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Nota editorial

No bom caminho

No segundo número do sétimo volume desta revista quase parece que as nossas preces expostas no editorial anterior foram ouvidas. Vieram da Alemanha 14 estudantes e investigadores consagrados para explorar seis ilhas de Cabo Verde e encontraram 18 novos registos de espécies terrestres relativamente às listadas por Arechavaleta *et al.* (2005). Estes novos registos incluem as primeiras observações de várias espécies para algumas dessas ilhas e ainda novas observações para Cabo Verde. Referimo-nos ao primeiro artigo intitulado "*Adições ao inventário da biodiversidade terrestre de Cabo Verde*". Esperemos que este sirva de motivação a outros grupos de investigação para trazerem mais estudantes a este arquipélago em viagens de estudo.

Também os portugueses responderam à chamada e parecem ter notado um fenótipo e comportamento diferentes nos polvos residentes nas ilhas Desertas. Neste segundo artigo, designado "*Um potencial novo endemismo: especiação do polvo comum,* Octopus vulgaris*, nas ilhas Desertas, Cabo Verde?*", as possíveis explicações para essas observações são discutidas, abrindo caminho para novos estudos genéticos pormenorizados sobre este tema. Note-se que esse artigo é resultante, uma vez mais, de uma bolsa atribuída pelo Fundo SCVZ Desertas. Aproveitamos esta deixa para informar que este Fundo brevemente abrirá um novo concurso, desta vez apenas para estudantes e investigadores de Cabo Verde. Por isso prevemos que 2019 será um ano que dará bons frutos nativos à *Zoologia Caboverdiana.*

Gostaríamos ainda de frisar que neste segundo número, esta modesta porém pertinente revista com revisão por pares dá um pequeno salto qualitativo, passando de dois artigos e uma nota breve para três artigos originais, onde também participam investigadores cabo-verdianos. Refirmo-nos mais precisamente ao terceiro e último artigo, designado "*Método* in situ *para avaliar dados biométricos de* Pinna rudis *Linnaeus, 1758*". Neste trabalho os autores apresentam uma alterativa aos métodos invasivos para obtenção de dados essenciais para estudar a morfologia destes bivalves. Tal poderá ser bastante útil considerando que se trata de uma espécie ameaçada a nível internacional.

Como exposto aqui, está claro que estamos no bom caminho e que 2019 trará diversas e profícuas leituras a todos os nossos membros, aos quais desejamos óptimas entradas. Bem hajam!

Doutora Raquel Vasconcelos
Editora-chefe da *Zoologia Caboverdiana*

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Editorial note

On track

In the second issue of the seventh volume of this journal it almost seems that our prayers expounded in the previous editorial were heard. Fourteen students and researchers from Germany came to explore six of the Cabo Verde Islands and found 18 new records of terrestrial species compared to those listed by Arechavaleta *et al.* (2005). These new records include the first observations of several species for some of these islands and further new observations for Cabo Verde. We refer to the first article entitled '*Additions to the checklist of terrestrial biodiversity of Cabo Verde'*. We hope this will motivate other research groups to bring more students to this archipelago on field trips.

Also the Portuguese answered the call and seem to have noticed a different phenotype and behaviour in the octopuses occurring on the Desertas Islands. In this second article, entitled '*A potential new endemism: speciation of the common octopus, Octopus vulgaris, in the Desertas Islands, Cabo Verde?*', possible explanations for these observations are discussed, opening the way for further detailed genetic studies on this topic. It should be noted that this article is, once again, the result of a grant awarded by the SCVZ Desertas Fund. We take this opportunity to inform that this Fund will soon open a new call, this time only for students and researchers from Cabo Verde. Hence, we predict that 2019 will be a year that will yield good native fruits to *Zoologia Caboverdiana*.

We would also like to point out that in this second issue, this modest but pertinent peer-reviewed journal takes a small qualitative leap from two articles and a short note to three original articles, in which Cabo Verdean researchers also participate. More specifically, we refer to the third and final article, entitled '*In situ* method for assessing the biometric data of *Pinna rudis* Linnaeus, 1758'. In this work the authors present an alternative to the invasive methods to obtain essential data to study the morphology of these bivalves. This can be very useful considering that this species is threatened at international level.

As explained here, it is clear that we are on the right track and that 2019 will bring many and fruitful readings to all our members, to whom we wish a frantic First. Best wishes!

Raquel Vasconcelos, PhD
Editor-in-chief of *Zoologia Caboverdiana*

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Artigo original | Original article

Additions to the checklist of terrestrial biodiversity of Cabo Verde

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RESUMO

Em resultado de seis semanas passadas em trabalho de campo em seis ilhas caboverdianas em Setembro/ Outubro de 2016 e 2017, apresentamos 18 adições à lista da biodiversidade terrestre do arquipélago (dez artrópodes, uma ave, dois fungos e cinco plantas). Quatro deles são os primeiros registos para Cabo Verde, os outros para ilhas particulares. De entre as espécies mais interessantes refira-se a mosca da fruta da maçã-de-Sodoma *Dacus longistylus*, provavelmente introduzida para o biocontrole da árvore tóxica da maçã-de-Sodoma e novas adições à distribuição de várias espécies de abelhas dos géneros *Amegilla*, *Megachile* e *Xylocopa*. As nossas observações indicam que o conhecimento da biodiversidade de Cabo Verde ainda está incompleto e que mais trabalho de campo é necessário.

Palavras-chave: fauna nativa, novos registos, *Dacus longistylus*, *Amegilla*, *Megachile*

ABSTRACT

Based on six weeks spent in the field on six Cabo Verdean Islands in September/ October 2016 and 2017, we present 18 additions to the checklist of terrestrial biodiversity of the archipelago (ten arthropods, one bird, two fungi, and five flowering plants). Four of them are first records for Cabo Verde, the others for particular islands. Most interesting are the apple of Sodom fruit fly *Dacus longistylus*, perhaps actively introduced for biocontrol of the toxic apple of Sodom tree and the additions to the distribution of several bee species of the genera *Amegilla*, *Megachile*, and *Xylocopa*. Our observations indicate that the biodiversity of Cabo Verde is still incompletely known and more fieldwork is needed.

Keywords: native fauna, new records, *Dacus longistylus*, *Amegilla*, *Megachile*

INTRODUCTION

In the Macaronesian region, the terrestrial and marine biodiversity of the Canary Islands and Madeira are well-studied but our knowledge of other archipelagos, including the Azores and Cabo Verde seems much less complete, when counting and comparing the species numbers in published checklists (Borges *et al.* 2010; Arechavaleta *et al.* 2005). This is especially the case for arthropods, where, for example, no species of the bee genus *Amegilla* is mentioned in the Cabo Verde Hymenoptera checklist (Baéz *et al.* 2005) even though Brooks (1988) already described and listed several Cabo Verde endemics of that genus. Bryophytes and even flowering plants probably also need more work in terms of basic taxonomy, ecology and biogeography. This type of information is crucial for conservation management but also for macroecological studies which rely on robust distribution data. As an exception, the avifauna of Cabo Verde is rather well-known due to the efforts of Hazevoet (1995) and others. While the information of the bird checklist (López-Jurado *et al.* 2005) is a bit outdated, the field guide of Garcia-del-Rey (2011) is still a good reference.

During two botanical and zoological trips to Cabo Verde in 2016 and 2017, we observed several animal, plant and fungus species not mentioned in the checklist of animals, plants, and fungi of Cabo Verde (Arechavaleta *et al.* 2005) or new to a particular island. The aim of this contribution is to publish those new records and discuss their importance.

MATERIAL AND METHODS

The first sampling took place in September/ October 2016, when the islands of Boavista, Sal, Santiago, São Vicente, and Santo Antão were visited by the senior author for three weeks. The second trip took place in September/October 2017, when all authors visited the five islands of the previous trip plus Fogo. On each of the islands, we went for half- or full-day hikes and tried to identify as many terrestrial species as possible, but we did not perform standardized monitoring or used any particular method for targeting a taxonomic group. All new records except birds are documented with photographs. We describe our observations and whenever possible provide details on numbers of individuals and ecology of the species in Cabo Verde.

RESULTS

Altogether, we add new observations for 18 species, ten of them arthropods, one bird, two fungi, and five flowering plants (Table 1).

ANIMALIA
Arthropoda

Arachnida
Araneae: The banded-legged golden orb-web spider *Nephila senegalensis*, so far reported from Brava, Fogo, Maio, Santiago, and Santo Antão (García *et al.* 2005), was found in high densities on Boavista in 2016 and 2017 (Fig. 1A). The huge females had their webs preferably in *Tamarix* and *Acacia* shrub, often across foot paths. The largest prey items seen in the webs included grasshoppers and female carpenter bees *Xylocopa modesta*.

