



Original research article

The cone snails of Cape Verde: Marine endemism at a terrestrial scale



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ABSTRACT

Cape Verde in the Eastern Atlantic is typical of many island groups in supporting a wealth of endemic species both terrestrial and marine. Marine gastropod molluscs of the genus *Conus*, commonly known as cone snails, occur in coastal tropical waters throughout the globe, but in Cape Verde their endemism reaches its apogee with 53 out of 56 species occurring nowhere else, the majority of which are restricted to single islands and frequently to single bays. However, Cape Verde is rapidly moving to a tourism-based economy with a projected boom in infrastructure development often coincidental with the shallow-water habitat of many range-restricted *Conus*. The conservation assessment of *Conus* to standards of the International Union for the Conservation of Nature (IUCN) Red List of Endangered Species, found that 45.3% of 53 species assessed from Cape Verde are threatened or near-threatened with extinction compared to 7.4% of 579 species in the rest of the world. The only three *Conus* species globally assessed as Critically Endangered and on the cusp of extinction are all endemic to Cape Verde. Our analysis of *Conus* species distribution, together with spatial data of coastal protected areas and tourism development zones, identify important areas for future research and new marine protection. Our findings show that endemism with its associated risks for *Conus* in Cape Verde has worldwide parallels with many non-marine taxa, while our proposed strategy for *Conus* conservation extends beyond the confines of the country and this taxonomic group.

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1. Introduction

Small islands and archipelagos, isolated by distance and ocean currents, support centres of endemism in both terrestrial and marine taxa (Roberts et al., 2002). However, these endemism 'hotspots' are often subject to threats from natural and anthropogenic forces that can have a disproportionate impact on the biodiversity they support (Fordham and Brook, 2010). Cape Verde in the tropical Eastern Atlantic is such a 'hotspot' and although it is poorly represented by mammals, it is rich in endemic invertebrates including 473 species of arthropod and 140 species of beetle (Triantis et al., 2010), and widely recognised for its endemic plants (Duarte et al., 2008; Romeiras et al., 2016) and reptiles (Vasconcelos et al., 2013). In the surrounding seas endemic zoanths occur (Reimer et al., 2010), and it is also here that marine endemism reaches its apogee in the venomous marine gastropod genus *Conus* (Peters et al., 2013).

Cape Verde is an archipelago of ten volcanic islands and several islets (Fig. 1) 570 km west of Senegal and is the most southerly of the Macaronesian islands. There is also a shallow seamount known as the João Valente Shoals between the islands of Boa Vista and Maio, with a platform at 14 m that is probably a guyot (Ramalho, 2011). The Canary Current

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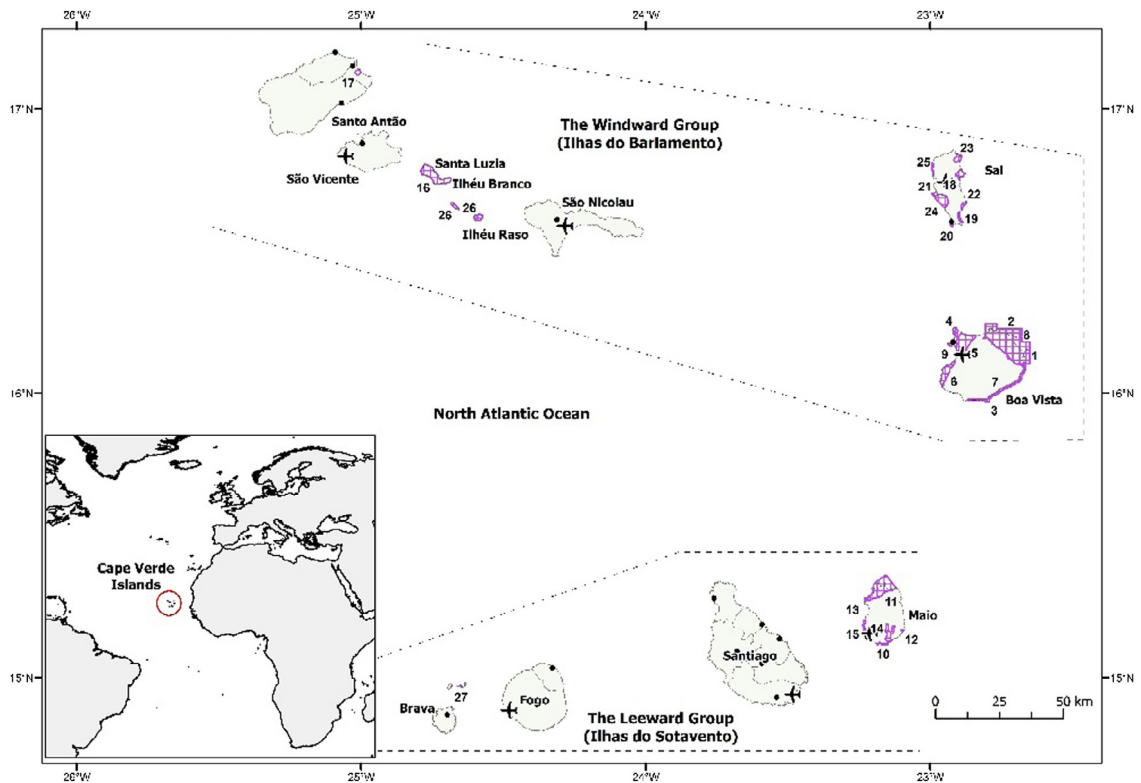


