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Front cover | Capa: Humpback whale *Megaptera novaeangliae* (Borowski, 1781), Boavista, 10 May 2012 (Pedro López Suárez).

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What is known about cookiecutter shark (*Isistius* spp.) interactions with cetaceans in Cape Verde seas?

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Keywords: cookiecutter sharks, *Isistius* spp., predation, Cetacea, North Atlantic, Cape Verde Islands

SUMMARY

In the North Atlantic, the waters surrounding the Cape Verde Islands are a 'potential hot spot' for cookiecutter shark *Isistius* spp. interactions with cetaceans. These occurrences were recently identified by the improved efforts of researchers to document cetacean strandings in the Cape Verde archipelago, as well as by the photo identification efforts of live whales and dolphins. The documentation of individual and mass stranding events confirmed that cookiecutter shark interactions with cetaceans in Cape Verde seas are remarkably common.

RESUMO

No Atlântico Norte, as águas que rodeiam as Ilhas de Cabo Verde constituem um 'hot spot' potencial para os tubarões-charuto *Isistius* spp., bem como para interações destes com cetáceos. As ocorrências foram identificadas em resultado de esforços recentes de investigadores para documentar arrojamentos de cetáceos no arquipélago de Cabo Verde, bem como através de fotografias de baleias e golfinhos vivos. A documentação quer de indivíduos quer de arrojamentos múltiplos de cetáceos confirmou que as interações destes com os tubarões-charuto nos mares de Cabo Verde são consideravelmente frequentes.

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INTRODUCTION

Two species of cookiecutter sharks have been identified in the North Atlantic, i.e. the cookiecutter shark *Isistius brasiliensis* (Quoy & Gaimard, 1824) and the largetooth cookiecutter shark *Isistius plutodus* Garrick & Springer, 1964. The latter was described less than 50 years ago (Garrick & Springer 1964) and is only known from 10 specimens, collected at scattered locations in the Pacific and Atlantic, with all specimens collected close to land (IUCN 2012). Its recent discovery and the rarity of records may be due to more localized or limited distribution or lower abundance and occurrence only in deeper waters (IUCN 2012). In August 2000, a specimen of *I. plutodus* was caught in a pelagic trawl at midnight at a depth of 90–100 m, over a water depth of 890–980 m, north of the Azores at 43°58′N, 28°32′W (Zidowitz *et al.* 2004) and this is believed to be the only record from the open North Atlantic. The cookiecutter shark *I. brasiliensis* is more widespread. In the eastern North Atlantic it has been documented in waters between Senegal, Guinea-Bissau and the Cape Verde Islands (Compagno 1984, Jahn & Haedrich 1987, Muñoz-Chápuli *et al.* 1988, SIAP *et al.* 2002, IUCN 2012).

I. brasiliensis is generally located in deep open oceanic waters, primarily in tropical regions, most often within 20 degrees latitude, north or south, of the equator. Cookiecutter sharks are found in deep water during the day and at night migrate towards the surface with the deep scattering layer (Parin 1966, Jones, 1971, Last & Stevens, 1994, Heithaus 2001). Although this shark is generally restricted to the tropics, its distribution extends into higher latitudes in regions of warm water currents (Jahn & Haedrich 1987).

Both *Isistius* shark species have been implicated for the oval scars found on cetaceans and pinnipeds (Jones 1971). *Isistius* sharks are often referred to as ectoparasites (Heithaus 2001) as they attach to prey with suctorial lips and a modified pharynx. Once attached, the shark spins and cuts out a plug of flesh with its large razor-sharp and serrated lower teeth. The plug is then sucked out, leaving a distinct circular wound (Compagno 1984, Clark & Kristof 1990, Shirai & Nakaya 1992, Gasparini & Sazima 1996). *Isistius* sharks also prey on large billfish, including marlin, as well as tuna, large squid, other sharks and stingrays (Papastamatiou *et al.* 2010). It is believed that *Isistius* sharks attract their prey by remaining motionless in the water column and using bio-luminescence to mimic bio-luminescent squid (Jones 1971, Reif 1985, Last & Stevens 1994, Widder 1998).

In the North Atlantic, there are documented cases of *Isistius* shark and cetacean interactions from the Gulf of Mexico, Caribbean, Bahamas, eastern Canada and the Azores (Table 1). So far, there has been little effort to document *Isistius* shark scars or wounds on free ranging or stranded cetaceans to establish which *Isistius* species may have been the predator. The present study promotes the necessity of studying the interactions between *Isistius* sharks and cetaceans in order to better understand their predator-prey relationships. In the eastern North Atlantic, this is the first study of the predator-prey relationships between cookiecutter sharks and cetaceans.

MATERIAL AND METHODS

We searched the literature for data on the occurrence of *Isistius* sharks in different parts of the North Atlantic. In addition, we scrutinized photographs (both published and unpublished) documenting free ranging and stranded cetaceans from the Cape Verde Islands for evidence of scars and wounds inflicted by *Isistius* sharks. Interest in this study was initially triggered by a mass stranding of 120+ rough-toothed dolphins *Steno bredanensis* near Sal Rei, Boavista, Cape Verde Islands, 19 October 2010. Fifty-three of these dolphins stranded alive and subsequently died at Praia do Estoril and at nearby Ilhéu de Sal Rei (16°17′N, 22°94′W), while *ca.* 50 more stranded but were returned to the sea with the help of local people or managed to return to the sea by themselves (Hazevoet *et al.* 2010). All dolphin carcasses inspected during this event had wounds or scars presumed to be the result of interactions with *Isistius* sharks. Some showed evidence of fresh bites (open and still bleeding), had open, intermediate or sub-dermal wounds

Table 1. North Atlantic cetaceans with evidence of *Isistius* shark interactions.

SPECIES	LOCATION	REGION	REFERENCE
Blainville's beaked whale *Mesoplodon densirostris*	Cape Verde Islands	North Atlantic	This paper, Fig. 6
Blainville's beaked whale *Mesoplodon densirostris*	Hatteras NC; Bahamas	North Atlantic	Mead (1989) Claridge (2006)
Bottlenose dolphin *Tursiops truncatus*	Texas	Gulf of Mexico	Weller *et al*. (1997)
Bryde's whale *Balaenoptera brydei*	Azores	North Atlantic	Steiner *et al*. (2008)
Clymene dolphin *Stenella clymene*	Caribbean	Caribbean	Perrin *et al*. (1981) Jefferson *et al*. (1995)
Clymene dolphin *Stenella clymene*	Gulf of Mexico	Gulf of Mexico	Mullin *et al*. (1994) Jefferson *et al*. (1995)
Cuvier's beaked whale *Ziphius cavirostris*	Puerto Rico	Caribbean	Pérez-Zayas *et al*. (2002)
Dwarf sperm whale *Kogia sima*	Venezuela	Caribbean	Bermúdez-Villapol *et al*. (2008)
Dwarf sperm whale *Kogia sima*	Veracruz, Mexico	Gulf of Mexico	Delgado Estrella *et al.* (1998)
False killer whale *Pseudorca crassidens*	Cape Verde Islands	North Atlantic	Hazevoet *et al*. (2010)
Fin whale *Balaenoptera physalus*	Cape Verde Islands	North Atlantic	Moore *et al*. (2003)
Gervais' beaked whale *Mesoplodon europaeus*	Hatteras NC	North Atlantic	Mead (1989)
Gervais' beaked whale *Mesoplodon europaeus*	Curaçao	Caribbean	Debrot & Barros (1992)
Harbour porpoise *Phocoena phocoena*	North Sea	North Atlantic	van Utrecht (1959)
Humpback whale *Megaptera novaeangliae*	Cape Verde Islands	North Atlantic	Moore *et al*. (2003) This paper, Fig. 7
Melon-headed whale *Peponocephala electra*	Cape Verde Islands	North Atlantic	Van Waerebeek *et al*. (2008)
Melon-headed whale *Peponocephala electra*	Florida	Gulf of Mexico	Bossart *et al*. (2007)
Melon-headed whale *Peponocephala electra*	Gulf of Mexico	Gulf of Mexico	Perryman *et al*. (1994) Barron & Jefferson (1993)
Minke whale *Balaenoptera acutorostrata*	eastern Canada	North Atlantic	Jefferson *et al*. (2008)
Pygmy killer whale *Feresa attenuata*	Cape Verde Islands	North Atlantic	López Suárez *et al*. (2012)
Pygmy killer whale *Feresa attenuata*	Veracruz, Mexico	Gulf of Mexico	Delgado Estrella *et al.* (1998)
Rough-toothed dolphin *Steno bredanensis*	Azores	North Atlantic	Steiner (1995)
Rough-toothed dolphin *Steno bredanensis*	Cape Verde Islands	North Atlantic	Hazevoet *et al*. (2010) This paper, Fig. 1-3
Rough-toothed dolphin *Steno bredanensis*	Senegal	North Atlantic	Cadenat (1949)
Sei whale *Balaenoptera borealis*	Azores	North Atlantic	Schilling *et al*. (1992)
Short Finned pilot whale *Globicephala macrorhynchus*	Cape Verde Islands	North Atlantic	This paper, Fig. 4
Sowerby's beaked whale *Mesoplodon bidens*	Sable Island Nova Scotia	North Atlantic	Lucas & Hooker (2000) Jefferson *et al*. (2008)
Sperm whale *Physeter macrocephalus*	Cape Verde Islands	North Atlantic	This paper, Fig. 5
True's beaked whale *Mesoplodon mirus*	New Jersey	North Atlantic	Mead (1989)

