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## Bibliographic revision and new records of bats (Chiroptera) for Cabo Verde Archipelago

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### RESUMO

A região Oeste africana apresenta uma das maiores falhas de conhecimento na distribuição e taxonomia das espécies, especialmente das menos conspícuas. Este trabalho apresenta um dos poucos estudos alguma vez realizado nas ilhas de Cabo Verde sobre morcegos. O conhecimento da distribuição das sete espécies registadas neste arquipélago é ainda muito escasso e com baixa resolução (geralmente ao nível da ilha), assim novos registos são esperados, o que terá muito valor para o estabelecimento de políticas conservacionistas. A revisão da informação dispersa e inacessível por via digital (devido à antiga data de publicação) da fauna de morcegos de Cabo Verde, incluindo os primeiros registos de morcegos para duas ilhas e novos dados de ocorrência para duas espécies em três ilhas, é apresentada. Acredita-se que este trabalho pode constituir uma referência para futuros trabalhos sobre morcegos na região pois também providenciamos registos acústicos que poderão ser revistos em futuras revisões taxonómicas.

**Palavras-chave:** mamíferos, distribuição, sonogramas

## ABSTRACT

The West African region possesses one of the largest knowledge gaps in the distribution and taxonomy of all species, especially inconspicuous ones. This work presents one of the few bat studies ever carried out in the Cabo Verde Islands. Knowledge on the distribution of the seven species recorded in this remote archipelago is still very scarce and with very low resolution (many at island level), so new records are expectable and invaluable for the establishment of conservation policies. A review on the scattered and digitally unavailable (due to the old date of publication) knowledge of the Cabo Verde bat fauna with the first bat records for two islands and new occurrence data for two species on three islands is presented. It is expected that this work can constitute a reference for future bat works in the region, while providing acoustic data that can easily be updated upon future taxonomic revisions.

