

Review of the distribution and conservation status of the terrestrial reptiles of the Cape Verde Islands

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Abstract Cape Verde has a higher number of reptile taxa and endemics than any of the five archipelagos in the Macaronesian region. Mapping the precise distributions and assessing the conservation status of reptiles is the first step towards effective conservation. Presence/absence and abundance data were gathered from extensive fieldwork and post-1980 literature. Evaluation of conservation status was considered at specific and subspecific levels, following IUCN Red List criteria and using RAMAS. Fieldwork confirmed the occurrence of 34 of 37 previously recorded taxa (31 native, three exotic). One taxon continues to be considered Extinct. Three broad distribution and rarity patterns were identified: widespread and abundant taxa occurring on ≥ 2 islands/islets, widespread or abundant taxa restricted to one island, and rare or limited range taxa occurring on small areas of islands or islets. More than a third of taxa have areas of occupancy < 20 km² and extents of occurrence < 100 km². Geckos are rarer than skinks because of their high habitat specialization, with 58% occurring on only one island/islet. About half of all taxa are potentially threatened, twice the proportion of those in the Canary Islands, a difference that could be explained by the smaller area and greater aridity of the Cape Verde islands. The criterion used for most threat categorizations is geographical range, and the most pervasive threats are natural disasters, intrinsic factors of the species and introduced species. The importance of applying conservation status at the subspecific level to island endemics is emphasized. Several conservation measures are proposed, including optimized design of protected areas.

Keywords Atlas, *Chioninia*, endemics, *Hemidactylus*, introductions, Macaronesia, Red List, *Tarentola*

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Introduction

Biodiversity loss is one of the top issues of the 21st century. Species with small range size and low gene flow are of particular concern as they have increased probability of extinction by chance alone (Pullin, 2002). For this reason, island populations have a higher risk of extinction than mainland populations (Frankham, 1997). Moreover, even though islands usually have a low number of species, the number of endemics is generally high (Kier et al., 2009), as is their vulnerability to the introduction of exotic species (Case et al., 1992). Thus, it is crucial to increase knowledge about native biodiversity in remote areas such as oceanic islands where species are particularly prone to extinction. One way of fulfilling this goal begins with the production of distribution atlases and updated Red Lists, as these are tools for conservation planning.

The Cape Verde Islands, an oceanic archipelago, lack detailed information on the distribution of biodiversity. Although there are preliminary inventories of the flora (Paiva, 1995), avifauna (Naurois, 1994; Hazevoet, 1995; Clarke, 2006) and herpetofauna (Schleich, 1987), there are no distribution atlases for terrestrial groups. There are no endemic mammals or amphibians. Intra-island distribution data for birds are being collected but accurate distribution data for reptiles are lacking. All native reptiles are endemics and the archipelago has the highest number of endemic reptile taxa in Macaronesia (Schleich, 1987; Pleguezuelos et al., 2002; López-Jurado et al., 2005; Oliveira et al., 2005), within three genera: *Hemidactylus* (Gekkonidae), *Tarentola* (Phyllodactylidae) and *Chioninia* (Scincidae; = *Mabuya* and *Macroscoincus*; Miralles et al., 2010).

After the discovery of this oceanic archipelago by the Portuguese in 1460 several surveys on the fauna of Cape Verde were conducted, leading to the first studies of the taxonomy, systematics and morphology of the Cape Verdean herpetofauna in the 19th century. In the 20th century a preliminary assessment of the reptiles listed 10 endemic terrestrial species (including 23 taxa), and reviewed their distributions at a coarse inter-island scale (Schleich, 1987). Later, taxonomic revisions made by Joger (1993), based on morphological analyses, increased to 12 and 26 the number of species and taxa, respectively. These data were