or completely healed scars (Fig. 2-3), which we assume having been caused by *Isistius* sharks, based on being similar in nature, shape and form to bites attributed to *Isistius* sharks found in the literature (cf. Jefferson 2002).

RESULTS

Our literature search and examination of photographs resulted in data on 20 North Atlantic cetacean species with documented interactions with *Isistius* sharks (Table 1). Of these, nine species photographed in the Cape Verde Islands showed evidence of interactions with *Isistius* sharks. Most cookiecutter shark scars were found on the ventral side of dead stranded odontocetes, but some scars were also found near the head and on the snout and flank. Larger dolphins appeared to have a greater number of scars than smaller dolphins, suggesting that larger or older dolphins may be subject to more frequent interactions than younger individuals or that scars simply accumulate through the dolphins' lifetime. Several humpback whales *Megaptera novaeangliae*, photographed on their Cape Verde wintering grounds, showed *Isistius* shark bites on the dorsal ridge and flanks.

Fig. 1. Rough-toothed dolphin *Steno bredanensis* with healed *Isistius* shark bites near the head, Praia de Estoril, Boavista, 7 March 2001 (Pedro López Suárez). Fig. 2. Presumed older rough-toothed dolphin with multiple healed *Isistius* shark scars, Praia de Estoril, Boavista, 19 October 2010 (Junior Ramos Fonseca).

DISCUSSION

Since the early 1900s, circular scars on cetaceans have been recognized and prompted numerous discussions regarding their source(s), usefulness and use in photo-identification studies (Lillie 1915, Mackintosh & Wheeler 1929, van Utrecht 1959). Initially, scientists suggested that these wounds and scars on whales and dolphins were possibly caused by ectoparasitic copepods *Penella* spp. (Ivashin & Golubovsky 1978) and/or lampreys (Pike 1951, Nemoto 1955). In the 1970s, scientists recognized that these wounds were caused by *Isistius* sharks (Jones 1971, Shevchenko 1977). Lillie (1915) and Mackintosh & Wheeler (1929) first described these oval scars and considered these 'marks' to be evidence of the regularity of whale migrations from cold to warm waters. This was based on the assumption that the scarring takes place in warm water and that their quantity increases with age (and subsequent migrations) of a given whale. This circular scar (matching a shark bite) suggested that the animal, at one time or another, resided in warmer tropical waters. The presence of these circular scars along the flanks of sei whale *Balaenoptera borealis*, Eden's whale *B. edeni*, Bryde's whale *B. brydei*, finback whale *B. physalus*, killer whale *Orcinus orca* and Cuvier's beaked whale *Ziphius cavirostris* facilitated photo-identification of individuals (Schilling *et al*. 1992, Moore *et al*. 2003, McSweeney *et al*. 2007, Steiner *et al*. 2008, Dwyer & Visser 2011). *Isistius* scars have also been used and suggested

Fig. 3. Rough-toothed dolphin *Steno bredanensis* with open wound and completely healed *Isistius* shark scars, Praia de Estoril, Boavista, 20 October 2010 (Mario Évora).

for cetacean population stock determination for several species (Shevchenko 1977, Moore *et al*. 2003, Goto *et al*. 2009). Dwyer & Visser (2011) provided detailed descriptions and photographs of *Isistius* shark bites on cetaceans in New Zealand waters, as well as categories and descriptions of bite marks on killer whales *Orcinus orca*.

Souto *et al*. (2007) recorded the regions of a cetacean's body which were most subject to *Isistius* shark attacks, i.e. flanks 40%, head and abdomen 20% each, dorsal 15% and genital 5%. The relatively high number of bites on the flanks is probably due to their surface being larger, offering greater opportunities for attack to the *Isistius* shark. As most scars are ventrally located, observers at sea conducting research based on photo-identification are unlikely to observe all the evidence, severity and degree of *Isistius* shark interactions. Stranded cetaceans have indeed shown that there are generally more *Isistius* scars on the flanks and ventral side of carcasses than on the dorsal side of the animals. *Isistius* sharks are likely to attack any animal which feeds on the organisms in the deep scattering layer and migrates through deep warm tropical waters. Cetaceans and large fish species which prey upon squid may be more susceptible to *Isistius* sharks interactions, as these species may be attracted to the ability of *Isistius* sharks to mimic potential prey such as luminescent squids. The prevalence of these oval shark bites on the ventral portion of the body may be related to the shark's preying tactic (Widder 1998). However, this does not explain the occurrence of oval bite scars on baleen whales and some odontocete species which do not eat squid.

The risk of *Isistius* shark predation most likely varies with migratory patterns of their prey, feeding behaviour of fish and cetacean populations, habitat, prey movements, residency over deep ocean waters, water temperature and water depth in both near shore and pelagic tropical waters. The extent of these interactions must be measured by investigative stranding networks and fisheries biologists. Fresh interactions between *Isistius* sharks and marine fauna may be more easily established on stranded marine mammals, as well as in fisheries involving large fish like swordfish, marlin and tuna (Papastamatiou *et al*. 2010).

The waters surrounding the Cape Verde Islands are rich with marine fauna. Greater effort to document cetacean and *Isistius* shark interactions describing *Isistius* shark bite marks, such as bite qualifier, bite depth and bite state (see Dwyer & Visser 2011), would aid in *Isistius* species identification.

CONCLUSIONS

Evidence of cetacean species documented with *Isistius* shark bite scars appears to be most often reported in tropical waters and at locations where marine mammal research communities are active. *Isistius* shark scars have been observed on many of the baleen whales passing through the Azores (L. Steiner pers. comm.), including blue *B. musculus*, finback, sei, Bryde's, minke *B. acutorostrata* and humpback whale. Dwyer & Visser (2011) provided an overview of 49 marine mammal species which have been targeted by *Isistius* sharks around the world. These worldwide predator-prey interactions and occurrences have been documented in Brazil, eastern Australia, Hawaii, the Gulf of Mexico, Caribbean and Azores (Dwyer & Visser 2011). Our Table 1 provides no new species, but adds additional references and localities for North Atlantic cetacean species.

The evidence of *Isistius* shark predation on 100% of the stranded rough-toothed dolphins on Boavista in October 2010 suggests that their movements between the islands and into deep tropical waters make this species particularly susceptible to *Isistius* shark predation. However, insufficient data exist on the rough-toothed

Fig. 4. Short-finned pilot whale *Globicephala macrorhynchus* with *Isistius* shark scars on ventral area, Praia de Boa Esperança, Boavista, 28 September 2010 (Gabriella Gatt).

Fig. 5. Sperm whale *Physeter macrocephalus* with *Isistius* shark wounds, Praia de Roque, Boavista, 8 March 2006 (Pedro López Suárez).