Chilopoda
Scolopendromorpha: One *Scolopendra morsitans* centipede so far known from Fogo, Maio, Sal, Santiago, Santo Antão, and São Vicente (Zapparolia *et al.* 2005), was found under stones in semi-desert habitat near Sal Rei, Boavista together with juvenile geckos (Fig. 1B).

Insecta
Diptera: The fruit fly *Dacus longistylus* (Fig. 1C) was found in considerable numbers on Fogo while mating on flowers and young fruits of *Calotropis procera*.

Orthopthera: The house cricket *Acheta domesticus*, so far reported from Maio, Santiago, Santo Antão, and São Vicente (Baéz & Oromí 2005), was found dead at Boavista airport (Fig. 1D). The large conehead *Ruspolia nitidula*, so far reported from Santo Antão and São Nicolau (Baéz & Oromí 2005), was found on Fogo during our 2017 trip (Fig. 1E).

Hymenoptera: *Apis mellifera*, so far reported from Santiago only (Baéz *et al.* 2005), was observed on Boavista, Fogo, and Santo Antão in high numbers on ice plant flowers (Aizoaceae) but also on ornamentals in gardens (Fig. 1F).

No leafcutter bee was listed by Baéz *et al.* (2005), but a specimen of a small, widespread African species, *Megachile concinna*, collected on Sal, was included in a recent phylogenetic analysis (Soltani *et al.* 2017). The species was now observed in relatively small numbers also on Boavista, Fogo, and Santo Antão (Fig. 2 A and B), where it visited different *Lotus* species as well as Brassicaceae and *Cleome* species (Capparidaceae).

The carpenter bee *Xylocopa modesta*, a native of Subsaharan Africa, has been reported from Santiago, Santo Antão, São Nicolau, and São Vicente (Baéz *et al.* 2005), and was found to be common on Boavista, Fogo, and Sal as well (Fig. 2C and D). On Boavista, we found the species nesting in considerable numbers in stems of dead *Phoenix atlantica* east of Sal Rei, both 2016 and 2017, and visiting flowers of ornamental plants in the gardens of Sal Rei.

We observed at least two *Amegilla* species: the yellow-ochre *Amegilla capeverdensis* (Fig. 2E) on Boavista and Sal, where it was common in coastal dunes on the flowers of *Lotus brunneri*. The holotype of the species is from Boavista (Brooks 1988), but the species has not been mentioned from Sal so far. We observed the slightly larger, much darker *Amegilla godofredi* (Fig. 2F) with orange hind legs on Santo Antão and São Vicente, where the females visited *Aeonium gorgoneum* (Crassulaceae) and *Echium stenosiphon* s.l. (Boraginaceae) flowers. The original type locality is São Vicente and additional material was collected on São Nicolau (Brooks 1988), but the species has not been mentioned from Santo Antão yet.

Table 1. New records (*) and previously known distribution (●) for the 18 discussed taxa in alphabetical order per island (SA, Santo Antão; SV, São Vicente; SL, Santa Luzia; Br, Branco; Ra, Raso; SN, São Nicolau; S, Sal; BV, Boavista; M, Maio; ST, Santiago; F, Fogo; B, Brava).

Taxon	**S A**	**SV**	**SL**	**Br**	**Ra**	**SN**	**S**	**BV**	**M**	**ST**	**F**	**B**
Acheta domesticus (L.)	●	●	-	-	-	-	-	*	●	●	-	-
Amegilla capeverdensis Brooks	-	-	-	-	-	-	*	●	-	-	-	-
Amegilla godofredi (Sichel)	*	●	-	-	-	●	-	-	-	-	-	-
Apis mellifera L.	*	-	-	-	-	-	-	*	-	●	*	-
Ceratophyllum demersum L.	*	-	-	-	-	-	-	-	-	-	-	-
Cucumis dipsaceus Ehrenb. ex Spach	*	*	-	-	-	-	-	-	-	*	*	-
Cucumis melo L. ssp. *meloides* Endl & H.Schaef.	-	-	-	-	-	-	*	*	●	●	●	-
Dacus longistylus Wiedemann	-	-	-	-	-	-	-	-	-	-	*	-
Gallinago gallinago (L.)	*	●	-	-	-	-	●	●	●	●	-	-
Megachile concinna Smith	*	-	-	-	-	-	●	*	-	-	*	-
Nephila senegalensis (Walckenaer)	●	-	-	-	-	-	-	*	●	●	●	●
Oxalis corniculata L.	●	●	-	-	-	●	●	*	-	●	●	●
Oxalis latifolia Kunth	*	-	-	-	-	-	-	-	-	-	-	-
Pisolithus tinctorius (Pers.) Coker & Couch	-	-	-	-	-	-	-	-	-	●	*	-
Podaxis pistillaris (L.) Fr.	●	●	-	-	●	-	●	*	-	●	-	-
Ruspolia nitidula (Scopoli)	●	-	-	-	-	●	-	-	-	-	*	-
Scolopendra morsitans L.	●	●	-	-	-	-	●	*	●	●	●	-
Xylocopa modesta F. Smith	●	●	-	-	-	●	*	*	-	●	*	-

Fig. 1. Arthropods of Cabo Verde. **A)** *Nephila senegalensis*, female, near Rabil (Boavista), October 2016 (photo by H. Schaefer); **B)** *Scolopendra morsitans* near shipwreck of Santa Maria in the Northeast of Boavista, October 2017 (photo by H. Schaefer); **C)** *Dacus longistylus*, female (top) and male (below) on flowers of *Calotropis procera* (Apocynaceae) near São Filipe (Fogo), October 2017 (photo by H. Schaefer); **D)** *Acheta domesticus*, female, found dead at Boavista airport, October 2017 (photo by J. Bretzel); **E)** *Ruspolia nitidula*, near Mosteiros (Fogo), October 2017 (photo by J. Bretzel); **F)** *Apis mellifera*, near Ponta do Sol (Santo Antão), October 2017 (photo by J. A. Weissmann); all scale bars correspond to 5 mm.

Fig. 2. Wild bees of Cabo Verde (photos in B, E and F by J. A. Weissmann and the others by H. Schaefer). **A)** *Megachile concinna* female visiting flowers of *Cleome viscosa*, Capparidaceae, near Sal Rei (Boavista), October 2016; **B)** *Megachile concinna* male on flowers of the endemic *Heliotropium ramosissimum*, Boraginaceae, Sal Rei (Boavista), October 2017; **C)** *Xylocopa modesta* female on flowers of *Grewia villosa*, Malvaceae, near Sal Rei (Boavista), October 2016; **D)** *Xylocopa modesta* male on flowers of the endemic *Lotus brunneri*, Fabaceae, Sal Rei (Boavista), October 2016; **E)** *Amegilla capeverdensis*, Sal Rei (Boavista), October 2017; **F)** *Amegilla godofredi* visiting flowers of the endemic *Echium stenosiphon*, Boraginaceae, Paúl valley (Santo Antão), October 2017; all scale bars correspond to 5 mm.

Aves

Charadriiformes: One individual of the common snipe *Gallinago gallinago* flew off a small riverbed in Ribeira de Paúl, Santo Antão, October 2017. The species was mentioned by Garcia-del-Rey (2011) as visitor to Boavista, Sal, Maio, Santiago, and São Vicente.

Pelecaniformes: An immature individual of the purple heron *Ardea purpurea*, possibly ssp. *bournei* due to its pale plumage, was observed at the sewage pond of the desalination plant of the 'Riu Touareg' Hotel in the south of Boavista near Praia de Santa Mónica in 2017.

Accipitriformes: An individual of the black kite *Milvus migrans* was observed at João Galego, Boavista in 2016 and at Monte Barro, Fogo in 2017.

FUNGI
Basidiomycetes

Boletales: The dead man's foot fungus *Pisolithus tinctorius*, so far reported only from Santiago (Baudet 2005) was found in *Eucalyptus globulus* and *Pinus canariensis* plantations in the northeastern part of Fogo (Fig. 3A).

Agaricales: The puffball fungus *Podaxis pistillaris*, so far reported from Raso, Sal, Santiago, Santo Antão, and São Vicente (Baudet 2005), was found in considerable numbers on Boavista in October 2016 and less common in 2017, especially in the surroundings of Sal Rei, where it seems to grow preferably in areas with dog or donkey faeces (Fig. 3B).