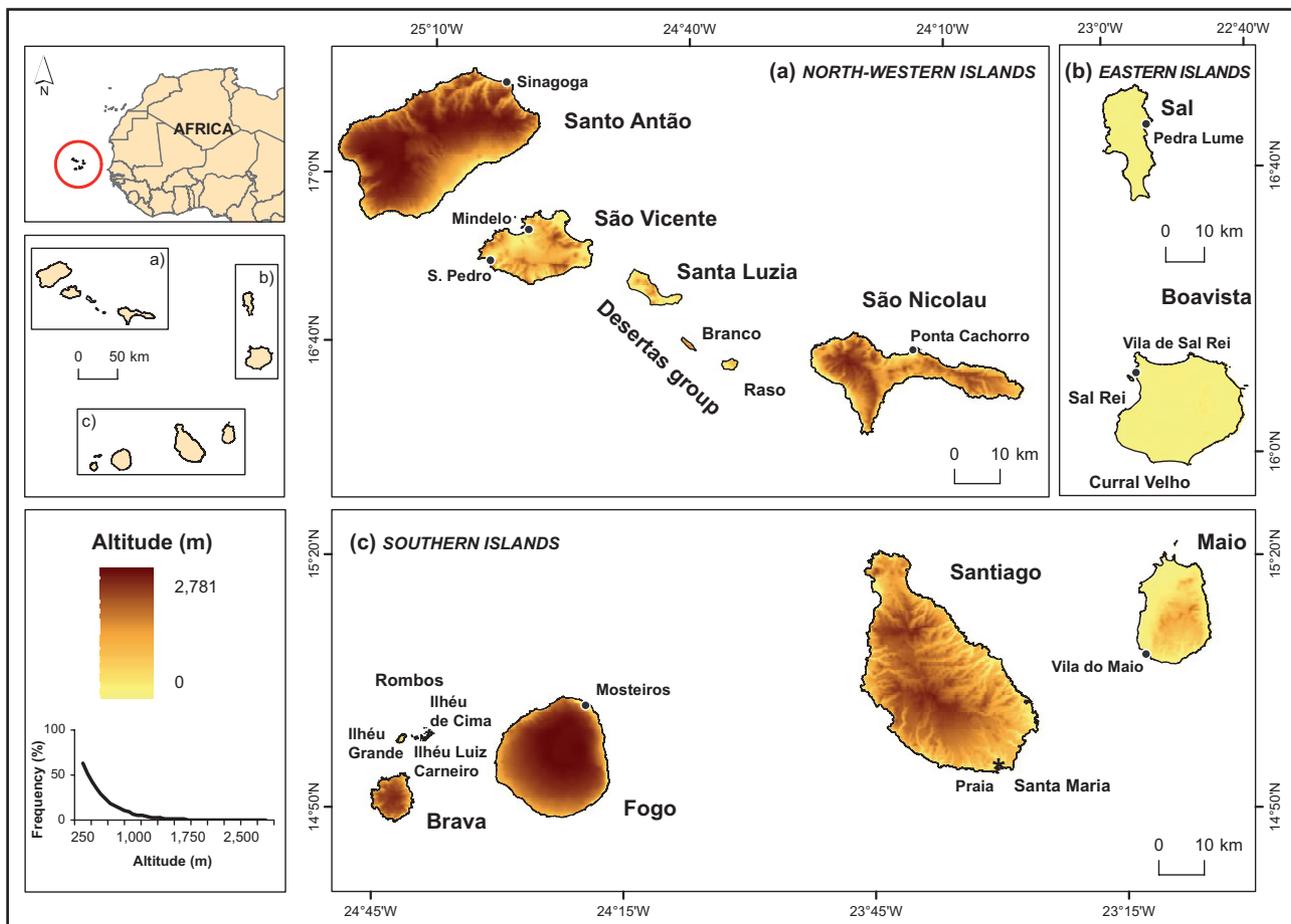


FIG. 1 The Cape Verde Islands, including altitudinal variation, and place names mentioned in the text.

compared with the now outdated (pre-2001) IUCN and German National List criteria to produce the first Red List for Cape Verde (Leyens & Lobin, 1996). The assessment considered 25% of the terrestrial reptiles to be Extinct or threatened (Schleich, 1996), prompting the promulgation of a law for the protection of plant and animal species. This law considered *Hemidactylus bouvieri ragozaensis* Gruber & Schleich (1982) as Critically Endangered; *Tarentola gigas brancoensis* Schleich (1984) and *Tarentola gigas gigas* (Bocage, 1875) as Endangered; *Hemidactylus bouvieri bouvieri* (Bocourt, 1870) as Rare and *Tarentola rudis* (Boulenger, 1906) and *Chioninia (=Mabuya) vaillanti* (Boulenger, 1887) as Undetermined (Anonymous, 2002).