Fig. 6. Blainville's beaked whale *Mesoplodon densirostris* with multiple *Isistius* shark scars, off northern Boavista, 14 April 2011 (Richard White).

dolphin's migratory patterns. Possibly, diving and nocturnal swimming and foraging behaviour make this species more prone to interactions with *Isistius* sharks than other odontocete species. Additional research is required to better understand these predator-prey interactions and how they may or may not influence marine mammal health and stranding events. Rough-toothed dolphins have been observed with *Isistius* shark bites in other regions of the northeastern Atlantic. Cadenat (1949) observed 'crater or oval holes' on stranded rough-toothed dolphins in Senegal. Reporting on the first sightings of rough-toothed dolphins in the Azores, Steiner (1995: 125-126) reported that "many individuals [had] blotchy white/pinkish patches on the flanks and undersides". Most likely, these 'blotchy white/pinkish patches' referred to healed *Isistius* scars. Muñoz-Chápuli *et al*. (1988) described *Isistius* shark wounds on swordfish *Xiphias gladius* from the northeastern Atlantic and suggested that the bulk of the northeastern Atlantic *Isistius* shark population may be found between 11°N and 16°N, thus coinciding with the latitude of the Cape Verde Islands.

In Cape Verde, all cetaceans on which cookiecutter shark bites have been reported were pelagic species or coastal species known to migrate through deep tropical waters, such as the humpback whale. The rough-toothed dolphin, despite being a well-known pelagic species, is the delphinid most often reported in the coastal waters of the eastern islands of Sal, Boavista and Maio, which have a larger shelf than the islands more to the west. However, the lack of specific studies on the behavioural ecology and temporal and spatial distribution of this species in the archipelago preclude further interpretation on why it appears to be the species most exposed to *Isistius* attacks. The uneven prevalence of cookiecutter shark bites and scars in short-finned pilot whales and melon-headed whales, two deep diving species that account for most of the stranding events in Cape Verde, illustrate the gaps in our knowledge and understanding of the relationships between *Isistius* sharks and cetaceans in these islands.

At this time, there has been no effort to systematically document *Isistius* shark scars or wounds on cetaceans, which would help in identifying which *Isistius* species is the predator. The present paper confirms the necessity for continuing study of the interactions between *Isistius* sharks and cetaceans in order to better understand their predator-prey relationships.

Fig. 7. Humpback whale *Megaptera novaeangliae*, female, with numerous *Isistius* shark bite scars, off Sal Rei, Boavista, 16 March 2011 (Pedro López Suárez).

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Diet of feral cats *Felis catus* L., 1758 on Santa Luzia, Cape Verde Islands

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Keywords: feeding ecology, feral cats, insular environments, introduced predators, Cape Verde Islands

ABSTRACT

The diet of feral cats *Felis catus* on Santa Luzia, Cape Verde Islands, was studied. A total of 147 prey items were identified during the analysis of 26 scat groups collected during the summer of 2010. House mouse *Mus musculus* was the most important prey, both in percentage of biomass and number of preys consumed (89.7% and n= 117, respectively). Reptiles were the second most important prey, represented by one skink species (*Chioninia stangeri*) and an unidentified gecko species. The remainder of the identified prey consisted of one bird species (*Passer iagoensis*) and one undetermined Tettigoniidae species (Insecta). No endangered species were identified in scats of this introduced predator, but future surveys must be carried out to further avoid threats to the island's biodiversity.

RESUMO

Foi estudada a dieta de gatos assilvestrados *Felis catus* na ilha de Santa Luzia, Cabo Verde. Foram identificadas 147 presas de um total de 26 dejectos recolhidos no Verão de 2010. A presa mais importante, tanto em percentagem de biomassa como em número de presas consumidas, foi o rato doméstico *Mus musculus* (89.7% e n= 117, respectivamente). Os répteis foram a segunda presa mais importante, maioritariamente lagartos (*Chioninia stangeri*), bem como de uma espécie não identificada de osga. Outras presas identificadas foram uma ave (*Passer iagoensis*) e uma espécie não identificada de Tettigoniidae (Insecta). Não foi detectada nenhuma espécie com estatuto de ameaça na dieta deste predador introduzido, porém outras monitorizações futuras deverão ser implementadas para evitar ameaças à biodiversidade desta ilha.

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INTRODUCTION

Domestic cats *Felis catus* L., 1758 have been introduced to many islands around the world, often causing a dramatic impact on their wildlife (Medina *et al*. 2011). Cats predate on a great variety of prey species, including mammals and invertebrates as well as birds and reptiles, according to their abundance and availability (Bonnaud *et al*. 2011), occasionally causing a severe decline in populations of both native and introduced prey species (Fitzgerald 1988, Medina *et al*. 2011). However, some authors do not consider dietary studies to provide sufficient information to assess the impact of a predator upon a prey population (Towns *et al*. 2006). Nevertheless, study of the diet of an introduced predator on an oceanic island is a useful tool and the first step towards interpreting and quantifying a predator's impact upon local wildlife (Paltridge *et al*. 1997).

In the Macaronesian region, the diet of feral cats has been extensively studied in the Canary Islands (see review by Nogales & Medina 2009). In this archipelago, introduced mammals (rabbits, rats and mice) constituted the main prey species, although native birds and reptiles also represented a considerable proportion of the consumed biomass. In Madeira and the Cape Verde Islands, fewer studies have been carried out. The most complete studies were done on Madeira and Fogo (one of the Cape Verde Islands), respectively (Medina *et al*. 2010), and a preliminary study was carried out on Santa Luzia (Donald *et al*. 2005). In these islands, where rabbits are not present, other introduced mammal species (mainly mice) were the main prey consumed, but in Santa Luzia native skinks were the most preyed upon species (Donald *et al*. 2005). These studies showed that several endangered species, such as giant lizards in the Canary Islands and Fea's petrel *Pterodroma feae* on Fogo, were predated by feral cats (Medina & Nogales 2009, Medina *et al*. 2010), lending importance to this type of study as a tool for recognizing threats on island native faunas.

Studies of feral cat diet provide important data for evading the negative impact of these predators on native island wildlife (Bonnaud *et al*. 2011, Medina *et al*. 2011). In the present contribution we provide further data on the diet of feral cats at a poorly studied site in the Cape Verde archipelago (Mateo *et al.* 2004), trying to attain a new approach to their impact upon Santa Luzia's native species.

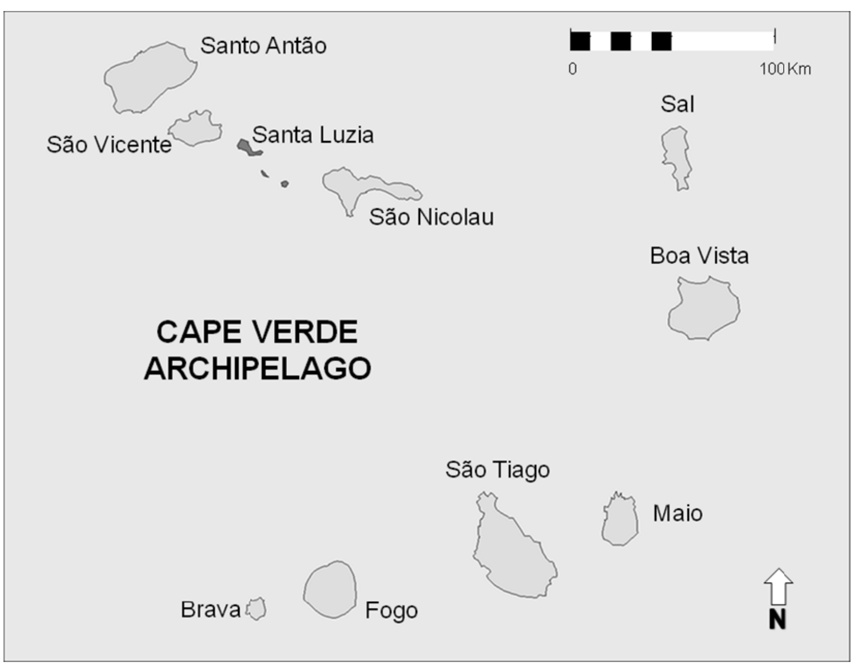

Fig. 1. Map of the Cape Verde archipelago showing the location of Santa Luzia island.

STUDY AREA

The archipelago of Cape Verde is situated in the eastern Atlantic Ocean, *ca*. 570 km off the western coast of continental Africa. It consists of 10 main islands and several uninhabited islets (Fig. 1). The three eastern islands are rather flat with a small number of peaks, reaching only a few hundred metres. The western islands are mountainous, locally reaching heights of 1,500 m (almost 3,000 m on Fogo), reflecting their younger geological age. Climate is warm and dry of a sahelian-tropical type and irregular monsoon rains reach the islands mainly in summer and autumn (for further information on the geology, climate and environment of the Cape Verde Islands, see Mitchell-Thomé 1976, Hazevoet 1995 and Duarte & Romeiras 2009).