PLANTS
Angiosperms

Ceratophyllales: *Ceratophyllum demersum* (Ceratophyllaceae), was found growing in small amounts in Ribeira do Paúl, Santo Antão (Fig. 3C).

Cucurbitales: A conspicuous representative of the gourd family *Cucumis dipsaceus* (Cucurbitaceae), which had not been included in the checklist (Sánchez-Pinto *et al.* 2005), was found in 2016 on Santiago, and in 2017 on Santo Antão, on disturbed ground at the southern margin of Ponta do Sol. It was also found on Fogo, at the western margin of the capital São Filipe (Fig. 3D). Another wild melon (Cucurbitaceae) was found on Boavista and Sal in 2016 and 2017, *Cucumis melo* ssp. *meloides* (Fig. 3E). This taxon was previously reported from Fogo, Maio, and Santiago (Sánchez-Pinto *et al.* 2005 [as *C. melo* L]).

Oxalidales: *Oxalis latifolia* (Oxalidaceae), a widespread field weed of South African origin was found growing along a path in fields on Santo Antão, Ribeira do Paúl, in 2017 (Fig. 3F). This is the first record of that species for Cabo Verde (Sánchez-Pinto *et al.* 2005). The related, also weedy *Oxalis corniculata*, already known from Brava, Fogo, Sal, Santiago, Santo Antão, São Nicolau, and São Vicente (Sánchez-Pinto *et al.* 2005), was found on Boavista in 2016 and 2017 (Fig. 3G).

Fig. 3. Fungi and flowering plants of Cabo Verde (all photos by H. Schaefer, except the penultimate by V. Rupprecht). **A)** *Pisolithus tinctorius*, Monte Velha (Fogo), October 2017; **B)** *Podaxis pistillaris*, Sal Rei (Boavista), October 2016; **C)** *Ceratophyllum demersum*, dry plant taken from small artificial reservoir in Paúl valley (Santo Antão), October 2017; **D)** *Cucumis dipsaceus*, Ponta do Sol (Santo Antão), October 2017; **E)** *Cucumis melo meloides*, near Sal Rei (Boavista), October 2016; **F)** *Oxalis latifolia*, field weed in Paúl valley (Santo Antão), October 2017; **G)** *Oxalis corniculata*, roadside weed in Sal Rei (Boavista), October 2016; scale bars in A, B, D correspond to 5 cm, and in C, E, F, G to 1 cm.

DISCUSSION

Most of our new records are for Boavista (nine species), but Fogo and Santo Antão come very close with seven new records each, whereas our short visits to Sal and São Vicente resulted in only three and zero additions, respectively. It is thus likely that this just reflects the time spent on each of these islands.

None of the 18 records we report is really surprising, as they mostly represent range expansions of species within Cabo Verde and not new colonisations from the continent.

The large conehead *Ruspolia nitidula*, for example, is a widespread grasshopper species known from Southern Europe, Asia, and Northern Africa, including the Canary Islands (Hochkirch *et al.* 2016) that now seems to be expanding in Cabo Verde. Despite several recent studies (e.g. Pauly *et al.* 2002, Straka & Engel 2012, Weissmann *et al.* 2017), the bee fauna of Macaronesia and especially of Cabo Verde is still incompletely known. So far, 21 bee species have been reported from Cabo Verde (Weissmann *et al.* 2017), including the honeybee, *Apis mellifera*, which according to locals, is not kept in bee hives, so most likely represents wild or feral colonies. Compared to other Macaronesian archipelagos, this diversity is quite similar to Madeira and the Azores, but much lower than in the Canaries. It is therefore expected that bees make up such a big proportion of our new records.

Our bird observations suggest follow-up fieldwork: snipe might have a small breeding population on Santo Antão, black kite might breed on Boavista, and the pale purple heron on Boavista could have been from the endemic Santiago population.

The few new colonisations we observed are the fruit fly *Dacus longistylus* and the flowering plants *Ceratophyllum demersum*, *Cucumis dipsaceus*, and *Oxalis latifolia*, all four supposedly new records for Cabo Verde (see Arechavaleta *et al.* 2005). The latter two species were most likely introduced unintentionally as contamination of soil or seeds. Both are weedy in tropical and subtropical areas worldwide and will probably spread throughout the archipelago within a few years' time. *Cucumis dipsaceus* was also found on São Vicente (R. Vasconcelos, pers. comm). *Dacus longistylus* is a different case: it is widely distributed throughout Northern Africa and Arabia and was recently discovered on *Calotropis* plants in Morocco (El Harym & Belqat 2017). No species of the genus *Dacus* was so far reported from Cabo Verde (Baéz & García 2005). It has been tested as a biocontrol agent to limit the spread of toxic *Calotropis procera* shrubs (Dhileepan 2014) and it seems possible that the flies we found on Fogo go back to such an intentional release, but we could not find any official confirmation of such biocontrol attempts. The rigid hornwort *Ceratophyllum demersum* (Ceratophyllaceae) is an almost cosmopolitan inhabitant of ponds and quiet streams. It grew in a place where the stream has been turned into a small artificial water reservoir. This is also the site where the first freshwater fish record of the archipelago *Poecilia reticulata* Peters has recently been found (Lucek & Lemoine 2012). We can confirm a healthy *Poecilia* population, which seemed to have grown since its first discovery in 2012. Whether the hornwort plants have been introduced on purpose together with the fish is unknown, a natural dispersal from the African mainland to Santo Antão attached to feet or plumage of water birds would be possible, but has not been documented so far for any of the few water plant species of Cabo Verde.

Cucumis melo ssp. *meloides* is the wild ancestor of African melon landraces cultivated in Sudan and possibly West Africa (Endl *et al.* 2018). Whether the Cabo Verde plants represent an indigenous population or more recent accidental introductions from the West African mainland remains to be studied with population genetics methods.

CONCLUDING REMARKS

We conclude that despite all the recent efforts, many taxonomic terrestrial groups of Cabo Verde still need a lot more fieldwork to achieve a reliable and comprehensive checklist, which is crucial not only for conservation and management within the islands but also for macroecological and evolutionary studies which compare species numbers of islands worldwide.

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A potential new endemism: speciation of the common octopus, *Octopus vulgaris*, in the Desertas Islands, Cabo Verde?

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RESUMO

Cabo Verde é uma região biogeográfica única, onde a co-ocorrência de espécies temperadas e tropicais origina um número anormalmente alto de espécies endémicas. Os cefalópodes são peças centrais nas redes tróficas em todo o mundo, interagindo como predador/ presa e competindo com peixes por nichos ecológicos. O nosso objectivo foi avaliar como a topografia, a disponibilidade de presas e a pressão predatória nas ilhas Desertas moldaram o comportamento e a ecologia da população de *Octopus vulgaris.* Foram realizados censos visuais (subtidais e intertidais) na ilha de Santa Luzia (20 dias) e no ilhéu Raso (oito dias). Indivíduos de *O. vulgaris* foram encontrados apenas em áreas intertidais, durante a maré baixa, e a morfometria média da população foi de 35,6 ± 10,4 cm (comprimento total) e 175,0 ± 53 g (peso húmido). O tamanho acentuadamente reduzido de *O. vulgaris*, apenas parcialmente explicável pela regra de Bergmann, e a exclusão das áreas subtidais, parecem dever-se principalmente a fortes pressões predatórias e competição interespecífica por nichos limitados de habitat. As alterações comportamentais e morfométricas induzidas podem ser o produto da plasticidade de desenvolvimento, ou indicar alterações genéticas mais profundas, que retratariam um potencial fenómeno de especiação das populações de polvos que residem nas ilhas Desertas de Cabo Verde.

Palavras-chave: complexo de espécies, contexto ecológico, pressão predatória, topografia

ABSTRACT

Cabo Verde is a unique biogeographical region, where by mixing temperate and tropical characteristics an unusually high number of endemic species are reported. Cephalopods are central pieces of trophic networks worldwide, interacting as predator/ prey and competing with fish for ecological niches. We aimed to assess how the topography, prey availability, and predatory pressure of the Desertas Islands shaped the behaviour and ecology of the existing *Octopus vulgaris* population. Visual census (both underwater and on tidal rock pools) were performed on Santa Luzia Island (20 days) and Raso Islet (eight days). *Octopus vulgaris* individuals were found only in intertidal areas, during low tide, and mean population morphometry averaged 35.6 ± 10.4 cm (total length) and 175.0 ± 53 g (wet weight). The markedly reduced size of *O. vulgaris*, only partly explainable by Bergmann's rule, and exclusion from subtidal areas, appears to have been mainly driven by severe predatory pressure and strong inter-specific competition for limited habitat niches. The induced behavioural and morphometric alterations may be the product of developmental plasticity, or have arisen from deeper genetic alterations, which would portray a potential speciation phenomenon of octopus' populations residing on Cabo Verde's Desertas Islands.