**Keywords:** mammals, distribution, sonograms

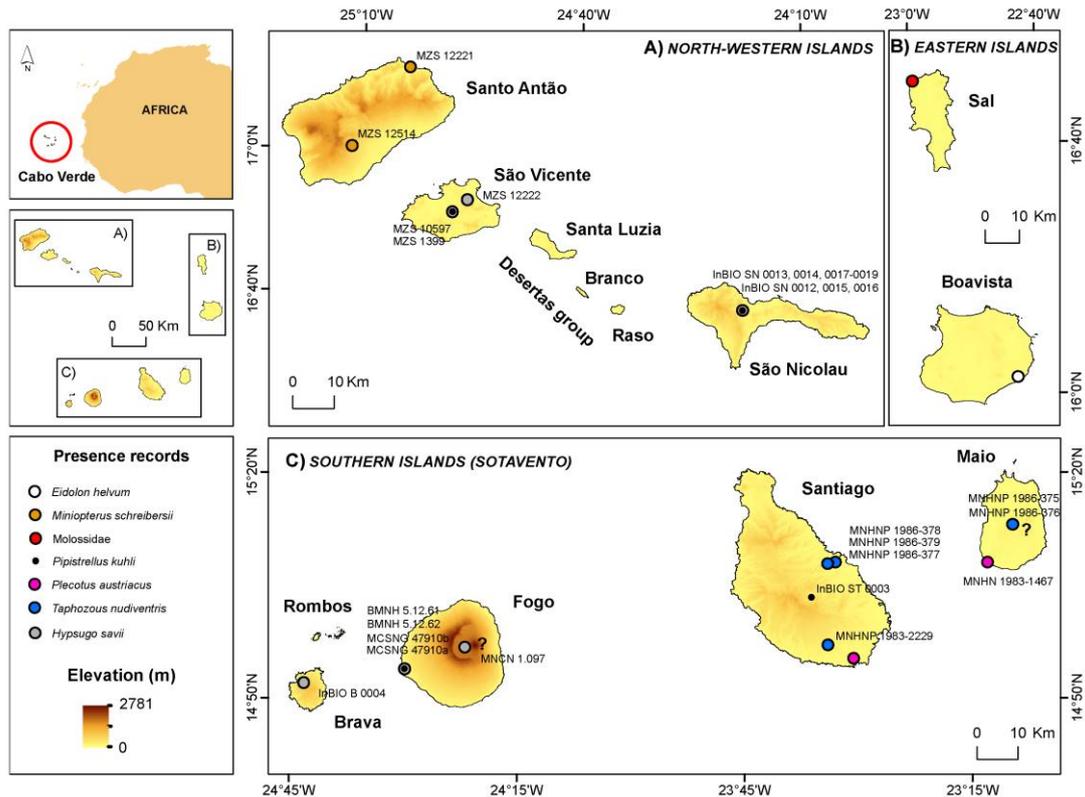
## INTRODUCTION

Very few studies and field expeditions have focused on the bats from Cabo Verde Islands. Some preliminary data published in the 1960's and 1980's indicate that there are up to five species of bats (four vespertilionids and one emballonurid) that might have colonised the islands by passive transport by boat, but the possibility that they have reached it by their own means is not excluded (Dorst & Naurois 1966, Pucetti & Zava 1988). Resident bats were identified as *Taphozous nudiventris* (Cretzschmar, 1830), *Hypsugo savii* (Bonaparte, 1837), *Pipistrellus kuhlii* (Kuhl, 1817), *Plecotus austriacus* (Fischer, 1829) and *Miniopterus schreibersii* (Kuhl, 1817) (Dorst & Naurois 1966, Hazevoet 2015, Ibañez & Fernández 1989, Masseti 2010, Pucetti & Zava 1988). All bat species were considered recent and rare on the archipelago (Tranier & Naurois 1985). Since then, no more information was published regarding those species, although a reference to another two, probably vagrant species, *Eidolon helvum* (Kerr, 1792) and an indeterminate species of Molossididae, occurred in 2010 and 2014, respectively (Hazevoet 2014, Jiménez & Hazevoet 2010). Knowledge on the distribution of bats in Cabo Verde is still very limited and lacking precise spatial localization (usually only the name of the island is given),

so new records are expectable and invaluable for the establishment of conservation policies, as some of these species (*M. schreibersii* and *E. helvum*) are classified as Near Threatened (Hutson *et al.* 2008, Mickleburgh *et al.* 2008).

The Cabo Verde Islands are located in the Atlantic Ocean (Fig. 1) and belong to the biogeographical region of Macaronesia. These islands are included in the Mediterranean biodiversity hotspot (Myers *et al.* 2000) and form a volcanic archipelago comprising 10 main islands plus several islets, with a total area of circa 4000 km<sup>2</sup>. In past studies, the presence of bats was detected in seven of those islands, namely Santo Antão, São Vicente, Sal, Boavista, Maio, Santiago, and Fogo (Fig.1).

The goal of this work is to provide new distributional information regarding the presence of bats in Cabo Verde based on a review of the scattered and digitally unavailable literature and our own fieldwork, in order to facilitate future research on the seven resident and vagrant species occurring in this remote archipelago. In addition, this work intends to provide reference material for future taxonomic revisions that should follow, and to act as a statement that bats do exist in the country and should be included in conservation plans.



**Fig. 1.** Summary of bibliographic and new records of all species of bats registered in the Cabo Verde Islands. See Table 1 for details of museum vouchers or sonograms depicted with their codes (when no code is presented, no voucher or sonogram was collected; when it starts with InBIO, it refer to new records). Question marks stand for unknown localities (records represented on the island's centroids).