Santa Luzia (35 km^2) is the smallest of the main islands of the Cape Verde archipelago. Together with the nearby islets of Branco and Raso, it is often referred to as one of the Desertas. It is uninhabited (but a family of goatherds lived there until the mid 1960s) and its highest point reaches 395 m a.s.l. Vegetation is characterized by the presence of only a single floristic zone (Duarte *et al*. 2008), dominated by drought resistant species such as *Cistanche phelipaea*, *Polycarpaea nivea*, *Zygophyllum simplex*, *Heliotropium ramosissimum*, *Frankenia ericifolia* and *Euphorbia tuckeyana* (Schleich & Wuttke 1983, Diniz & Matos 1994, Sánchez Pinto *et al*. 2005). Santa Luzia's fauna has been poorly studied and only 57 terrestrial invertebrates, three terrestrial reptiles, *ca.* 8 breeding birds and one mammal species have been reported (Hazevoet 1995, Arechavaleta *et al*. 2005, Siverio *et al.* 2007, Masseti 2010, Hazevoet & Masseti 2011, Hazevoet 2012). Two other reptile species, presumed to have occurred on the island in the past, are now considered extinct (Siverio *et al*. 2007).

METHODS

The diet of feral cats on Santa Luzia was determined by analysing scats, a commonly used method in the research of mammalian carnivore diet (Delibes 1980, Trites & Joy 2005). In July 2010, a total of 26 scat groups were collected at different localities of the island. In contrast to other mammalian predators, feral cats frequently bury their faeces (Bradshaw 1992), making it often difficult to estimate the date of deposition. Therefore, the collected material (which included both old and fresh scats) probably covered all seasons, as scats remain unaltered over a long period before disintegrating (Medina *et al*. 2006). This complicates the study of feeding ecology of feral cats, as seasonal prey availability becomes difficult to interpret. Scats were broken up at the laboratory after having been saturated in water. Prey items, magnified 16x using a binocular microscope, were identified at the species level whenever possible, using hairs, bones, feathers, arthropod exoskeletons and reference collections. Although it is difficult to quantify the number of individual prey from scats, because the same prey may appear in more than one dropping (Delibes 1980), the minimum number of preys was estimated by counting bone remains, jaws and, especially, opposite mandibles and teeth (incisors). The ingested biomass was calculated from values obtained from bibliographic resources. In the case of invertebrates, only preys weighing more than 0.05 g were considered in order to avoid counting indirect prey items, previously ingested by lizards (Medina *et al*. 2006, Medina & García 2007).

Statistical analysis involved a chi-square test to compare the quantity of different prey types consumed, using the number of prey items in the scats. Analysis consisted of comparing the number of a certain prey item with respect to the total number of the remaining prey identified (Medina *et al*. 2006).

RESULTS AND DISCUSSION

A total of 147 preys was identified from the analysis of 26 scat groups collected on Santa Luzia (Table 1). The small number of faeces sampled may reflect the rather small feral cat

	No. Prey	% Prey	FO (%)	% Biomass
MAMMALS	117	79.6	100	89.7
Mus musculus				
BIRDS	3	2.0	11.5	2.2
Passer iagoensis				
REPTILES	25	17.0	53.8	8.0
Scincidae				
Chioninia stangeri	17	11.6	46.2	5.5
Gekkonidae indet.	8	5.4	23.1	2.5
INVERTEBRATES	2	1.4	7.7	0.1
Tettigoniidae indet.				
PLANT MATERIAL			53.8	

Table 1. Results of the analysis of feral cat *Felis catus* scats from Santa Luzia, Cape Verde Islands (n= 26).

population on the island (cf. Donald *et al*. 2005). House mouse *Mus musculus* was the only mammal prey detected, constituting more than 89% of the total consumed biomass and being the main prey consumed (χ^2= 51.49; df= 1; p< 0.001). Reptiles were represented by two different families, Scincidae (*Chioninia stangeri*) (n= 17) and Gekkonidae (eight individuals not identified at the species level). Only one bird species, iago sparrow *Passer iagoensis*, and one unidentified Tettigoniidae (Insecta) species made up the remainder of the feral cat diet on Santa Luzia (Table 1).

On oceanic islands where other mammal species (usually mice, rats and rabbits) have also been introduced, these constitute the main prey for feral cats (Fitzgerald & Turner 2000, Nogales & Medina 2009, Bonnaud *et al*. 2011). On Santa Luzia, mice are the only available mammal prey of feral cats (Masseti 2010, Hazevoet & Masseti 2011). Mice also constituted the main prey of feral cats on Fogo island (Medina *et al*. 2010) and generally is an important prey in open shrub environments (Nogales & Medina 2009), which is the principal ecosystem on Santa Luzia (Duarte *et al*. 2008). However, Donald *et al*. (2005) found skinks, not mice, to be the main prey on Santa Luzia. This may be due to seasonal variations in population size and activity patterns of both prey species, as studies were performed in different seasons, i.e. winter (Donald *et al*. 2005) and summer (this study). Feral cats are known to change their diet according to seasonal variation of prey availability (Konecny 1987). Birds are important prey species on islands with important colonies of seabirds (Bonnaud *et al*. 2011). On Santa Luzia, where only a small number of bird species breed, only remains of one passerine species were found in scats. In other studies of feral cat diet in the Cape Verde archipelago (i.e. Santa Luzia: Donald *et al*. 2005, Fogo: Medina *et al*. 2010), birds also only formed a small part of feral cat diet. However, elsewhere in Cape Verde, on Boavista island, feral cats have been identified as important predators of breeding red-billed tropicbirds *Phaethon aethereus* (P. López Suárez *in litt*). In our study, reptiles were the second most important prey of feral cats on Santa Luzia, these being well known as an important prey in open habitats (Nogales & Medina 2009) and at low latitudes (Fitzgerald 1988). Although reptiles rarely represent a significant percentage of the biomass consumed by cats on islands (Bonnaud *et al.* 2011), they were the most important prey for cats on Santa Luzia in winter (Donald *et al.* 2005). In contrast, reptiles were the second most important prey group, both in number and frequency of occurrence, on Fogo in winter (Medina *et al*. 2010). If available, large insects, such as *Coleoptera* or *Acrididae*, are frequently preyed upon by feral cats (Fitzgerald & Turner 2000, Nogales & Medina 2009, Bonnaud *et al*. 2011).

It is difficult to assess the bearing of an introduced species on the decline of another species (Towns *et al*. 2006), but the study of diet is considered the first step towards interpreting the impact of feral cats on prey populations (Paltridge *et al* 1997). Although the iago sparrow is listed as a Least Concern species in the IUCN Red List (IUCN 2012), it is endemic to the Cape Verde Islands and included in the diet of feral cats on Santa Luzia. In insular environments, feral cats are known to become the top predator on the food chain (Nogales *et al*. 1992), threatening a large number of species on islands worldwide (Fitzgerald & Turner 2000, Medina & Nogales 2009, Medina *et al*. 2011). Remains of the giant skink *Chioninia* (= *Macroscincus*) *coctei*, long considered extinct, have been claimed to have been identified in cat scats from Santa Luzia (Mateo *et al.* 2004), although this has not yet been substantiated beyond reasonable doubt. Future surveys should be carried out to obtain definitive data on the possible survival of this skink, formerly thought to have been endemic to the islets of Raso and Branco only.

Santa Luzia has been suggested as a suitable place for natural re-colonization or deliberate introduction of the Raso lark *Alauda razae* (Donald *et al*. 2005), a Critically Endangered species (IUCN 2012) endemic to Raso islet. However, cat presence on Santa Luzia is considered a negative factor in this connection. Though feral cat eradication is considered feasible on a small and uninhabited island (Campbell *et al*. 2011) such as Santa Luzia, removing this introduced predator could cause an increase in the mouse population that could in turn negatively affect native (or, in the case of the Raso lark, introduced) species on the island. Therefore, if a feral cat eradication project is to be carried out on Santa Luzia, in order to avoid the mesopredator release effect (Courchamp *et al*. 1999), the simultaneous eradication of both the introduced predator (cats) and its principal introduced prey (mice) should be considered.