Genetic studies conducted after 2000 by Brehm et al. (2001), Brown et al. (2001), Carranza et al. (2000, 2001, 2002), Carranza & Arnold (2003, 2006) and Jesus et al. (2001, 2002) for phylogeographical purposes indicated the need for a systematic revision of the reptiles of Cape Verde. An extensive survey of Cape Verde has been carried out since 2006, collecting genetic and morphological data, to review the systematics of endemic reptiles (Arnold et al., 2008; Miralles et al., 2010; Vasconcelos et al., 2010, 2012b). These studies have increased to 22 the number of recognized

endemic reptile species, with 31 taxa. The significant taxonomic revisions, naming previously unnamed populations and describing three new species and three new subspecies, increased the number of species by 83% and the number of taxa by 19% compared to the previous assessment (Schleich, 1996), and indicated the need to revise the distribution maps of all taxa and assess their conservation status using current IUCN criteria (IUCN Standards and Petitions Subcommittee, 2010).

The objectives of this study are to provide distribution data at an intra-island scale and to assess the conservation status of the endemic reptiles of Cape Verde. The fulfilling of these two goals will provide guidance for future management and conservation efforts.

Study area

The Cape Verde Islands belong to the biogeographical region of Macaronesia in the Atlantic Ocean (Fig. 1). They form a volcanic archipelago comprising 10 main islands plus several islets, with a total area of 4,067 km². Island size varies from the 1,004 km² Santiago to the 6 km² Raso. The age of

the islands is 2.6–26 million years, with islands closer to the mainland being the oldest, and consequently the flattest (Torres et al., 2002; Duprat et al., 2007).

The topography of Cape Verde ranges from plains to high mountains, reaching almost 3,000 m on the summit of the active volcano of Fogo. The elevation, steepness and orientation of mountains influence the amount of precipitation that each island receives. Cape Verde is situated just north of the Intertropical Convergence Zone and has a tropical dry climate with a long dry season, frequent long droughts, and an irregular short wet season from July to September (Duarte & Romeiras, 2009). Mean annual temperature is relatively constant (22 °C) because of the moderating influence of the ocean. Annual precipitation is low (< 250 mm) and highly variable both spatially and temporally (Hijmans et al., 2005) and there are almost no permanent water courses.

Methods

Sampling

The 10 islands were surveyed over 2006–2008 during the dry season, from mid May to mid July. Sampling stations (Appendix 1) were randomly chosen and stratified according to habitat availability, based on agro-ecological and vegetation zoning maps (adapted from Diniz & Matos, 1986, 1987, 1988a,b, 1993, 1994, 1999a,b,c; Appendix 2), with the number of stations per habitat proportional to habitat area. Using this approach most of the variability between and within each habitat, in altitude, topography, climate and geographical position, was encompassed by the sampling stations. The sampled area, 440 stations of 1×1 km², corresponds to c. 11% of the country's area. Each station was sampled only by day (because of logistic constraints), along transects, for 35 minutes on average (5–120 minutes, according to the difficulty of the terrain), by two observers walking parallel to each other, totalling nearly 264 hours of sampling. Presence/absence and abundance data of taxa (no. of individuals observed or per km²) were recorded. Abundance data were taken as an indicator of the order of magnitude of the number of mature individuals.

Presence data

A total of 2,139 presence observations were collected from three sources: (1) 1,375 from fieldwork, consisting of indirect evidence (skins, eggs or skeletons) or direct captures of the animals (released afterwards), (2) 610 from the literature, and (3) 154 from *GenBank*. Total presence data (N) corresponds to the total data collected from the three sources. The geographical coordinates of fieldwork observations were recorded with a global positioning system.

Coordinates from literature records (Duméril & Bibron, 1839; Gray, 1845; Bocourt, 1870; Bocage, 1873, 1875, 1896, 1897, 1902; O'Shaughnessy, 1874; Vaillant, 1882; Boulenger, 1885, 1887, 1906; Peracca, 1891; Orlandi, 1894; Serpa-Pinto, 1896; Angel, 1935, 1937; Loveridge, 1947; Dekeyser & Villiers, 1951; Mertens, 1955; Greer, 1976; Schleich, 1980, 1982a,b, 1984, 1987, 1996; Gruber & Schleich, 1982; Schleich & Wutke, 1983; Joger, 1984a,b, 1993; Brygoo, 1985, 1990; Pinheiro, 1990; Hazevoet, 1995; Mateo et al., 1997, 2005, 2009; López-Jurado et al., 1998, 1999, 2005; Andreone, 2000; Carranza et al., 2000, 2001, 2002; Brehm et al., 2001; Brown et al., 2001; Jesus et al., 2001, 2002, 2005; Andreone & Guarino, 2003; Carranza & Arnold, 2003, 2006; González & López-Jurado, 2004; Chadwick & Slater, 2005; Frazen & Glaw, 2007; Köhler & Güsten, 2007; Köhler et al., 2007a, b; Arnold et al., 2008) and *GenBank* data were determined from topographical maps (1:25,000). All coordinates were recorded or determined on the WGS84 datum and mapped using *ArcGIS v. 9.3* (ESRI, Redlands, USA).