## MATERIAL AND METHODS

Acoustic surveys were carried out on 10 Cabo Verde Islands from 2006 to 2008 during the dry season, from mid-May to mid-July. Ultrasound surveys were made with a D-240x (Pettersson Elektronik AB, Uppsala, Sweden) and recorded on an Edirol R-09 (Roland). Records were all made between 17:30 and 20:00 pm (circa one hour before sunset until one hour after sunset) in urbanised areas with low buildings and no trees. Sound analyses were made using BatSound Pro 4.2 (Pettersson Elektronik AB, Uppsala, Sweden) with a 1024 pt FFT and Hamming window for spectrogram analysis (Russo & Jones 2002; Amorim *et al.* 2014). Acoustic identification of bat calls, where frequency, duration and pattern were used as descriptors, were based on Russo & Jones (2002) and ACR (2017). It is likely that the current taxonomic status of

Cabo Verde bats will be revised in the near future (see Discussion). Therefore, we decided to compare call characteristics with both Africa and European call libraries, especially to help in the discrimination of *Pipistrellus* and *Hypsugo* calls. Records were deposited in figshare repository (<https://figshare.com/>).

The geographical coordinates of fieldwork observations were recorded with a global positioning system (GPS) device. Previous records from the literature were gathered in a database. Coordinates from literature records were determined from topographical maps (1:25,000). All coordinates from new and previous observations were recorded or determined on the WGS84 datum and mapped using ArcGIS v. 9.3 (ESRI, Redlands, USA).