Key-words: ecological context, predatory pressure, species complex, topography

INTRODUCTION

Cabo Verde has never been connected to mainland Africa and is comprised of 10 islands located approximately 450 km off the West African coast (Duda & Rolán 2005, Duarte & Romeiras 2009). In the northwesternmost section of the Windward Islands, São Vicente was connected with the Desertas during the Pleistocene, which are composed of Santa Luzia Island, and Branco and Raso Islets, nowadays separated by depths of ~200 m (Ancochea *et al.* 2015, Freitas *et al.* 2015). Supported by a recently acquired status of Natural Reserve and Marine Protected Area and associated reduced anthropogenic pressures, the Desertas are a privileged location for life to thrive (Anonymous 2014, Almeida *et al.* 2015). Special biogeographical characteristics (supporting temperate, subtropical and tropical organisms) enabled the speciation of an unusually high number of endemic species (e.g. Duda & Rolán 2005). Although one of the top 10 hotspots of marine biodiversity in the world (Almeida *et al.* 2015), the limited extension of the continental platform, highly dynamic oceanographic currents and restricted intertidal area, make the Desertas ecosystems extremely vulnerable to anthropogenic pressures, such as overfishing (Roberts *et al.* 2002).

Coleoid cephalopods, such as the shallow-water common octopus *Octopus vulgaris* (Cuvier, 1797), are cosmopolitan species known for their 'live-fast-die-young' life cycles and ability to adapt to several habitat and intra-habitat changes. The main factors influencing distributional patterns of a given population, at a local scale, are topography, availability of prey, and predatory risk (Mather & O'Dor 1991). For *O. vulgaris*, topography is a crucial ecological feature, given its benthic nature and background-matching behaviour (Hanlon & Messenger 1996). These animals are more associated with complex habitats, e.g. rocky and coral reefs, than simple structured ones, as sandy bottoms (Mather 1982).

Regarding trophic interactions, octopuses are known for influencing abundance and diversity within ecosystems, due to the marked top-down and bottom-up pressures they exert (Packard 1972), being sought by a multitude of predators, including fish and mammals (Katsanevakis & Verriopoulos 2004), while exhibiting a high nutritive demands and voracious appetite (Katsanevakis & Verriopoulos 2006). Octopuses are frequently generalist and mobile predators, shaping their foraging decision-making process according to the characteristics of the prey (Wells 1978). Despite their flexibility, octopuses preferentially use chemotactile methods to hunt for prey in rock and coral crevices while hovering through the seabed (speculative hunting), while the visual senses are primed for predatory avoidance (camouflage matching) and ambushing prey that wanders close to their den (Mather & O'Dor 1991, Forsythe & Hanlon 1997).

As most cephalopods, *O. vulgaris* co-evolved with fish since their massive diversification, living mostly in vertebrate-dominated environments (Packard 1972). Therefore, cephalopods and fish are competitors for ecological niches, and the distribution and size of respective populations directly affect each other (Ambrose 1988, Taylor & Bennett 2008). The Desertas Island are, both from biotic and abiotic standpoints, unique habitats where the population status of these cephalopods is virtually unknown (Almeida *et al.* 2015). Thus, here we aimed to assess how the *O. vulgaris* population is distributed throughout the multilayered, biodiversity-rich environments of the Desertas. Moreover, we aimed to highlight the key roles that geographical isolation and topography of the Desertas Islands, as well as their unique ecological contexts, might have in variations of behaviour and ecology in *O. vulgaris*.

MATERIAL AND METHODS

Fieldwork for this study was performed in the Desertas Islands, Cabo Verde. On Santa Luzia Island (20 sampling days), the main areas covered were Praia de Francisco (front and rocky bottoms on both sides), Praia dos Achados, and Portinho, at the end of Praia de Palmo a Tostão (Fig. 1A). On Raso Islet (eight sampling days), only rocky substrate was observed, and the main location searched was Ponta de Casa (Fig. 1B). Branco Islet was not sampled, given its low accessibility and impracticable logistics. Combining both islands, sampling spanned approximately one month (10 September – 8 October 2017), and analyzed areas comprised sandy beaches and rocky shores.

Underwater, the preferred method used for searching for *O. vulgaris* and registering marine fauna was snorkeling (normally 0–15 m deep), in 2-h sampling sessions for 3–4 times a day. The researcher and volunteers followed a straight line from an edge of the are marked in red in Fig. 1, and performed continuous census until closing the square. In smaller areas, this procedure was repeated (2 to 3 times) until the 2h-limit was reached. Nevertheless, one dive resorting to SCUBA was also performed in the south coast of Raso (25 m), which enabled searching in deeper waters during a longer period. Snorkeling sampling lasted for 25 days and an averaged 6–8 hours per day, which added to a total effort of ~180 h of active search.

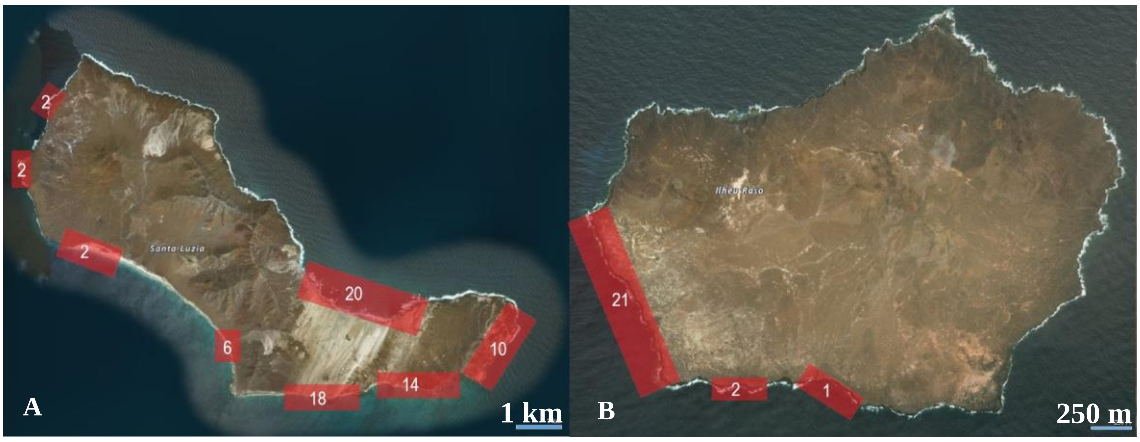

Fig. 1. Sampled areas in the Desertas, Cabo Verde (in red). **A)** Sampled areas on Santa Luzia Island (from upper left and counter-clockwise: Ponta de Algoder, Ponta Branca, Ponta de Água Doce, Ponta de Praia, Portinho, Pesqueiro da Salema, Praia de Francisco – Praia de Roque, and Ponta da Mãe Grande – Ponta de Creoulo; and **B)** on Raso Islet (from left to right: Ponta da Baleia – Ponta de Casa, Chã de Posende, and Ponta da Cruz). The numbers depict the amount of two-hour sessions performed on each location.

Rocky intertidal pools were surveyed by researchers and fishermen on Raso, both visually and using tools (i.e. spear) to prospect for animals in holes. On Santa Luzia, fisherman reports and dead individuals (locally used as bait for coastal fishing) were taken as evidence for the presence of *O. vulgaris* and their small-sizes (two different fishermen teams were interviewed about the distribution, habitat and size of octopus on both islands).

Six individuals, representatives of the population observed, were sampled for morphometric measurements, photographed (Morphobank project P3289) and stored afterwards in 96% ethanol at the University of Cabo Verde collections (UCV).

RESULTS

By snorkeling or SCUBA, no subtidal records of vagrant *O. vulgaris* were noted, either foraging or otherwise (i.e. in dens, camouflaging in rocks, etc.), after a total of 74 and 24 sampling two-hour sessions, on Santa Luzia and Raso, respectively. In fact, *O. vulgaris* were only detected in the intertidal rock pools during low tide in both islands. Specifically, 18 intertidal occurrences were recorded by fishermen on Santa Luzia, across the south side of the island, but mostly in the eastern section. Regarding Raso, 16 intertidal occurrences were recorded by fishermen and researchers in the southwestern section (Fig. 2).