Fig. 1. Map of Cape Verde with protected areas with a marine or coastal element shown in green, major towns as black circles and airports with a plane symbol. Protected Area names and sizes may be cross-referenced to the key in this map from Table S1. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

flowing south-west from Morocco brings nutrient-rich waters to the region attracting both artisanal and international fishing fleets (Mundt, 2012). With the exception of Santa Luzia, all the islands are inhabited. Service industries account for 73% of the country's economy, with agriculture and fisheries together constituting only 9% (Nshimyumuremyi and Simpasa, 2015). Cape Verde has few natural resources apart from marine products and services and the land is generally unsuited to agriculture, such that around 80% of food is imported (de Carvalho, 2013).

Tourism is now considered Cape Verde's primary economic force and including directly associated sectors, is responsible for 40% of gross domestic product (2014), forecast to increase to 49% by 2025 with visitor numbers expected to reach nearly 701 000 by 2025 (World Travel & Tourism Council, 2015). In addition to attracting foreign investment tourism also drives the construction sector (AfDB et al., 2013) including new harbour facilities at Porto Grande, São Vicente, and international airports on Boa Vista and São Vicente to augment those already on Sal and Santiago. Plans have also been agreed for the development of a large international casino on the islet of Santa Maria off the southern coast of Praia, Santiago (Semedo and Gomes, 2015).

To support and develop tourism while protecting the natural environment, Integrated Tourism Development Zones (ZDTI) have been delineated (Cabo Verde, 1994) and selected for geographical location and landscape suitability (Fig. 2). Tourism Reserve and Protection Zones serving as buffers to ZDTIs offer some natural protection from development, although incursion from ZDTIs into these zones has made their value questionable (GEF/UNDP, 2013). Prior to development for each ZDTI a management plan is required which must then undergo a full environmental impact assessment. No form of extraction is allowed within a ZDTI (Decree-Law 29/2006). ZDTIs are managed by Cabo Verde Investimentos (CVI) and the Sociedade de Desenvolvimento Turístico das Ilhas de Boa Vista e Maio (SDTIBM) on behalf of the government. Currently, there are 25 ZDTIs designated principally around Santiago, Maio, Boa Vista, Sal and São Vicente, in which large-scale investment in infrastructure is anticipated (Fig. 2) (SDTIBM, 2010).

In 2003, Decree-Law No. 3/2003 (44/2006 amended) nominated 47 protected areas (PA) for Cape Verde (Tables S1 & S2); however, not all have been gazetted and most are not staffed owing to a complexity of land ownership and lack of funding (Laurie and Benchimol, 2013). All have suffered from a general lack of management capability (Laurie and Benchimol, 2013; UNDP, 2009). A large-scale initiative to consolidate all PAs under a single structural plan was launched in 2009 through a joint enterprise between the United Nations Development Programme (UNDP), the Global Environment Facility (GEF), and the Government of Cape Verde (UNDP, 2009). The project's long-term goal was "to conserve globally significant terrestrial and marine biodiversity in priority ecosystems of Cape Verde through a protected area system's approach". Central to the

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