very hard to tell whether these new records are natural occurrences or introductions. This is especially true for *Vertigo*, since no species from this genus is known to naturally occur in Brazil (there is a record of the non-native *V. ovata* Say, 1822; Simone 2006). Therefore, the present *Vertigo* sp. seems to be a non-native species. Land and freshwater gastropods have been unintentionally introduced in many parts of the world and their impacts on native ecosystems are particularly drastic on oceanic islands (Régnier et al. 2009, Cowie 2011, Hayes et al. 2012). Moreover, the native land and freshwater mollusks of oceanic islands seem to be the most susceptible species to extinction (Abdou & Bouchet 2000, Purvis et al. 2000), accounting for the largest proportion of declared extinct species (Régnier et al. 2009).

The presence of *Bradybaena similaris*, the single previously recorded non-native species on Trindade (Alves 1998), could not be confirmed in the present work. Nevertheless, it is a readily identifiable species and there is no reason to doubt the record. *Bradybaena similaris* is native to Southeast Asia and a worldwide invader, very widespread and well established in Brazil (Simone 2006, Carvalho et al. 2008).

With the present records, a total of 10 species (not counting *Bradybaena similaris*) is known from Trindade Island. All the newly recorded species herein were found in great numbers on Trindade Island in the 1980s, mainly in vegetation near the beaches, but expeditions in recent years were unable to find them again, either dead or alive. Moreover, most of the other native species also could not be found alive (Salvador et al. 2013), with the notable exception of *Happia* sp. and *Succinea lopesi* found in 2013 living on the top of the island's peaks, which might have acted as refuges (Salvador et al. 2014). This apparent extinction could be related to the introduced mammals: goats, introduced at the beginning of the 18th century (Silva & Alves 2011), and house mice, unintentionally introduced with the first settlers (Castro 2010).

The introduced goats caused a drastic deforestation on Trindade, resulting in the extirpation of many endemic plant species (Alves 1998, Castro 2010, Silva & Alves 2011). The extinction of native plants and the resulting loss of habitat might have played a role in the disappearance of the land snails. The goats were completely eradicated only in 2005, leading to a slow recovery of the native flora (Silva & Alves 2011). The snails should therefore be able to reestablish themselves if some populations have managed to survive, as remarked by Salvador et al. (2013, 2014). However, introduced house mice still remain, their numbers reaching tens of thousands (Silva & Alves 2011). Mice will prey voraciously on land snails, especially if other food sources are scarce (Allen 2004), and the snails of a proper size to become their prey would be the native orthalicoids *Bulimulus brunoi* and *Naesiotus arnoldoi*. Still, it is too early to assume that the island's species are extinct; as the recent discovery of living snails on the island's peaks has shown (Salvador et al. 2014), there is still hope for Trindade's mollusks.

Finally, it should be noted that, unfortunately, Trindade Island is still open to future invasions and some measures to avoid this should be taken. Previous experiences with invasive snails make it clear that preventing an invasion is much easier than trying to control or eradicate an invasive species (Cowie 2011). Even so, mollusks usually receive little attention when compared to plants and insects (Keller et al. 2007). Since Trindade does not have a large permanent settlement and thus the flow of people is limited, it would not be too difficult to implement and maintain an inspection and quarantine program (on the lines described by Robinson 1999 and Cowie 2011) to search for alien species in ships and their cargo and to properly deal with them.

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