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From Cape Verde to the Netherlands via Portugal and France: the journey of an early specimen of the giant skink *Chioninia coctei* (Duméril & Bibron, 1839)

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Keywords: *Chioninia coctei*, giant skink, Royal Cabinet of Natural History of Ajuda, João da Silva Feijó, natural history collections, Geoffroy Saint-Hilaire

ABSTRACT

An old specimen of the extinct giant skink *Chioninia coctei* (Duméril & Bibron, 1839), endemic to the islets of Branco and Raso, Cape Verde Islands, in the Naturalis Biodiversity Center, Leiden, the Netherlands, had been misidentified as *Leiolopisma telfairii* (Desjardin, 1831). The specimen, acquired by the Leiden Museum from the Muséum national d'Histoire naturelle in Paris during the 19th century, is demonstrated to be one of the specimens of *C. coctei* sent to Portugal by João da Silva Feijó during the 1780s. It was brought from Lisbon to Paris by Étienne Geoffroy Saint-Hilaire during the Napoleonic invasion in 1808. Together with the specimen remaining in the Paris museum, it is the oldest known of the species. The likely pathway of dispersal, as well as the general characteristics of the specimen, are discussed.

RESUMO

Um espécimen antigo do extinto lagarto gigante *Chioninia coctei* (Duméril & Bibron, 1839), endémico dos ilhéus Branco e Raso do arquipélago de Cabo Verde, encontra-se actualmente nas colecções do Naturalis Biodiversity Center, Leiden, Paises Baixos, erroneamente identificado como *Leiolopisma telfairii* (Desjardin, 1831). O espécimen, que terá dado entrada no Museu de Leiden vindo do Muséum national d'Histoire naturelle de Paris no século XIX, é aqui apresentado como um dos espécimenes de *C. coctei* enviados para Portugal por João da Silva Feijó durante a década de 1780. Terá sido enviado de Lisboa para Paris por Étienne Geoffroy Saint-Hilaire durante a invasão Napoleónica de 1808. Conjuntamente com o espécimen presente no Museu de Paris, apresenta-se como o exemplar mais antigo da espécie que actualmente se conhece. É discutida neste artigo a trajectória singular de dispersão do exemplar, bem como as suas características gerais.

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INTRODUCTION

The Cape Verde giant skink *Chioninia coctei* (Duméril & Bibron, 1839)[1] is an endemic and iconic species of the Cape Verde Islands, considered extinct since the beginning of the 20th century (Schleich 1996, IUCN 2012). Very few specimens remain in natural history collections around the world (Andreone 2000). During recent investigations into the history and pathways of dispersal of 18th and 19th century Portuguese natural history collections (cf. Ceríaco & Bour 2012), indications emerged that an old specimen of *C. coctei* – misidentified as *Leiolopisma telfairii* (Desjardin, 1831), a species from Round Island, near Mauritius – could be present in the collections of the Naturalis Biodiversity Center (formerly Rijksmuseum van Natuurlijke Historie) in Leiden, the Netherlands, having been presented to the Leiden museum by the Muséum national d'Histoire naturelle in Paris during the 19th century. At the time, exchanges of specimens between natural history museums were common practice and considered a sign of goodwill and collaboration between scientists and institutions. These transfers often consisted of duplicate specimens, as natural history investigations (and thus the composition of collections) largely focused on taxonomic diversity amongst species rather than variation within populations. Therefore, the usual policy of museums was to retain a single (sometimes one male, one female and one juvenile) representative of a species, transferring most duplicates to other museums. This web of transfers contributed to the spread of natural history knowledge throughout Europe, as well as enriching natural history collections. Many of today's natural history collections are a direct result of this process of dispersal and the study of these collections is a subject of study for both biologists and historians (Ceríaco *et al*. in press).

To confirm the identity of the skink specimen discussed herein and to trace the pathway that led to its current repository, Dr Esther Dondorp, curator of herpetology at the Naturalis Biodiversity Center, and Dr Chris Smeenk, emeritus curator of mammalogy at the same institution, were contacted. In order to study the specimen first-hand, the Naturalis collections were visited in January 2013. In this paper, a brief history of the specimen is presented, highlighting its rarity and the singularity of its pathway of dispersal.

THE ROYAL CABINET OF NATURAL HISTORY OF AJUDA

The beginning of natural history collections in Portugal can be traced back as far as 1768 with the foundation of the Royal Botanical Garden and Cabinet of Natural History of Ajuda in Lisbon, under the superintendence of the Paduan naturalist Domingos Vandelli (1735-1816). Under the direction of Vandelli, the Royal Museum of Ajuda followed the prevailing European trends in Natural History, such as the adoption of the Linnean system of nomenclature and the exploration of vast and largely unknown overseas territories. Vandelli, who was also professor of chemistry and natural history at the University of Coimbra, trained several students to carry out 'philosophical voyages' to the Portuguese overseas territories. From the 1780s onwards, these voyages resulted in 1,000s of specimens, enriching and bringing international fame to the Cabinet of Ajuda. One of Vandelli's students, the naturalist João da Silva Feijó (1760-1824), was entrusted the 'philosophical voyage' to the Cape Verde Islands. Feijó's voyage to Cape Verde was mired with difficulties and, in terms of collections, much less profitable than the voyages of some of his colleagues, such as that of Alexandre Rodrigues Ferreira to Brazil. Nevertheless, his voyage resulted in some shipments of natural history products to Ajuda (Pereira 2002, Ceríaco *et al*. in press). By the late 18th century and mostly due to these voyages, the Cabinet of Ajuda housed one of the richest natural history collections in Europe, which aroused the interest of foreign naturalists. In 1808, after the Napoleonic invasion of Portugal, the French zoologist, Étienne Geoffroy Saint-Hilaire (1779-1844), was appointed to visit and study the Portuguese natural history collections with the main objective of selecting material lacking in the Paris museum. Obviously, due to its rich Brazilian collections, the Cabinet of Ajuda was the main target and Geoffroy selected a considerable number of specimens, mostly from Brazil. The original inventory of specimens selected lists about 76 mammals, 284 birds, 32 amphibians and reptiles, 97 fishes, as well as a large number of invertebrates, mineralogical and fossil specimens, herbariums, books and manuscripts (Daget & Saldanha 1989). For several years, these specimens were studied by naturalists of the Paris museum, leading to the description of dozens of species new to science, and some are still used in scientific discourse today (cf. Ceríaco & Bour 2012). After the end of the Napoleonic era, the Cabinet of Ajuda entered a prolonged phase of decline, ultimately resulting in its closure in 1836 and the transfer of all of its remaining collections to the newly created National Museum of Lisbon, at the time housed at the premises of the Academy of Sciences in Lisbon. The museum and its collections remained there until 1858, when it was transferred to the Polytechnic School of Lisbon, under the supervision of the Portuguese zoologist José Vicente Barbosa du Bocage (1823-1907). The few remaining specimens from Ajuda were incorporated in the new collections made from the second half of the 19th century onwards, until a catastrophic fire destroyed almost all in 1978.

GIANT SKINK SPECIMENS FROM AJUDA

The first specimens of *C. coctei* were collected by João da Silva Feijó in 1784, during his 'philosophical voyage' to the Cape Verde Islands. In one of his inventories[2], listing the natural products collected on the island of Santa Luzia and the islets of Branco and Raso and remitted to the Royal Cabinet of Ajuda, Feijó refers to '*2 Lagartos do d.ª Ilheo*' (two lizards from the islet [of Branco]). In another manuscript[3], written after Feijó's return to Portugal, while working at the Cabinet of Ajuda, the naturalist briefly refers to the species as 'a large and fat kind of lizard', with a skin 'covered with fish scales', and used by the locals to make footwear, pointing out that the species only occurred on one of the uninhabited islets west of the island of São Nicolau (see Carreira 1986). This was the first and only reference to the species made by a Portuguese naturalist until 1873.