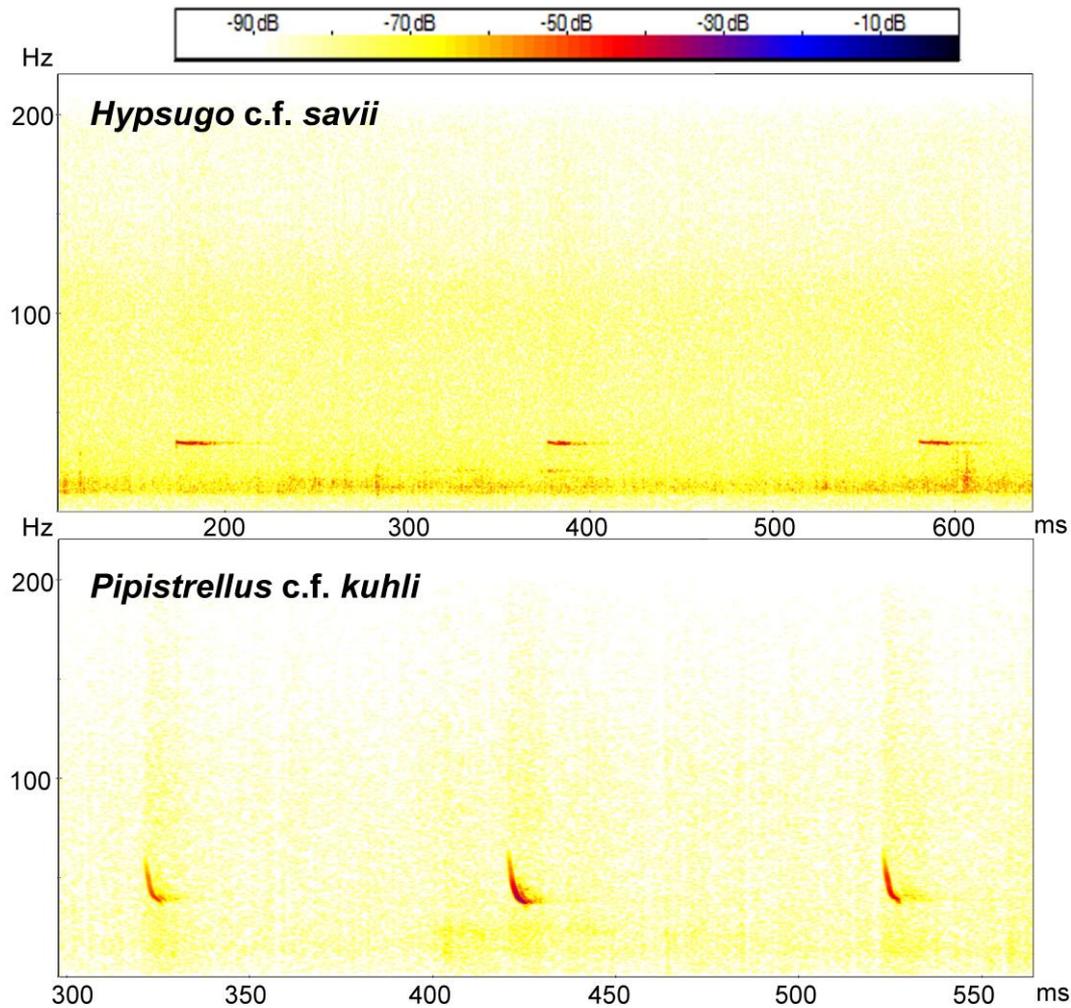
## RESULTS

For this study, 15 new records with sonograms and 22 bibliographic records were gathered. All bibliographic and new records are depicted in Fig. 1 and detailed in Table 1 and some relevant sonograms in Fig. 2. A list of all material available at the Museum National d'Histoire Naturelle de Paris

(MNHN), Museo Civico di Storia Naturale, Genova (MCSNG), British Museum Natural History, London (BMNH), Museo Zoologico de La Specola, Firenze (MZS), Museo Nacional de Ciencias Naturales, Madrid (MNCN) and the figshare repository is following:

**Table 1.** Details of all records of bats registered in the Cabo Verde Islands by island, with museum voucher codes and sonogram codes, identified sex (F, female; M, male; -, unknown), record type, year of collection (year), and location (islands and locality).

Island	Locality	Taxa	Code	Sex	Record type	Year
Boavista	Ervatão	<i>E. helvum</i>	(just seen)	F	bibliographic	2010
Brava	Nova Sintra	<i>H. c.f. savii</i>	InBIO B0004	-	this study	2006
Fogo	São Filipe	<i>H. savii</i>	MCSNG 47910a	M	bibliographic	1898
Fogo	São Filipe	<i>H. savii</i>	MCSNG 47910b	F	bibliographic	1898
Fogo	São Filipe	<i>H. savii</i>	BMNH 5.12.61	M	bibliographic	1898
Fogo	São Filipe	<i>H. savii</i>	BMNH 5.12.62	-	bibliographic	1898
Fogo	unknown	<i>H. savii</i>	MNCN 1.097	F	bibliographic	-
Fogo	São Filipe	<i>P. c.f. kuhlii</i>	InBIO F0005-0007, 0009	-	this study	2007
Maio	Vila do Maio	<i>P. austriacus</i>	MNHN 1983-1467	-	bibliographic	1965
Maio	unknown	<i>T. nudiventris</i>	MNHNP 1986-375	-	bibliographic	1965
Maio	unknown	<i>T. nudiventris</i>	MNHNP 1986-376	F	bibliographic	1965
Sal	Ponta Preta	Molossidae	(just seen)	-	bibliographic	2014
Santiago	São Jorge	<i>P. c.f. kuhlii</i>	InBIO ST0003	-	this study	2007
Santiago	Praia	<i>P. austriacus</i>	(just seen)	-	bibliographic	1965
Santiago	Pedra Badejo	<i>T. nudiventris</i>	MNHNP 1986-377	F	bibliographic	1968
Santiago	Pedra Badejo	<i>T. nudiventris</i>	MNHNP 1986-378	M	bibliographic	1969
Santiago	Pedra Badejo	<i>T. nudiventris</i>	MNHNP 1986-379	F	bibliographic	1969
Santiago	Trindade	<i>T. nudiventris</i>	MNHNP 1983-2229	M	bibliographic	1969
Santiago	Santa Cruz	<i>T. nudiventris</i>	(just seen)	M	bibliographic	2015
Santo Antão	unknown	<i>H. savii</i>	(not confirmed)	-	bibliographic	-
Santo Antão	Ribeira Grande	<i>M. schreibersii</i>	MZS 12221	F	bibliographic	1984
Santo Antão	Paúl	<i>M. schreibersii</i>	MZS 12514	M	bibliographic	1986
São Nicolau	Ribeira Brava	<i>H. c.f. savii</i>	InBIO SN0013, 0014, 0017-0019	-	this study	2006
São Nicolau	Ribeira Brava	<i>P. c.f. kuhlii</i>	InBIO SN0012, 0015, 0016	-	this study	2007
São Vicente	unknown	<i>H. savii</i>	MZS 1399	M	bibliographic	1909
São Vicente	Monte Verde	<i>H. savii</i>	MZS 12222	-	bibliographic	1984
São Vicente	unknown	<i>P. kuhlii</i>	MZS 10597	F	bibliographic	1909