Mean size and weight (± SD) of analyzed *O. vulgaris* individuals averaged 35.6 ± 10.4 cm and 175.0 ± 53 g (Table 1).

Fig. 2. *Octopus vulgaris* individual (UCV 2019/00011, see Table 1 for details) found in the intertidal rocky areas of Raso Islet (photo by Eduardo Sampaio).

Table 1. Morphometric measurements from six representative individuals of *O. vulgaris* collected on Raso Islet (Morphobank project P3289) and deposited at the University of Cabo Verde (UCV), with respective voucher and collection codes.

Voucher	Collection	Total Length (cm)	Weight (g)
UCV 2019/00009	OCTOCVD1	32.1	197
UCV 2019/00010	OCTOCVD2	41.2	193
UCV 2019/00011	OCTOCVD3	48.9	260
UCV 2019/00012	OCTOCVD4	28.0	65
UCV 2019/00013	OCTOCVD5	36.6	149
UCV 2019/00014	OCTOCVD6	30.1	91

DISCUSSION

Average size and weight of *O. vulgaris* were found to be remarkably lower to what was registered for other biogeographical regions, and such is referenced to be little changed over the year, by local fisherman (Salamansa and São Nicolau fishermen, per. comm.). Moreover, September is usually when individuals with larger sizes are found in other geographical reasons, given that it is their mating season (Katsanevakis & Verriopoulos, 2004), and there is no reason (up to this point) to think that this is not the case in Cabo

Verde. Reports from the Mediterranean Sea describe that this species can reach over 3 m of total length, and wet weights of 7 kg (Quetglas *et al.* 1998), and 6 kg in the Southern Indian Ocean (Guerra *et al.* 2010).

There are several hypotheses which may underpin this severe morphological reduction. First, there is a general biological rule that states that animal body size increases with latitude, as reduced surface to volume ratios provide more efficient heat conservation, whereas larger ratios in smaller individuals facilitate heat loss, and are thus selected near the tropics. Thought to be applicable only for endotherms (Bergmann 1847), later this rule was found to be pervasive for marine ectotherms (Atkinson 1994), including the majority of cephalopod classes (Rosa *et al.* 2012). Concomitantly, the smaller size relatively to European and Indian Ocean populations of *O. vulgaris* could be partially underpinned by Bergmann's rule. However, in a similar latitudinal gradient, *O. vulgaris* are reported to reach up to 6 kg in African mainland and neighbouring Senegal (Domain *et al*. 2000). Concurrently, the maximum weight reported for an individual octopus by fishermen on São Vicente Island was roughly 2 kg, and even that weight was considered well over what is found in the population of the Desertas Islands (this study, Salamansa and São Nicolau fishermen, pers. comm.). Thus, such a marked reduction in average size, especially in the Desertas, has probably been selected by additional biological/ ecological mechanisms.

Simultaneously, no *O. vulgaris* individuals were found foraging through subtidal areas in the Desertas Islands. As sampling was performed throughout the day (between approximately 8 a.m. and 19 p.m), we consider that sampling timing was not an issue for finding *O. vulgaris* foraging. This species is known to hunt during the day in other areas of the world (e.g. Europe and America), with multiple occurrences being described by both divers and snorkelers alike (Mather & O'Dor 1991). Moreover, dens with individuals were not found outside the intertidal area of both Santa Luzia and Raso. Since the availability of prey does not seem to be a constraint in the Desertas Islands (Almeida *et al.* 2015), predatory pressure even by fishermen and topography appear to be the main factors conditioning the species distribution. In fact, both Raso and Santa Luzia are characterized by a high presence of diurnal and nocturnal predators on rocky reefs (Fig. 3A and B). Moreover, other fish that are not regular predators of octopus, compete with them for space for habitat, such as dens and sheltered rock structures (Fig. 3C and D), which further strengthens the idea that octopuses would very rarely hunt out in the open, i.e. go on foraging bouts, and are as such driven towards the intertidal.

Despite the fact that our sampling reported no *O. vulgaris* in subtidal areas, the nearshore topography of these islands are quite different. While the coast of Raso is mostly circumvented by vertical rock walls which immediately drops to 20–30 m, Santa Luzia is heterogeneously characterized by gradual slopes down to 5–10 m for the first 15 m offshore, thus potentially providing a more suitable shelter for octopuses to inhabit and forage. However, given this more extended rocky substrate, Santa Luzia is also populated by carnivorous elasmobranchs (potentially being a nursery area) which are known to feed on cephalopods, such as the nurse shark, the guitarfish (Fig. 3E) and the black tip shark (Fig. 3F), dampening any topographical benefits. Rockpools are usually the home of small crabs, shrimps and mollusks, which are all part of the regular diet of octopus (Mather & O'Dor 1991). Conversely, small cryptic fish that are confined to these habitats (e.g. blennies), across tide changes during the day, do not possess the necessary size to prey on *O. vulgaris*, feeding mostly on similar smaller organisms, or are herbivorous. Moreover, *O. vulgaris* are known to possess the ability to change between rock pools in search for food, or to avoid potential predation, making these habitats considerably safer, compared to subtidal areas.

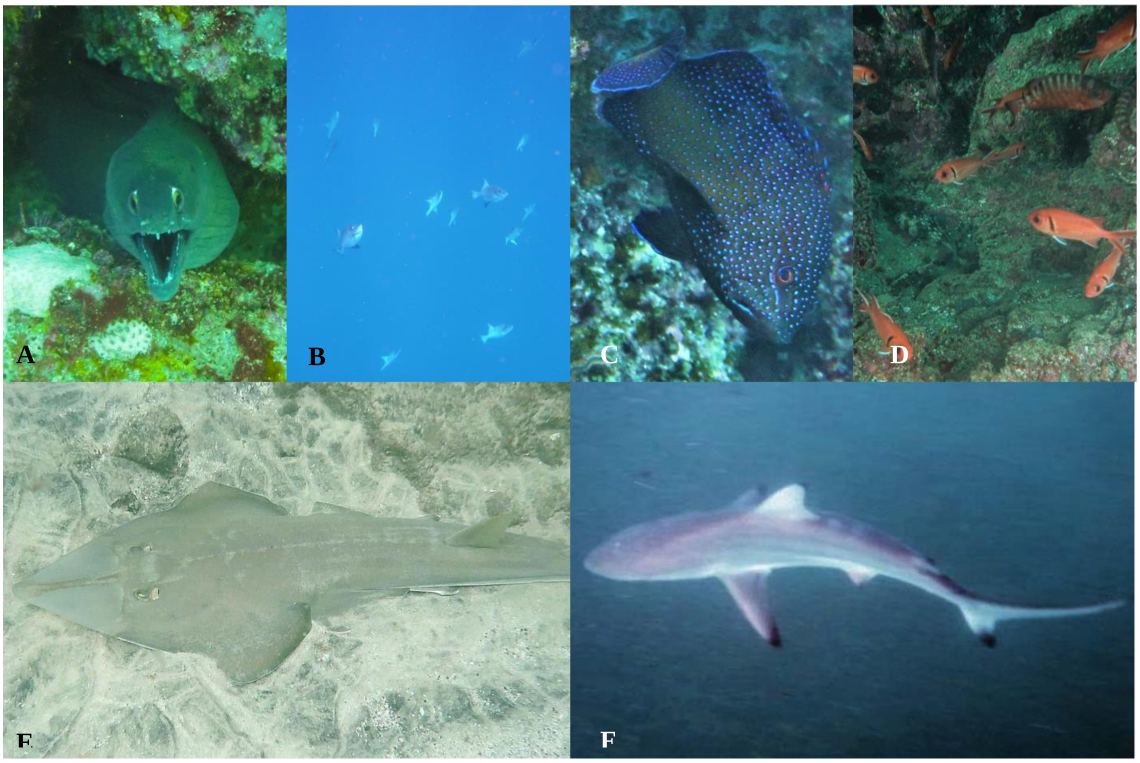

Fig. 3. Predators and competitors of *O. vulgaris* usually found adjacent to intertidal areas (shallow subtidal) of the Desertas Islands (photos by Eduardo Sampaio). **A)** Purplemouth moray *Gymnothorax vicinus*; **B)** ocean triggerfish *Canthidermis sufflamen*; **C)** bluespotted seabass *Cephalopholis taeniops;* **D)** blackbar soldierfish *Myripristis jacobus,* glasseye snapper *Heteropriacanthus cruentatus*, and Atlantic bigeye *Heteropriacanthus fulgens*; **E)** blackchin guitarfish *Glaucostegus cemiculus*; **F)** blacktip reef shark *Carcharhinus melanopterus*.