The amphibians and reptiles sent to Paris by Geoffroy were handed to Bernard Germain Lacépède (1756-1825), curator of the reptile (including amphibians) and fish department of the Paris museum. Lacépède produced a rather detailed list of all the specimens received[4], using a notation system to indicate the importance of each specimen. This notation used the symbols +, ++ and +++, in which '*la croix unique, expliquait-il, désginent les objets qui manquent à la collection, la double croix ceux qui en ountre sont inconnus, la triple croix les objets les plus remarquables*' (the single cross refers to those objects that are lacking in the collection, the double cross to those that are unknown, the triple cross to those most remarkable). Marked ++ were '*2 autres Scinques tout à fait nouveaux*' (two other completely new skinks). These specimens were inserted in the first section of the list ('*§ 1 - Conservés secs et emapillés*', i.e. conserved dry and stuffed), implying that the two '*Scinques*' were mounted specimens. Since no other new scincid is known to have been present in the Ajuda collections, these are inferred to be specimens of *C. coctei* sent to Portugal by Feijó during his sojourn in the Cape Verde Islands.

After their arrival in Paris, one specimen was studied by some of the foremost naturalists of the time, i.e. Georges Cuvier (1769-1832), André Marie Constant Duméril (1774-1860) and Gabriel Bibron (1805-1848). The first to examine the specimen was Cuvier, who extracted the skull and depicted it in his magnum opus, *Recherches sur les Ossements Fossiles* (Cuvier 1824). Duméril & Bibron (1839) described the species and named it *Euprepes coctei*, based on the single specimen present in the Paris museum (MNHN 8299-Sc 371), the same from which the skull studied by Cuvier was taken. Despite the fact that two individuals had been sent by Geoffroy in 1808, only a single specimen figures in Cuvier's (1824) and Duméril & Bibron's (1839) works. It is important to note that Duméril & Bibron (1839) did not know the geographical origin of the animal, but only that it had been brought from Portugal to Paris by Geoffroy, and they put forward the hypothesis that the specimen originated from the coasts of Africa. This situation was mainly due to the lack of original labels on most of the Ajuda specimens, a problem that has led to numerous errors (Daget & Saldanha 1989).

The specimen currently present in Leiden was apparently sent from Paris to the Netherlands before Duméril & Bibron (1839) described and named the species. In a catalogue[5] from 1835 in the Naturalis archives, signed by Hermann Schlegel (1804-1884), at the time curator of vertebrates under the Leiden museum's first director Coenraad Jacob Temminck (1778-1858), 102 items are listed, one of which (No. 92) reads '*Scincus Telfarii* [sic], *île de France*' (the old French name of Mauritius). '*Scincus Telfarii*' (= *Leiolopisma telfairii*), then recently described by Desjardin (1831), is a species of 'giant skink' endemic to Round Island, off Mauritius, somewhat similar in general appearance to *C. coctei*. This listing most probably refers to the specimen in Naturalis discussed here, since, according to the original label, the specimen was identified as '*Scincus Telfarii*' from '*Île Ronde*' (Fig. 1). This is repeated on the pedestal, which, in Schlegel's handwriting, reads '*Ile ronde près de Mauritius*'. However, despite the apparent correspondence between catalogue and labels, there is a discrepancy, since the labels mention the specimen having been acquired from the Paris Museum in 1838, while the catalogue is dated 1835. The annual reports of the Leiden Museum over these years do not shed light on this, but perhaps the material from Paris arrived later or - more likely - was catalogued only in 1838. During this period, Temminck regularly filed complaints with the government about the lack of space at the museum's original premises and shipments of specimens often remained unpacked for years (Holthuis 1995). Given the above, it seems altogether reasonable to assume that the specimen is in fact the second *C. coctei* reported by Lacépède.

After Duméril & Bibron's (1839) description, more than 30 years passed before something was heard again about the taxon. Having received three live specimens of the species from Francisco Frederico Hopffer, head of the public health service in Cape Verde, combined with information received from French correspondents, Bocage (1873a,b) was able to establish that the islet of Branco constituted the natural habitat of the species. He proceeded by coining a new genus, *Macroscincus*, for it (Bocage 1873b). Around the same time, he identified three more specimens of *C. coctei* in the collections of the Lisbon museum that had once belonged to the Cabinet of Ajuda (Bocage 1873a,b, 1896). Moreover, Bocage (1873a,b) mentioned that he had located an original manuscript list in which the specimens, including two '*lagartos*' (Bocage 1896), shipped by Feijó in 1784 were recorded, clearly the same list as referred to above.

THE LEIDEN SPECIMEN

The Leiden specimen is an old mounted animal attached to a small pedestal (23 x 34.5 cm), which in turn is attached to a larger pedestal (27 x 62 cm), with the catalogue number RMNH-RENA 17057 (Fig. 1). The animal is mounted in a straight position, with the open mouth almost closed. The general state of conservation is good, with the exception of the tail which is cracked in several places. Since the animal is mounted on the smaller pedestal, it is almost impossible to detach it without damaging the specimen. Therefore, the only measurement taken was the total length of 56.5 cm. In addition to its general appearance, the specimen shows all the distinctive characters of *C. coctei*, such as the multi-cusped teeth and the shape of the head scales. Comparing the specimen with other mounted examples of *C. coctei*, particularly those in the collections of the *Escola Secundária Passos Manuel* in Lisbon, which date from the second half of the 19th century, it is obvious that the Leiden specimen is much older, due to its general appearance and the taxidermical techniques employed. The specimen shows many similarities with the Paris specimen and also shows some distinctive characteristics of the old Ajuda taxidermical techniques, such as the large belly scar and the typical 'waxed' appearance, both similar to the Paris specimen.

With its taxonomic identity and provenance now being established beyond reasonable doubt, it could be assumed that the Leiden specimen of *C. coctei* is part of the type series. Because neither a holotype nor a lectotype has been fixed, the Leiden specimen would automatically be a syntype (cf. Art. 72.1, 72.4 and 73.2 of the Code; ICZN 1999). However, the situation is complicated by the fact that, as mentioned above, there exists a list by Feijó in which he explicitly mentions the shipment of two specimens. Because Bocage (1873a,b, 1896) located another three *coctei* specimens from Ajuda in the Lisbon museum, there must have been at least five in the Cabinet of Ajuda[6].

Fig. 1. *Chioninia coctei* (Duméril & Bibron, 1839), RMNH-RENA 17057, Naturalis Biodiversity Center, Leiden, the Netherlands, 14 January 2013 (Luis Ceríaco; ©Naturalis Biodiversity Center).

This implies that Feijó made more than one shipment of *C. coctei* specimens, making it impossible to know whether the two specimens selected by Geoffroy were precisely the two included in Feijó's list. Although the precise duration of his stay has as yet not been clarified, it seems that Feijó remained in the islands for several years, having ample time to obtain more specimens. Another, in view of the times and circumstances rather remote possibility is that the three specimens discovered by Bocage (1873a,b) were not shipped by Feijó, but were obtained from another source at some time during the early 19th century. In any case, as the three specimens in the Lisbon museum were destroyed in the 1978 fire, to all intents and purposes it seems judicious to consider the two surviving specimens from Ajuda, presently in Paris and Leiden, as constituting the type series of *C. coctei*.

DISCUSSION

Based on its external characteristics, the specimen presently in the collections of the Naturalis Biodiversity Center in Leiden can be positively identified as a specimen of *C. coctei*. Despite the lack of definitive data, but supported by an array of circumstantial evidence, it can be concluded that it originally came from the Royal Cabinet of Natural History of Ajuda and therefore was collected by João da Silva Feijó during his 'philosophical voyage' to the Cape Verde Islands. There are several arguments that support this: 1) its incorporation in the collections of the Paris museum must have been the result of Geoffroy's shipment of specimens from Portugal, since no other naturalists visited the Cape Verde Islands and sent specimens of *coctei* after Feijó for more than 80 years; 2) although Duméril & Bibron (1839) described the species based on a single specimen from the Cabinet of Ajuda, two specimens had been shipped to Paris by Geoffroy; 3) the species' geographical distribution remained unknown until 1873, when new specimens arrived in Lisbon (Bocage 1873a,b), reinforcing the first argument; 4) the Leiden specimen still has the original labels and identification as '*Scincus telfairii*' from '*île Ronde*' and the note of being offered by the Paris Museum, dating from before the publication of Duméril & Bibron's (1839) description, thus agreeing with the reference in the Leiden catalogue; and 5) the taxidermical techniques and general characteristics of the specimen positively match with other remaining Ajuda specimens, including the *coctei* specimen in Paris.