When an endemic taxon was found outside its previously known range within the archipelago it was considered a probable recent anthropogenic introduction if it was genetically close to individuals found on the island of origin of the taxon (Miralles et al., 2010; Vasconcelos et al., 2010) and if, after extensive sampling, only a small number of individuals was found mainly on the coast rather than inland.

Conservation status

Conservation status was evaluated at specific and subspecific levels, following the methodology and criteria of the IUCN Red List guidelines (IUCN Standards and Petitions Subcommittee, 2010). A taxon was considered threatened when it qualified as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR), according to the criteria of population reduction (A), geographical range (B), small population size and decline (C), or very small or restricted population (D; IUCN Standards and Petitions Subcommittee, 2010). Non-indigenous and fossil taxa were listed as Not Evaluated (NE).

Criteria were applied with *RAMAS Red List v. 2.0* (Akçakaya & Ferson, 2001). Parameters for categorization were (1) population number, estimated from the number of mature individuals using abundance data, (2) population reduction, estimated from subfossil and published data, (3) area of occupancy (AOO), calculated from the number of occupied cells \times area of an individual cell (1×1 km²) considering only observations after 1980, (4) extent of occurrence (EOO), estimated by the minimum convex polygon method, which determines the area contained within the shortest continuous imaginary boundary that can be drawn to encompass all the occurrences of a taxon

(calculations made with *Hawth's Tools* extension for *ArcGIS*, Beyer, 2004), and (5) population fragmentation, based on the number of locations (corresponding to the number of habitats where occurrence was registered; see Sampling above and Appendix 2), and number of subpopulations (quantified by the number of islands or islets of occurrence of a taxon). The only exceptions to (5) were applied to *Tarentola darwini* and *Chioninia spinalis santiagoensis*, which each presented two evolutionarily significant units on the same island and thus the number of subpopulations did not coincide with the number of islands or islets of their occurrence (Miralles et al., 2010; Vasconcelos, et al. 2010).

Taxa were considered to have a restricted range (RR) if AOO was $< 20 \text{ km}^2$ or the number of locations of occurrence was ≤ 5 (Akçakaya & Ferson, 2001). An exception was made for *Chioninia spinalis spinalis*, which was not considered to be RR because, even though its value of AOO was $< 20 \text{ km}^2$, this was assumed to be the result of an underestimation of presences. Sampling occurred during the dry season and this, together with the steep slopes of Fogo Island, made detection difficult. Major threats for each taxon were assessed using a standardized list (IUCN, 2010; Appendix 3) implemented in RAMAS and were evaluated based on information gathered from fieldwork and published data.

Results

Presence data

During the fieldwork we made 50 observations of exotic taxa and 1,325 of native taxa, and the literature and *GenBank* data together contributed 21 and 743 observations of exotic and native taxa, respectively. A total of 38 taxa were recorded, of which 31 were native (not counting fossil species) and six exotic (Table 1). Of these, only 34 taxa (31 native and three exotic) were confirmed by fieldwork. The distributions of observations are given in Appendices 4–7. Detailed information about doubtful and historical records is given in Appendix 8.

Three exotic reptile species were confirmed to be present (Appendix 4). The most abundant and widespread species is *Hemidactylus angulatus*, which occurs on at least six islands and one islet. The most recent introduction recorded is *Agama agama* on Santo Antão, São Vicente and Santiago. Fieldwork produced first records of *Hemidactylus mercatorius* (referred as *Hemidactylus mabouia* by previous authors) on Santo Antão and Brava and confirmed the occurrence of the species on São Vicente.

Fieldwork confirmed the following introductions of endemic taxa: (1) *Chioninia delalandii* in Vila do Maio, Maio (originally present on all other southern islands) and

Mindelo, São Vicente, (2) *Tarentola maioensis* (originally from Maio) at Ponta Cachorro, São Nicolau, and (3) *Tarentola substituta* (originally from São Vicente) in Sinagoga, Santo Antão (Table 1).