Considering all these facts, we argue that the population of *O. vulgaris* on the Desertas Islands has migrated almost exclusively to the intertidal area, which shaped behavioural and morphological adaptations. In this case, the octopus's 'drive to explore' cited by Mather & O'Dor (1991) may have been out-selected in favor of a more cautious approach, taking into account the intense predatory pressure and competition for suitable habitats within the rocky shores of the Desertas.

Future enquiries with a larger temporal coverage and DNA analyses should be planned to understand if what was found for this *O. vulgaris* population may derive from developmental plasticity, or if these peculiar ecological contexts have led to more profound changes, and potentially leading to a speciation phenomenon. If so, we may be looking at a newly found endemic species to Cabo Verde, which would attest to the biological heritage of these islands, fruit of its unique combination of biogeographic and ecological conditions.

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In situ method for assessing the biometric data of *Pinna rudis* Linnaeus, 1758

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RESUMO

Pinna rudis Linnaeus, 1758, é uma espécie de bivalve pertencente à família Pinnidae com uma distribuição Atlântico-Mediterrânica. A degradação do habitat tem sido considerada a principal causa de declínio populacional no passado recente, elevando o estatuto de conservação à categoria de vulnerável em algumas paragens. Estudos sobre a dinâmica populacional serão necessários para o delineamento de estratégias para a conservação da espécie. Além disso, é necessário o desenvolvimento de novos métodos de colheita de dados individuais, uma vez que os indivíduos são altamente sensíveis à extracção e manipulação. No presente estudo é proposto um método não invasivo para recolha *in situ* de dados morfométricos de *P. rudis*. Para isso, foram amostrados 900 m^2 do fundo marinho da praia de Matiota, na ilha de São Vicente, arquipélago de Cabo Verde e colhidos 18 espécimes para calcular as relações entre comprimento e largura da concha. A equação de regressão entre os parâmetros permitiu estimar o tamanho total de 59 indivíduos de *P. rudis* encontrados nessa praia. O método não invasivo adoptado permitiu determinar o tamanho total dos indivíduos sem removê-los do substrato, o que poderá permitir fazer estudos comparativos da espécie em diferentes zonas.

Palavras-chave: bivalvia, Cabo Verde, morfometria, método não invasivo.

ABSTRACT

Pinna rudis Linnaeus, 1758 (Bivalvia: Pinnidae) has an Atlantic-Mediterranean distribution. Habitat degradation is considered the main cause of population declines in the recent past, raising the conservation status of the species to the category of vulnerable in some places. Population dynamics studies of *P. rudis* are still necessary to fully understand its conservation requirements. Moreover, new methods of individual data collection should be developed as individuals are highly sensitive to extraction and manipulation. In the present study, we propose a non-invasive method to collect *P. rudis* morphometric data *in situ*. For this, we sampled 900 m^2 of the sea bed at Matiota Beach on São Vicente Island, Cabo Verde Archipelago, and collected 18 individuals to compute the relationship between shell length and width. The regression equation between the parameters allowed us to estimate the total size of 59 *P. rudis* individuals obtained from the beach. The non-invasive method adopted allowed determination of the total size of the individuals without removing them from the substratum and, thereby, allowing the comparative study of the species in different zones.

Keywords: bivalvia, Cabo Verde, morphometry, non-invasive method

INTRODUCTION

Pinna rudis Linnaeus, 1758 is distributed throughout the Mediterranean and the northeast Atlantic (Azores, Madeira, Selvagens, Canaries and Cabo Verde), extending as far south as Saint Helena and the Gulf of Guinea (Poppe & Goto 1993, Barea-Azcón *et al.* 2008). It occurs on sandy, rocky and muddy substrata, at depths that can exceed 40 metres (Sempere *et al.* 2006). Its life cycle is characterized by two phases, one planktonic and the other fixed to the substratum via byssal threads (Basso *et al.* 2015). On the seabed, *P. rudis* shells frequently provide a hard substratum for other species to settle upon, a phenomenon known as epibiosis (Gómez-Rodríguez & Pérez-Sánchez 1997). These epibiotic associations give their shells an irregular appearance often full of colour. The diversity and complexity of epibiotic organisms tend to increase with the age of *Pinna* specimens (Basso *et al.* 2015). As such, numerous biofouling species of algae, molluscs, bryozoans, polychaetes, ascidians, cnidarians and sponges occur on *P. rudis* shells (García-March 2005).

Due to habitat degradation, often caused by fishing activities, anchors and alterations to the rocky bottom of coastal areas, *P. rudis* populations are declining. This has led to their inclusion in Annex II of the Bern Convention as a 'strictly protected' species (in synonymy with also cited *P. pernula* Chemnitz, 1785), the Barcelona Convention as a 'Threatened or Endangered' marine species (Nebot-Colomer *et al.* 2016), and in the *Libro Rojo de los Invertebrados de Andalucía*, as 'Vulnerable' (Barea-Azcón *et al.* 2008). The ecological importance of *P. rudis* has been studied mainly in the Mediterranean Sea, specifically with regard to the interaction of shell epibionts (Richardson *et al.* 1997, Wirtz & D'Udekem-d'Acroz 2001, 2008, Cosentino & Giacobbe 2007, 2008, Barreiros *et al.* 2016), differences in shell ornamentation (Cosentino & Giacobbe 2006), the capacity for induced shell repair (Dietl & Alexander 2005) and population structure and growth (Nebot-Colomer *et al.* 2016).

Except for taxonomic/ biogeographically related studies (e.g., Ávila 2000, Segers *et al.* 2009, Gómez & Pérez 2011, Sanna *et al.* 2013), no ecological studies on *P. rudis* are known for the Macaronesian archipelagos.

Unfortunately, many studies upon *P. rudis* require the removal of individuals from the substratum, putting at risk their survival since they no longer have the ability to produce new byssus threads (Ruppert *et al.* 2004). Given the protected status of *P. rudis*, it is important to develop methodologies that relate total shell length with the dimensions of its non-buried parts. Hence, the main objective of this study was to use a non-invasive methodology to determine the size structure of *P. rudis*, using individuals resident off Matiota beach, on São Vicente Island (Cabo Verde) as a model. It is expected that this methodology will contribute to the expansion of ecological studies, such as spatial distribution and population size and structure in other habitats and locations, especially marine protected areas.

MATERIAL AND METHODS

This study was carried out on Matiota beach (16° 53' 22" N and 24° 59' 46" W) in Porto Grande Bay, São Vicente Island. This coastal area is located between Ponta de João Ribeiro to the NE and Ponta do Morro Branco to the SW. The bay is semi-circular with a diameter not exceeding 4 km, is characterized by calm waters protected from strong sea currents and with depths varying from 10 to 30 m (Almada 1993).

Data collection was performed by diving using SCUBA along strip transects, 3 m wide and 60 m long. Five transects were laid perpendicular to the shore, 15 m apart, and anchored to the seabed with removable weights. Each individual of *P. rudis* identified within each strip transect was marked with a flag connected to a bottom weight and a surface float for counting and *in situ* data collection. The depths at which individuals were located was determined with a graduated cable (to the nearest 5 cm), which also had a basal weight and a surface float, and the length and maximum width of each shell (to the nearest 1 cm) above the sediment-seawater interface was determined with a ruler (Fig. 1A and B). After data collection, all the markers and transects were removed.

A total of 18 shells were sampled haphazardly to establish relationships between observable morphometric characteristics and total shell length. Biometric data were obtained from the 18 collected shells (Fig. 1C) with a calliper. The variables measured were: (i), posterior shell length (PL), that is the height of the shell projecting above the substratum measured underwater; (ii), the height of the shell buried within the substratum (AL); (iii), maximum shell width (MW); (iv), minimum shell width (mw) and (v), maximum shell length (ML) measured in the laboratory.

The maximum shell length of each individual was estimated based on the adaptation of the method applied by García-March & Ferrer (1995) to *Pinna nobilis* Linnaeus, 1758. Maximum shell size was obtained by summing the posterior and anterior lengths (ML= PL+AL). The relationship between anterior height and minimum width (AL= a+b*mw) or maximum width (AL= a+b*MW) was established through linear regression using the PAST software version 3.15 (Hammer *et al.* 2001). The regression significance was tested using ANOVA at a confidence level of 95%. These two equations were then used to estimate the theoretical sizes (and errors) in relation to the obtained data.

This strategy aimed at allowing the non-destructive assessments of population size structure at Matiota Beach. With the size data of the entire population sampled in the study area it was possible to infer the distribution of the sizes, using 5 cm classes.