The correct identification of this specimen and its pathway of dispersal constitute a considerable novelty vis-à-vis the unfortunate story of *C. coctei*, but also provides new data for investigators. For biologists this identification is not only important because it corrects an identification error perpetuated through time, but also because it represents the discovery of a specimen of an extinct species. Therefore, the remaining specimens represent the only opportunity to study the species and they are in fact the only material evidence of *C. coctei*'s former existence, a situation that is even more pregnant given the rarity of specimens of *coctei* in museums around the world. For historians of science, the pathway of dispersal of this particular specimen is a fine example of the web of transfers, practices and relations amongst 19th century natural history institutions in Europe. This case has particular importance because it illustrates a pathway of specimens from the Ajuda collection so far unknown, but also because it represents a very old specimen, still surviving today. The specimen can therefore reclaim its legitimate place as a rare and historical representative of the legendary, but tragically extinct, Cape Verde giant skink.

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NOTES

[1] For the use of *Chioninia* rather than *Mabuya* or *Macroscincus* for the giant skink, see Miralles *et al.* (2010).

[2] *Lista das Producçoens de S^{ta} Luzia; Ilheos Raso; e Br^{co} que observou, recolheo e remeteo p.^{a} o Real Gabinete do Prince N. Snr. em o anno de 1784*, presently in the historical archive of the Museu Bocage, Lisbon - AHMB Rem. 558C.

[3] *Ensaio filosófico e Político sobre as Ilhas de Cabo Verde, escrito e oferecido à Real Academia das Ciências por João da Silva Feijó, naturalista que foi encarregado do serviço de S. Mag. do exame das mesmas Ilhas em 1797*.

[4] *Reptiles et Poissons rapportés du Portugal par M. le Professeur Geoffroy St Hilaire.*

[5] *Catalogue de Reptiles cédés en Juin 1835 sous titre d'échange du Musée de Paris à celui des Pays-Bas.*

[6] Indeed, unaware that in fact two specimens had been moved to Paris, Bocage (1902) concluded that Feijó had shipped a total of four specimens of *C. coctei*.

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Short note | Nota breve

Has the magnificent frigatebird *Fregata magnificens* in the Cape Verde Islands reached the end of the road?

Pedro López Suárez, Cornelis J. Hazevoet & Luís Palma

Keywords: magnificent frigatebird, Cape Verde Islands, extinction

On 6 October 2012, the remains of a frigatebird were recovered at João Barrosa beach (16°01.387'N, 022°43.610'W), southeastern Boavista, Cape Verde Islands. The carcass had been found in mid September 2012, during a beach survey to monitor loggerhead turtle nesting activity in the area and was then buried in the sand. The field assistant of the Cabo Verde Natura 2000 turtle project who found the bird indicated the location of the corpse to the first author. His description of the bird allowed it to be identified as an adult female magnificent frigatebird *Fregata magnificens* Mathews, 1914. The remains consisted of numerous black and white feathers as well as several bones, including the skull, thorax and wing bones, which are preserved at the Cabo Verde Natura 2000 headquarters at Sal Rei, Boavista. Some feathers, together with remains of an egg and tissue of a mummified male found at Ilhéu de Baluarte in 2005 (see below), were deposited at the Centro de Análise Molecular, Centro de Investigação em Biodiversidade e Recursos Genéticos (CMA/CIBIO), Vairão, Portugal.

During the 20th and 21st centuries, Ilhéu de Baluarte and Ilhéu do Curral Velho, off the eastern and southern coast of Boavista island, respectively, have been the only known breeding sites of the magnificent frigatebird in the Cape Verde Islands and the eastern Atlantic (Hazevoet 1995, Lopez-Suárez *et al.* 2007). In theory, albeit not in practice, both islets are Integral Reserves under Decree No. 3/2003 of Cape Verde law. The magnificent frigatebird was listed as critically endangered in the First Red List of Cape Verde (Hazevoet 1996). Historical data indicate that in the past the species also bred at Ilhéu dos Pássaros, off Sao Vicente, and at Ilhéu de Rabo-de-Junco, off Sal (Hazevoet 1995). During the mid 19th century, it was said to be more numerous at Ilhéu dos Pássaros than anywhere else in the archipelago (Keulemans 1866). Its demise and disappearance there has most likely been due to the islet's position at the entrance of Porto Grande, São Vicente, which became an important coaling centre during the second half of the 19th century (cf. Hazevoet 1994).

Although colonization of the archipelago could have occurred by random dispersal of individuals from the western Atlantic, it also seems possible that the Cape Verde frigatebird population constitutes a relic of a pan-Atlantic distribution. Bombard (1953) frequently met with frigatebirds across the whole width of the Atlantic on his extraordinary solitary voyage from the Canary Islands to Barbados in October-December 1952. Their occasional occurrence in the Azores, Madeira and Canary Islands (Garcia-del-Rey 2011) also points to trans-Atlantic movements rather than being attributable to stray birds from the tiny Cape Verde population. The few frigatebirds seen off

2008	Male	Female	Total
02 March	2	-	2
09 March	1	1	2
13 March	-	2	2
16 March	-	2	2
2009			
25 February	-	1	1
29 March	1	2	3
14 April	-	1	1
05 December	1	2	3
2010			
12 April	1	2	3
13 November	-	1	1
2011			
13 March	1	-	1
21 March	1	1	2
10 October	-	-	1 (sex unknown)
12 November	1	1	2
2012			
01 April	1	1	2
12 April	1	-	1
22 November	-	1	1

Table 1. Sightings of magnificent frigatebirds *Fregata magnificens* at Ilhéu de Curral Velho, Boavista, Cape Verde Islands, during the years 2008-2012.

Mauritania (Lamarche 1988) and The Gambia (Gore 1990) may have concerned birds from the Cape Verdes, although this is impossible to ascertain. Historically, the magnificent frigatebird may thus have had a continuous distribution across the tropical Atlantic from the Caribbean to the Cape Verde Islands (see also Bourne 1957), but there are no indications that, in historical times, it has bred elsewhere in the eastern Atlantic.

A pan-Atlantic distribution would throw doubt on the validity of a separate 'subspecies' (*lowei* Bannerman, 1927) for birds from the Cape Verde Islands (cf. Bourne 1957, Hazevoet 1995). Bannerman (1927) named his alleged subspecies on account of the 'enormous bill' of a mere two specimens (a male from Boavista and a female collected off The Gambia). However, bill size (as well as other size measurements) of Cape Verde birds shows substantial overlap with those obtained from Caribbean and Galapagos birds (cf. Bourne 1957). Nevertheless, Hailer *et al.* (2011) demonstrated that magnificent frigatebirds from the Galapagos Islands are strongly differentiated from non-Galapagos birds (i.e. birds from the rest of the eastern Pacific and western Atlantic), both genetically and in body measurements. Their study did, however, not include samples from the Cape Verde Islands. Our anticipated genetic analysis, as well as measurement data from a larger number of individuals, may shed further light on the possible distinctiveness of Cape Verde frigatebirds.

The Cape Verde frigatebird population may never have exceeded more than a few dozens of pairs, although no less than Christopher Columbus, in his famous *Diario del descubrimiento*, reported the sighting of a frigatebird on the Atlantic Ocean in September 1492 and commented that "there are many of these in the Cape Verde Islands" (Hartog 1993). During recent decades, the population has declined rapidly. In 1965, Naurois (1969) estimated the total breeding population at Ilhéu de Curral Velho to be 10-12 pairs. During the years 1988-1992, no more than five pairs were present on Baluarte and Curral Velho together (Hazevoet 1995), while Noeske & Pfützke (1994) reported two breeding pairs at Curral Velho islet in 1993. Six birds (four males – two in breeding condition – and two females), perching on two nests, were seen at Baluarte islet, 6 April 2003 (Dirk Colin & Nico Geiregat *in litt.*).

Magnificent frigatebird *Fregata magnificens*, female, Ilhéu de Baluarte, Boavista, Cape Verde Islands, 4 June 2003 (Pedro López Suárez).