**Fig 2.** Examples of the recorded sonograms for each species (*Pipistrellus c.f. kuhli* on top and *Hypsugo c.f. savii* below). Six records were made for the first species and eight for the second and are available in Figshare ([10.6084/m9.figshare.6269582](https://www.figshare.com/figure/6269582)).

## EMBALLONURIDAE

*Taphozous nudiventris* Cretzschmar, 1826.

Distribution: Santiago and Maio Islands; 6 specimens on MNHNP and no sonograms available (Table 1):

MNHNP 1983-2229, male collected in 1969 on Santiago, farm near Trindade

MNHNP 1986-375, unknown sex, collected in 1965 on Maio, unknown locality

MNHNP 1986-376, female collected in 1965 on Maio, unknown locality

MNHNP 1986-377, female collected in 1968 on Santiago, Pedra Badejo

MNHNP 1986-378, male collected in 1969 on Santiago, Pedra Badejo

MNHNP 1986-379, female collected in 1969 on Santiago, Pedra Badejo

Male collected in 2015 on Santiago, Santa Cruz beach and release at the site

## VESPERTILIONIDAE

*Hypsugo savii* (Bonaparte, 1837)

Distribution: Santo Antão (cited in Masseti 2010 but not confirmed in the literature, possibly new record), São Vicente, São Nicolau (new record), Brava (new record) and Fogo Islands; 6 specimens on MCSNG, BMNH and MZS and 6 sonograms (Table 1):

MCSNG 47910a, male collected in 1898 on Fogo, São Filipe  
 MCSNG 47910b, female collected in 1898 on Fogo, São Filipe  
 BMNH 5.12.61, male collected in 1898 on Fogo, São Filipe  
 BMNH 5.12.62, unknown sex, collected in 1898 on Fogo, São Filipe  
 MZS 1399 male collected in 1909 on São Vicente, unknown locality  
 MZS 12222, unknown sex, collected in 1984 on São Vicente, Monte Verde  
 MNCN 1.097 female collected in unknown date on Fogo, unknown locality  
 INBIO SN0013, 0014, 0017-0019, unknown sex, recorded in 2006 on São Nicolau, Ribeira Brava  
 INBIO B0004, unknown sex, recorded in 2006 on Brava, Nova Sintra

***Pipistrellus kuhlii*** Kuhl, 1819

Distribution: São Vicente, São Nicolau (new record), Santiago (new record) and Fogo (new record); 1 specimen at MZS and 8 sonograms (Table 1):

MZS 10597, female collected in 1909 on São Vicente, unknown locality  
 INBIO ST0003, unknown sex, recorded in 2007 on Santiago, São Jorge  
 INBIO F0005 to 0009, unknown sex, recorded in 2007 on Fogo, São Filipe  
 INBIO SN0012, 0015, 0016, unknown sex, recorded in 2006 on São Nicolau, Ribeira Brava

***Plecotus austriacus*** (Fischer, 1829)

Distribution: Maio and Santiago; 1 specimen at MNHN and one observation record (Table 1):

MNHN 1983-1467, unknown sex, collected in 1965 on Maio, Vila do Maio  
 1 individual of unknown sex seen in 1965 at Santiago, Praia

***Miniopterus schreibersii*** Kuhl, 1819

Distribution: Santo Antão; 2 specimens at MZS (Table 1):

MZS 12221, female collected in 1984 on Santo Antão, Ribeira Grande  
 MZS 12514, male collected in 1986 on Santo Antão, Paúl

**MOLOSSIDAE**

Distribution: Sal; no specimens, one observation record (Table 1), probably vagrant:

Indeterminate free-tailed bat, unknown sex, collected in 2014 on Sal, Ponta Preta and released at the site.