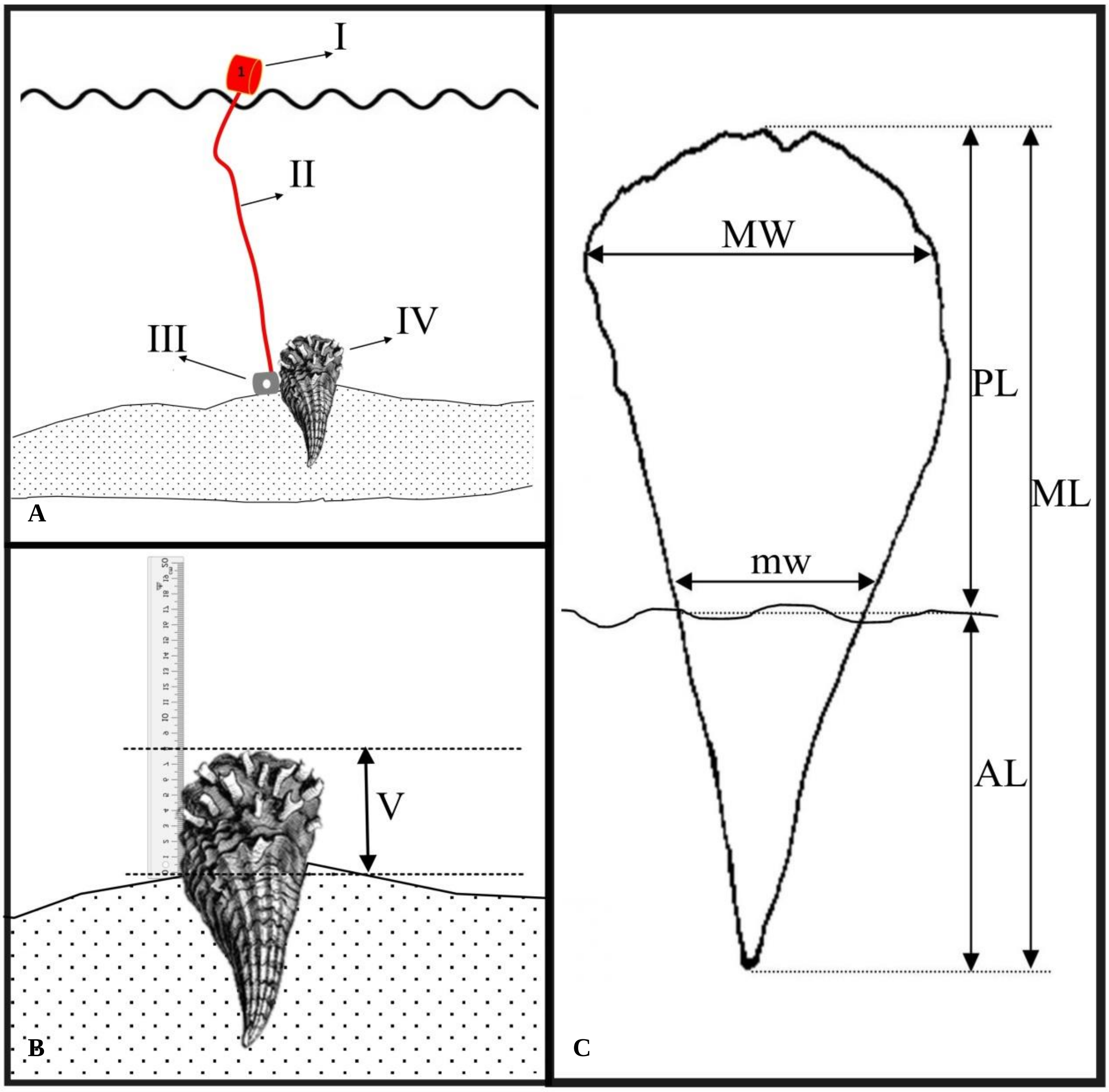

Fig. 1. *Pinna rudis* biometric data and sampling scheme. **A**) Sample marking scheme (I, float; II, connecting cable; III, weight; IV, test individual). **B**) Determination of the length of the shell external to the substratum (V). **C**) Illustrative chart with the biometric data used to measure *P. rudis shells* (ML, maximum length; PL, posterior length; AL, anterior length; MW, maximum width; mw, minimum width).

RESULTS

The entire area covered by this study was 900 m^2 and 59 *P. rudis* individuals were collected, including 53 living and 6 dead ones. These were found at depths of between 1 and 3 metres (standard error, SE ± 25 cm) with a density distribution of between 2 and 3 m. The ANOVA results revealed that both models were statistically significant (mw-PL: F_1= 8.73, p = 0.009, MW-PL: F_1= 5.32; p= 0.03). The best linear regression (R^2= 0.59) was obtained between minimum width and anterior shell height (mw-AL). The uses of MW-AL linear regression may be less precise (R^2= 0.50) because the values are more dispersive (Fig. 2A and B). The plotting of the residues showed a smaller dispersion in the mw-AL ratio than MW-AL, which showed a greater accuracy in terms of overall size estimation (Fig. 2C and D).

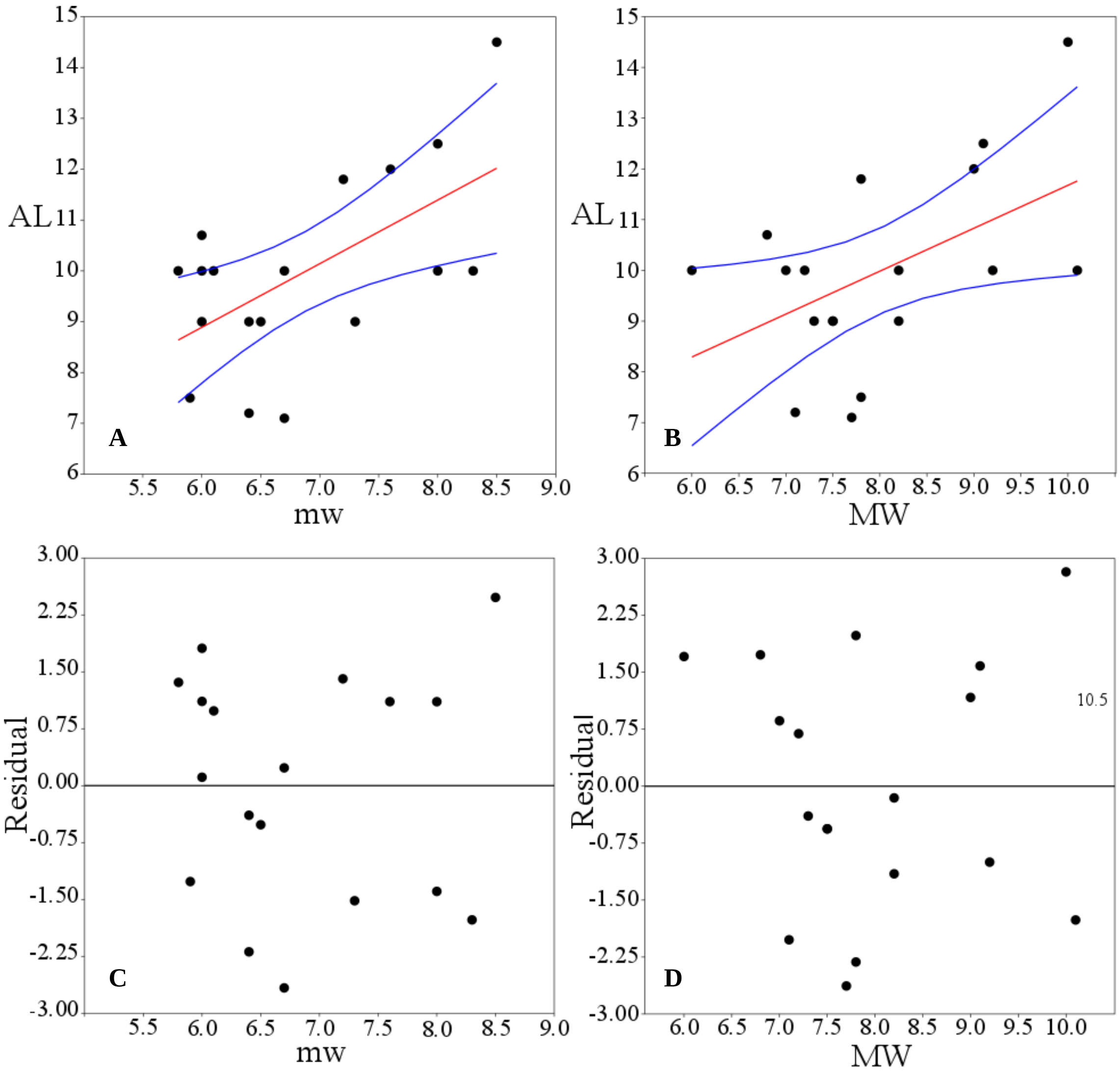

Fig. 2. Linear regression and residual graphs of the measurements obtained. **A)** Correlation between minimum shell width (mw) and anterior shell length (AL) (AL= 1.35* mw+ 1.38); and **B)** between maximum shell width (MW) and anterior shell length (AL) (AL= 0.85* MW+ 3.21); **C)** dispersion of the residuals obtained from the relationship between mw-AL; and **D)** dispersion of the residuals obtained from the relationship between MW-AL. The red lines represent the correlation between AL-mw and AL-MW, and the blue lines show the 95% confidence interval of the data.