The finding of a mummified male on Baluarte islet, 25 January 2005, reduced the known population to five birds. In 2006, a maximum of two females and two males was counted, all on Curral Velho islet (López Suárez *et al*. 2007). From 1999-2000 to 2005-2006, the population was regularly surveyed for seven consecutive breeding seasons. Reproductive failure, either resulting from genetic (inbreeding depression) or demographic (ageing, lack of recruits, Allee effect) imbalances, is considered to have brought the frigatebird to the verge of extinction (López Suárez *et al*. 2007). However, the initial decline of the frigatebird population in Cape Verde was likely triggered by human persecution, as has been the case for several other seabird populations since the islands were first colonized by man during the 15th century (Hazevoet 1994, 1995).

Since 2007, the frigatebird population has only been monitored occasionally and most information during the past five years has come from opportunistic sightings provided by birdwatchers, fishermen and sporadic surveys of Baluarte and Curral Velho islets by the first author (Table 1). During the summer of 2011, local fishermen saw three individuals on Baluarte islet. A single nest, occupied by a male, was reported on Curral Velho islet, 22 April 2012. In 2012, there were no sightings of more than two individuals together. Several sightings of a single female and a single male have been made in the area of Curral Velho and at the bay of Sal Rei, the main town on Boavista island, and these two birds were thought to represent the total remaining population (P. López Súarez *in* Hazevoet 2012). During the years 2007-2010, there have also been occasional sightings of single birds off the islands of São Vicente and Sal (Hazevoet 2010, 2012). It is as yet unclear whether these concerned local wanderers or birds originating from populations in the western Atlantic.

The death of the female found in September 2012 may signal the prelude to the imminent extinction of the magnificent frigatebird in the Cape Verde Islands. Further monitoring during the breeding season will be needed to establish whether the breeding population has now indeed been reduced to two individuals, a male and a female. However, if birds from the western Atlantic indeed reach the Cape Verde Islands, there remains the (albeit remote) possibility of replenishment of the Cape Verde population. Calls for the protection of the frigatebird's breeding sites in Cape Verde have been made for almost 50 years (Naurois 1964, Bannerman & Bannerman 1968, Bannerman 1973, Le Grand *et al.* 1984, Nørrevang & Hartog 1984, Hartog 1990, Hazevoet 1994, 1995, 1996), but have met with little or no response from the local authorities so far. With the population now reduced to the smallest number of birds possible, it is of utmost importance that decisive steps are taken to uphold the law and enforce strict protective measures in order to save this emblematic bird of the Cape Verde Islands.

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Short note | Nota breve

An aberrantly coloured buzzard *Buteo bannermani* on Santo Antão, Cape Verde Islands, in November 2012, with notes on the past and present status of the species

Magnus Robb & René Pop

Keywords: Cape Verde buzzard, *Buteo bannermani*, aberrant plumage, population size

On 30 November 2012, we observed a white presumed Cape Verde buzzard *Buteo bannermani* Swann, 1919 in the northern mountains of Santo Antão, Cape Verde Islands. The bird was defending a territory on the west side of the road between Corda and Vila da Ribeira Grande. Judging from the amount of time it spent in aerial display, it probably concerned a male. RP managed to make a series of photos, including some of the bird perched at a distance of *ca*. 60 m (Fig. 1 & 2). In these it was possible to confirm that the eyes were dark and neither pale nor reddish, identifying the bird as an adult and excluding the possibility of an albino. Its apparent mate was a bird of normal appearance.

Fig. 1. Cape Verde buzzard *Buteo bannermani*, Santo Antão, 30 November 2012 (René Pop).

The plumage of the aberrant buzzard appeared essentially all-white. From below, however, the first primary on each wing appeared to be a very pale brown or creamy and may have been moulted recently, while the whiter appearance of the other flight feathers may have been due to bleaching. The pinkish colour of the bill of the white buzzard observed in Santo Antão would indicate either leucism (a partial or total lack of both melanins in feathers) or ino, while the very pale brown of the first primary would appear to narrow this down to ino, a colour aberration caused by the qualitative reduction of both melanins due to incomplete synthesis (oxidation) of both eumelanin and phaeomelanin (Grouw 2010, 2013). However, ino is almost exclusively restricted to females, while – in view of its display behaviour - our bird was most likely a male. Therefore, it probably concerns a strong example of dilution, a quantative reduction in colouration that can be caused by a range of different mutations (H. van Grouw *in litt*.). It should be noted that correct identification of colour aberrations in birds in the field is often problematic and not always possible (Grouw 2013). As far as we know, this is the first documented example of a white Cape Verde buzzard.

Fig. 2. Cape Verde buzzard *Buteo bannermani*, Santo Antão, 30 November 2012 (René Pop).

In the common buzzard *B. buteo* (L., 1758), white birds (leucistic or otherwise, not to be confused with sometimes very pale individuals from northern European populations) are occasionally reported. A quick search on the internet produced the following recent examples:

- A bird in flight, similar in general appearance to the Cape Verde buzzard reported here, was photographed in Austria in March 2008 (http://tinyurl.com/c57bsaz; accessed 16 February 2013);
- A wholly white common buzzard (probably a 'brown' mutant (a change of appearance of the eumelanin granules; see Grouw 2006, 2010), showing sparse brown upperwing-coverts, was photographed in Fife, Scotland in September 2010 (http://tinyurl.com/c378tr5; accessed 16 February 2013);
- Possibly the same bird was photographed at Loch Ken, west of Dumfries, Scotland, in June 2012 (http://tinyurl.com/83ydvh5; accessed 16 February 2013);
- A wholly white common buzzard, showing just a few brown feathers on the nape (probably a form of dilution), was photographed near Roskilde, Denmark, 6 January 2013 (http://tinyurl.com/bc5vwu2; accessed 6 February 2013).

In addition, largely white common buzzards showing 'brown' mutation were reported from western Poland in August 2005 and southern Poland in August 2011 (Ciach *et al.* 2011). Another common buzzard, also showing 'brown' mutation, was photographed in Drenthe, the Netherlands, in November 2012 (Bottema & Bottema-MacGillavry 2013).

The Cape Verde buzzard is probably the rarest *Buteo* in the world and the total population may not exceed a few 10s of pairs, with the largest numbers occurring on the islands of Santiago and Santo Antão (Hazevoet 1995). It was listed as critically endangered in the First Red List of Cape Verde (Hazevoet 1996). During our six day stay on Santo Antão in late November and early December 2012, we observed a total of between five and seven Cape Verde buzzards in the northern part of the island, although we did not carry out a systematic survey. A week's survey on Santo Antão in June 1999 only yielded four buzzard sightings (Palacios 2002). In the early 1990s, the population on Santiago was estimated at *ca.*

10 pairs (Hazevoet 1995) and has since remained within that size range (C.J. Hazevoet *in litt.*). Until the late 1960s, a small breeding population probably also existed on São Nicolau (Naurois 1973), but there is only one recent record of a single bird in March 1996 (Hazevoet 1997). There are also records from Fogo (3), Brava (1), São Vicente (1) and Boavista (3), but so far no indication of breeding there (Hazevoet 1995, 2003). The single record from São Vicente is of some interest as it concerns the type specimen of *bannermani* in The Natural History Museum (BMNH), Tring, UK, said to have been collected 'near Mindelo Bay', 26 September 1913 (Hazevoet 1995). Being the only record for the island, one may wonder if it had perhaps been brought from nearby Santo Antão and purchased at the port town of Mindelo on São Vicente. The three records (two old, one recent) from Boavista may in fact not refer to *bannermani*. James (1984) provisionally identified a second year male in BMNH, collected on Boavista in May 1897, as *B. cirtensis* (Levaillant, 1850). Moreover, a recently fledged female (indicating local breeding) in the Cleveland Museum of Natural History, Ohio, USA, collected on Boavista in March 1924 and received on loan at the Yale Peabody Museum, New Haven, Connecticut, USA, where it was examined in December 1991, also showed characters of *cirtensis*, although this was hard to certify due to the specimen being of a juvenile and the dearth of comparative material at hand at the time (C.J. Hazevoet *in litt.*). The sighting of a single buzzard on Boavista, 25 March 2001, may perhaps be referable to a vagrant *cirtensis* rather than *bannermani* (Hazevoet 2003). Indeed, the desert-like environment on Boavista is quite similar to the habitat of *cirtensis* on the African mainland, while on Santo Antão and Santiago (and formerly on São Nicolau), *bannermani* almost exclusively haunts the mountainous interior regions of these islands.

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