***Eidolon helvum*** (Kerr, 1792)

Distribution: Boavista; no specimens, one observation record (Table 1), probably vagrant:

Female collected in 2010 on Boavista, Ervatão beach and release at the site.

**DISCUSSION**

This study presents the first records of chiroptera for two of the islands of this archipelago (São Nicolau and Brava). Two bat species, identified as *Hypsugo* c.f. *savii* and *Pipistrellus* c.f. *kuhlii*, were also detected for the first time on three islands (on São Nicolau, Fogo, Brava, and possibly Santo Antão, and on São Nicolau, Fogo and Santiago, respectively). Based on the data gathered until now, the most widespread species in the

Cabo Verde Islands seem to be *Hypsugo* c.f. *savii*, with confirmed records in four out of 10 islands, comprising also the oldest records for the archipelago, dating from 1898 (Table 1). This species and *Pipistrellus* c.f. *kuhlii* are the only ones distributed both on the northern and southern islands of the archipelago; all the remaining taxa have records only on one or at most two islands of Cabo Verde (Fig. 1).

The known distributions of bats in Cabo

Verde show a highly scattered pattern. A recent colonisation, passive transport of individuals brought by boats or storms and/or poor sampling effort have been proposed as plausible explanations. Some authors state that the origin of chiroptera in Cabo Verde is recent, and so most species did not had enough time to colonise other islands, and that occasionally individuals might involuntarily reach different islands of the archipelago due to boat traffic (Chevalier 1935, Pucetti & Zava 1988). In fact, the migratory *E. helvum* is a common and widespread in countries adjacent to Cabo Verde, such as Guinea-Bissau and Senegal, with single individuals being recently found in the Canary Islands (Jiménez & Hazevoet 2010) and Cabo Verde, Boavista (Hazevoet 2014).

Poor sampling effort may be also undermining current knowledge on bat distributions. In fact, each new observation indicates a new chiroptera taxon or a new island of occurrence, what clearly indicates that bats have been continuously neglected in biodiversity surveys, maybe a consequence of their low detectability and difficulty in species identification. Therefore, it is essential to perform further extensive sampling in Cabo Verde to thwart this knowledge gap.

It is import to highlight that most of the known bat species for Cabo Verde are

identified as species related to the western Palearctic. At the time exploration missions in Cabo Verde were carried out, identifications of bat species were only based on morphological characters associated to European bats (ACR 2017). Bat colonization of Cabo Verde Islands can in fact be old, previous to the human occupation of the islands (from the 15<sup>th</sup> to the 17<sup>th</sup> century). Thus, it is possible that adaptation to the arid Cabo Verdean habitats could have led to speciation of native cryptic species or subspecies similarly to the Canary Islands due to the large distance from the African continent (Juste *et al.* 2004). In addition, some sub-Saharan species are recorded at the northern limit of their distribution, e.g. *Taphozous nudiventris* (Tranier & Naurois 1985). Only future studies including genetic analyses and detailed morphologic analyses of the voucher specimens (e.g. skulls and forearms) may confirm the previous morphological identification of these species. Hence, it would be very important to perform bat trapping to get tissue samples and to perform DNA analyses on the museum vouchers kept in alcohol (ongoing). Current taxonomy of some of these species is possibly outdated and uncertain classification of specimens was already recognised in Cabo Verde (Benda *et al.* 2004, Juste *et al.* 2004).

## CONCLUDING REMARKS

Considering the undersampling of bats in Cabo Verde, it is highly likely that sound identifications will be useful in future taxonomic reassessments for some species. Knowledge presented in this study can be a valuable tool since new bat occurrence were identified in two islands using ultrasound recordings that will be made available on-line. These records can also provide a baseline to build from. So, even after taxonomic reviews

it will be easy to associate our records to possible new taxa, especially considering the low species richness of Cabo Verde. This study highlights the strong need for further studies on bats in Cabo Verde, both to increase knowledge on distributions, as well as to reassess their taxonomic status. It also highlights that most bats species are resident and hence should be included in conservation plans.

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