The errors of the total sizes estimated for each linear relationship revealed that the correlation between MW-AL was less efficient in estimating total shell size (Table 1).

The equation for total size estimation was then established based on the relationship between mw-AL: ML= PL+1.25 mw+1.38.

The *P. rudis* average size estimated for the study area was 19.1 cm ± 0.64 cm (sample size, n= 59), and frequency analysis of the total sizes showed that 95% of the distribution was encompassed between 10 and 25 cm (Fig. 3).

Table 1. Measurements obtained from and estimated for 18 *Pinna rudis* individuals. ML, maximum shell length; AL, anterior length below the sediment-water interface; mw, minimum width; MW, maximum width; AL_1(mw), anterior length estimated from the equation based on mw (AL_1= 1.25mw+1.38); AL_2(MW), anterior length estimated from the equation based on MW (AL_2= 0.85MW+3.21); $ML_1(AL_1)$, maximum length estimated from AL_1 (ML_1= PL+AL_1); $ML_2(AL_2)$, maximum length estimated from AL_2(ML_2= PL+AL_2); ML_1 - ML, ML_1 error; ML_2 - ML, ML_2 error.

Observed data				Estimated data				Error	
ML	AL	mw	MW	AL_1(mw)	AL_2(MW)	$ML_1(AL_1)$	$ML_2(AL_2)$	ML_1-ML	ML_2-ML
17.00	10.00	8.00	9.20	11.38	11.00	18.38	18.00	-1.39	-1.00
16.50	10.00	6.00	7.00	8.88	9.14	15.38	15.64	1.11	0.86
15.00	9.00	6.50	7.30	9.51	9.39	15.51	15.39	-0.52	-0.39
13.10	7.20	6.40	7.10	9.38	9.22	15.28	15.12	-2.19	-2.02
24.50	14.50	8.50	10.00	12.01	11.68	22.01	21.68	2.48	2.82
15.50	9.00	6.40	7.50	9.38	9.56	15.88	16.06	-0.39	-0.56
12.80	7.50	5.90	7.80	8.76	9.82	14.06	15.12	-1.26	-2.32
18.50	11.80	7.20	7.80	10.38	9.82	17.08	16.52	1.41	1.98
20.00	12.50	8.00	9.10	11.38	10.92	18.88	18.42	1.11	1.58
16.50	10.70	6.00	6.80	8.88	8.97	14.68	14.77	1.81	1.73
17.00	10.00	5.80	6.00	8.63	8.29	15.63	15.29	1.36	1.71
15.00	9.00	7.30	8.20	10.51	10.15	16.51	16.15	-1.52	-1.15
18.50	12.00	7.60	9.00	10.88	10.83	17.38	17.33	1.11	1.17
17.00	10.00	6.70	7.20	9.76	9.31	16.76	16.31	0.23	0.69
15.50	9.00	6.00	7.50	8.88	9.56	15.38	16.06	0.11	-0.56
17.00	10.00	6.10	8.20	9.01	10.15	16.01	17.15	0.98	-0.15
19.50	10.00	8.30	10.10	11.76	11.76	21.26	21.26	-1.77	-1.76
13.50	7.10	6.70	7.70	9.76	9.73	16.16	16.13	-2.67	-2.63

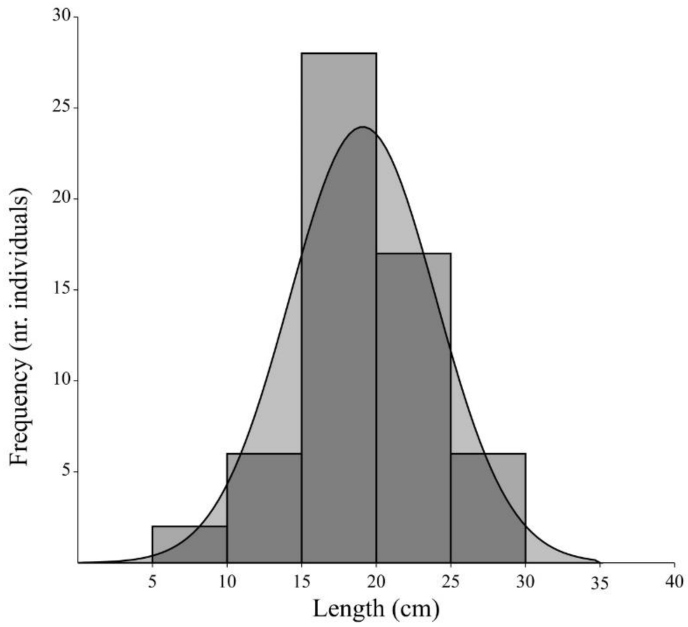

Fig. 3. Histogram showing the frequencies of *Pinna rudis* shell sizes in the population resident at Matiota Beach, São Vicente Island, Cabo Verde.

DISCUSSION

The linear regression between individual total length (ML) and posterior margin length (PL) showed a relatively high determination coefficient when compared with the maximum width (MW) regression. This posterior size measurement to estimate total size is thus more accurate than width parameters, demonstrating a high efficiency that allows the extrapolation of non-destructive biometric data. This methodology is still not accurate (given that the R^2 value is low), due to the measurement mode (usually performed using SCUBA) that still lacks and requires an adjustment in the laboratory to minimize errors.

A similar technology has been proposed by García-March *et al.* (2002) to study the growth rate of the *P. nobilis* population from Moraira (Alicante, Western Mediterranean), giving an adjusted growth equation fitted to the measurements obtained with two devices. In spite of different species, the relation obtained for *P. rudis* presented a lower average error value (mean error = 1.30) than those obtained for *P. nobilis* by Garcia March (mean error = 1.79). In both studies this values are more imprecise in smaller pinna shell.

The results have proved the usefulness of this method when there is a need to measure many individuals of protected/cryptic species, although the error demonstrates that measurements are poorly accurate. Such an imprecision may be closely related to the irregularities of the substratum that makes it difficult to obtain an accurate estimation of minimum width. The shell size analysis revealed a wide range of mean sizes (between 15 and 25 cm), corresponding mostly to adults. Also, the minimum size recorded for *P. rudis* was 10.1 cm, and may be related to the non-breeding season (early summer), which decreases the probability of finding smaller individuals (Basso *et al.* 2015). A similar analysis of *P. rudis* shell size was performed by Nebot-Colomer *et al.* (2016), but most of these individuals had shell lengths ranging from 15 to 20 cm. This difference in values may be due to differences in environmental conditions that influence both growth and survival rates. Most individuals were found in caves and in *Posidonia oceanica* beds, at depths of between 4 to 40 metres - different from individuals collected from coral communities at depths of from 0 to 4 metres (Nebot-Colomer *et al.* 2016).

This is the first attempt to estimate the population size structure of *P. rudis* in the Cabo Verde Archipelago. This *in situ* measurement method may be a useful and non-invasive tool for obtaining more *P. rudis* biometric data based on only a single measurement that is easy to assess underwater. In very fragile ecosystems such as Cabo Verdean Marine Protected Areas, this less invasive method can be replicated widely to obtain more biometric data for *Pinna* specimens. More studies are, however, needed to better understand the ecological benefits of *P. rudis*, namely in eutrophic zones, in order to propose efficient management and conservation measures for the entire archipelago.

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Capa | Front cover

Espécime de *Octopus vulgaris* (Cuvier, 1797) encontrado no intertidal rochoso do ilhéu Raso; *Octopus vulgaris* specimen (Cuvier, 1797) found in the intertidal rocky areas of Raso Islet. (fotografia de | photo by Eduardo Sampaio)

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