Of the 31 endemic taxa five belong to the genus *Hemidactylus*, 14 to *Tarentola* and 12 to *Chioninia* (Table 1). Unsuccessful searches were conducted for *Chioninia* (= *Macrosцинus*) *coctei* by three observers on Santa Luzia Island during 5 days. Three broad distribution and rarity patterns were identified for extant taxa: (1) widespread and abundant taxa, occurring on two or more islands or one island and distant islets (e.g. *Hemidactylus boavistensis*, *Tarentola raziana* and *C. delalandii*), (2) widespread or abundant taxa, restricted to one island and its neighbouring islets (*Tarentola boavistensis*, *T. darwini* and *Chioninia spinalis maioensis*), and (3) rare or limited range taxa, occurring on an islet or a small part of an island (*H. bouvieri* spp., *Hemidactylus lopezjuradoi*, *Tarentola bocagei*, *T. gigas* spp., *T. rudis*, *Tarentola protogigas* and *C. vaillanti* spp.; Table 1; Appendices 5–7).

The native *C. delalandii* and *T. darwini* have the largest EOO and AOO, *T. g. brancoensis* and *T. g. gigas* have the smallest EOO, and *H. lopezjuradoi* and *H. b. bouvieri* the smallest AOO (Table 1, Appendices 5–7). *C. delalandii* is the taxon with the highest number of confirmed subpopulations, followed by *H. bouvieri*, *Chioninia stangeri* and *H. boavistensis*. About 40% of the reptile taxa have an AOO $< 20 \text{ km}^2$, geckos 1.5 times more than skinks (47% of geckos vs 33% of skinks). About a third (36%) of all taxa have an EOO $< 100 \text{ km}^2$, especially geckos (53% of geckos vs 8% of skinks).

About 30% of the taxa occur in < 5 locations, and 58% occur on only one island or islet, with a similar pattern for geckos and skinks (Table 1). Thirteen of the reptile taxa (42%) have a restricted range, with higher values for geckos than for skinks.

Most (71%) of the taxa were recorded below 250 m altitude but 24% occur at 250–1,000 m (Appendices 4–7). Examples of taxa occurring at altitudes above 1,000 m are *C. delalandii*, *Chioninia fogoensis*, *C. s. spinalis*, *Chioninia vaillanti vaillanti* and *Tarentola caboverdiana*.

Conservation status

A summary of the current conservation status of the endemic taxa is presented in Table 1. About half of the reptiles are threatened (Table 1). One taxon is categorized as Extinct, c. 16% of the taxa as Critically Endangered or Endangered, and 19% as Vulnerable. Geckos have twice (63%) the percentage of threatened taxa as skinks (33%), with 80% of *Hemidactylus* categorized as Critically Endangered.

The most frequently used criterion for categorization of threat was geographical range (B; 56%). The most pervasive

threats were natural disasters (74%), specifically droughts and volcanoes, and intrinsic factors of taxa (42%), specifically restricted range and low densities (Table 1; Appendix 3).

Discussion

This research presents for the first time accurate within-island information on the distribution of the terrestrial reptiles of Cape Verde, including newly described and revised taxa, and a revised conservation assessment using the IUCN criteria for all taxa, many of them previously categorized as Data Deficient or Undetermined (*T. boavistensis*, *T. substituta*, *T. rudis* and *C. vaillanti*; Schleich, 1996).

The considerable extent of occurrence of two introduced and invasive *Hemidactylus* species, *H. angulatus* and *H. mercatorius*, is alarming, with *H. angulatus* widespread on Santiago and Boavista Islands, and *H. mercatorius* having spread to other islands. It is known that introduced *Hemidactylus* can cause catastrophic declines and extinctions of endemic geckos, as *H. frenatus* did with *Nactus* species on the Mascarene Islands (Cole et al., 2005). In addition, island invasions can be fast and human-mediated and recent reptile extinctions have occurred exclusively on islands (Case et al., 1992). Given that some endemic forms, such as *H. bouvieri* and *H. lopezjuradoi*, Critically Endangered, and that *H. angulatus* is probably already displacing some populations of the endemic *H. boavistensis* (López-Jurado et al., 1999) information regarding the extent of this threat is vital and monitoring is required. New taxa are being introduced in the archipelago, such as *A. agama* on Santo Antão (Vasconcelos et al., 2009), and recently also on São Vicente (E. Lopes, B. Martins & R. Vasconcelos, pers. obs) and Santiago (A. Rendall, G. Semedo, J. Semedo & R. Vasconcelos, pers. obs), and measures are required to prevent the entry of further exotic taxa to this vulnerable ecosystem.

