

**In preparation for J. of Conch.**

## **An annotated checklist of the extant and Quaternary land molluscs of the Deserta Islands, Madeiran Archipelago**

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### **Introduction**

The Madeiran Archipelago has a rich and largely endemic fauna of land snails that have attracted attention since the early 19<sup>th</sup> century. While PAIVA (1867) and WOLLASTON (1878) provided early accounts of this fauna, including species known only as Pleistocene or Holocene fossils, later work has added considerably to their work both by new discoveries and taxonomic revision (WALDÉN 1973; BANK, GROH & RIPKEN 2002; SEDDON 2008; BANK 2009; GROH *et al.* 2009). The Archipelago, consisting of Madeira itself, Porto Santo with its associated islets and the three islands of the Desertas, Chão, Deserta Grande and Bugio, holds many species or subspecies confined to one island or island group.

Within the Archipelago, the fauna of the Desertas has been the least studied, mainly due to relative inaccessibility. Further, while there are massive and well-worked fossiliferous deposits on both Madeira and Porto Santo (GOODFRIEND *et al.* 1996; CAMERON *et al.* 2006), only a single fossiliferous site (on Bugio) was known (WOLLASTON 1878). Accounts of the Desertan fauna were complicated by disputes between PAIVA and WOLLASTON as to the origin and status of a number of records (TEIXEIRA *et al.* 2019 a). More recently, CAMERON & COOK (1999) reported fossils from a single site on Deserta Grande, and provided a checklist of Desertan species both fossil and recent. GROH (unpublished) had also detected fossil material from Deserta Grande in 1985.

Work in the 21<sup>st</sup> century has transformed this situation. Many fossiliferous deposits have been found on Deserta Grande, and more species have been recovered from the deposits on Bugio, resulting in the discovery of new taxa (TEIXEIRA *et al.* 2019 a). Increased surveying, mainly by I.S. and D.T. has yielded new records of living taxa, including new species (TEIXEIRA *et al.* 2019 a & b). Here, we provide a new, annotated checklist for the land mollusc fauna of the Deserta Islands incorporating these new discoveries and taxonomic revisions.

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**Late Quaternary land snail faunas from the Desertas Islands (Madeira): high diversity and endemism is followed by impoverishment and extinction in recent times**

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**Introduction**

Understanding the tempo and mode of faunistic changes (e.g., changes in diversity, individuals' density, speciation, extinctions, etc.) and identifying the environmental stressors that drive such shifts is an urgent scientific and societal task to better predict future faunistic outcomes under current warming and urbanized scenarios. In particular, land snails are ecologically relevant organisms that contribute to the organic matter decomposition and calcium cycle. However, it is well understood that snails are declining rapidly worldwide due to their high sensitivity against environmental and human disturbances (Lydeard et al. 2002). Over the last decade, it has been increasingly demonstrated that ecological and conservation issues are best informed when using a geohistorical (long-temporal) perspective because ecological (short-time) scales are not sufficiently long to embrace the entire range of environmental variability and the subsequent response of organisms. In the present investigation, we measure faunistic changes of land snail assemblages from the Desertas Islands of the Madeira archipelago throughout the Quaternary (last ~100 ka) and discuss potential drivers of ecological changes to the present combining geochronology, isotope geochemistry and biodiversity metrics.

The Madeiran archipelago is an ideal location to conduct this research because it has a very rich and mainly endemic land snail fauna as a result of accelerated speciation events typical of oceanic islands (e.g. Lowe 1831, 1855, Paiva 1867, Wollaston 1878, Waldén 1983, Bank et al. 2002, Seddon 2008). Faunistic trends of these organisms over geological (multi-millennial) time scales are achievable in this region because fossil assemblages of pristinely preserved shells are plentiful across a variety of Quaternary sedimentary deposits on Madeira (loc. cit., Groh & Hemmen 1984a, 1986a, Hemmen & Groh 1985, Hutterer & Groh 1993, Neubert & Groh 1998), and on Porto Santo and its neighbouring islets (e.g. Groh & Hemmen 1984b, 1986b, Hemmen & Groh 1984, 1985, 1986, Cameron et al., Seddon). Fossil shelly assemblages have been excavated from massive aeolian deposits of calcareous sands, paleosols and colluvial sediments. On the island of Madeira, the oldest land snail shells on these islands have been dated to >100 ka, while the most recent subfossils coincide with the time of human colonisation at around 1420 CE. On Porto Santo, rich but regionally differentiated faunas appear to have remained relatively stable until the arrival of humans (Cameron et al., 2006). In contrast, the pre-colonisation faunas on Madeira appear to change in the proportions of forest and open-country species recorded, and cold periods are characterised by rapid sand accumulation and no fossil preservation, leaving a gap in the record between c. 45 and 8 ka (Cameron & Cook, 1996). In both cases, more than 30% of the species-level taxa recorded in the deposits are now extinct, and most of this extinction is likely caused by human activity (Goodfriend et al., 1994; Cameron & Cook, 1996 & 1999).

While previous published work has investigated the snail faunas on Madeira and Porto Santo, fossil and modern snail assemblages from The Desertas Islands (Chão, Deserta Grande and Bugio) are less known. The Desertas Islands are more challenging to study due to limited accessibility constrained by the terrain, and the lack of sandy aeolian deposits from which fossil shells might be recovered. Until recently, only two reliable sources of fossils were known: from "muddy deposits" on the southern summit of Bugio (Wollaston, 1878) and from small areas of calcarenite at the northern extremity of Deserta Grande (Cameron & Cook,

1999). The first of these, initially described in the mid-19<sup>th</sup> century, was undated and had not been re-examined, while the small samples from the latter, beyond the reliable range of radiocarbon dating, were dated to somewhere between 60 and 90 ka (Cameron & Cook, 1999).

Within the 21<sup>st</sup> century, the activities of staff employed by the Parque Natural da Madeira, and most particularly by Isamberto Silva, have transformed our knowledge of the Desertan snail fauna. The known extant fauna has been increased beyond that catalogued by Cameron & Cook (1999), including some “Lazarus” species (Teixeira et al., in prep.). Further, many small colluvial deposits containing shells have been found on Deserta Grande, and the deposits on the summit of Bugio have been sampled again in a systematic manner. Studies on the assemblages found in these deposits have already resulted in the description of new taxa and the nomenclatural revision of others (Teixeira et al., 2019). Dating of individual shells within some of these deposits has been used to explore the time-averaging effects of colluvial reworking and accumulation (New et al., 2019).

In this paper, we present the first comprehensive survey of land snail communities throughout the Quaternary to the present (last 100ka) of the Desertas Islands. Snail diversity and community structure shifts are then investigated through time to assess the tempo and mode of ecological change. Finally, faunistic changes are compared to climate and human factors to attempt to identify stressors that have shaped snail communities in these oceanic and volcanic islands. Data presented here are constrained by stable isotopes and geochronology, and are compared to published studies from other nearby islands.

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**Revision of the genus *Serratorotula* from Porto Santo  
with description of a new species.**

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