Our extensive sampling did not confirm the introduction of the endemics *T. nicolauensis* to Mindelo, São Vicente (Jesus et al., 2002) or *C. delalandii* to Sal Rei, Boavista (Schleich, 1987). This may be because of low population sizes, or the extinction of the populations, as suggested by López-Jurado et al. (1999) in the latter case. However, our sampling detected new introductions of *T. substituta* on Santo Antão and *C. delalandii* on São Vicente.

Our searches and those of previous expeditions since 1912 for the native *Chioninia coctei* have been unsuccessful. Some authors considered *C. coctei* to be Extinct by the beginning or second half of the 20th century (Chevalier, 1935; Schleich, 1982a, 1984; Hazevoet, 1995) and it has been categorized Extinct by IUCN since 1986 (Schleich, 1996). Extinction was because of over-collection, prolonged droughts and

predation by feral cats (Andreone, 2000). Bocage (1896) also noted the unsustainable collection of specimens by naturalists. Nevertheless, there is still the possibility that a few individuals survive on Santa Luzia or other islands or islets (Appendix 8). Several threatened Cape Verde taxa have restricted ranges, with particular habitat associations or a low number of records (Appendix 9) and may be at risk of extinction.

The major threats to the biodiversity of this archipelago are habitat fragmentation for agriculture and cattle, introduced species, direct exploitation by hunting, collection and logging (Leyens & Lobin, 1996), and severe droughts (MAAP-DGA, 2004). For reptiles, the major threats are natural disasters such as droughts and volcanic activity, intrinsic factors of the species such as low densities and restricted ranges, and exotic species (Appendix 3). The endemic *Hemidactylus* and *T. p. protogigas* are potentially the most threatened taxa.

IUCN criteria were applied at the subspecific level as Cape Verde is an insular system and reptile populations face conservation problems that need to be addressed at that level. For example, *T. protogigas* is Critically Endangered on Fogo because of supposed continuing decline and restricted range but on Brava and Rombos the species is Vulnerable.

The frequent classification of threatened taxa based on the IUCN Red List criterion B, related to geographical range, is a common pattern in reptile assessments (Pleguezuelos et al., 2002, 2010; Oliveira et al., 2005), associated with the lack of data concerning population trends and probability of extinction related to criteria A and E, respectively. Use of criterion D, related to population size or restricted range, was unusually frequent compared to other reptile assessments in the Mediterranean basin because these reptile taxa often occur on small islands and are sometimes even restricted to islets. However, if comparisons were limited to the assessments of other insular reptiles of that hotspot, criterion D would turn up more frequently (Pleguezuelos et al., 2002; Oliveira et al., 2005), as is the case for *T. bischoffi* from Selvagens (Madeira archipelago) and *Gallotia bravoana* from La Gomera (Canaries).

In Macaronesia Cape Verde may have the highest percentage of threatened taxa (52%), followed by Madeira (50%; Oliveira et al., 2005) and the Canary Islands (25%; Pleguezuelos et al., 2002). Without considering the reptiles of Madeira, as it hosts a maximum of only five taxa, the high percentage of threatened taxa compared to the Canaries is alarming. It could be explained by the small total area of the Cape Verde archipelago (c. 50% less than the Canary Islands), which restricts ranges of taxa, and by the increasing aridity that is affecting the islands, especially at lower altitudes (Langworthy & Finan, 1997), which could have led to population reductions and extinctions. In the previous century cyclic droughts were caused by climate changes in Cape Verde but projections of rainfall changes for the region

TABLE 1 Cape Verde reptile taxa, total presence data (N, see text for details), data used for assessment of conservation status (extent of occurrence, EOO; area of occupancy, AOO; number of localities in which a taxon was found; number of subpopulations, the latter two with number of doubtful occurrences in parentheses: see Appendix 8 for further details), Red List category, criteria used for Red List categorization (IUCN Standards and Petitions Subcommittee, 2010), and major threats (IUCN, 2010; Appendix 3).

Taxa ¹	N ²	EOO ³ (km ²)	AOO ⁴ (km ²)	No. of localities ⁴	No. of subpopulations	Red List category ⁵	Criteria	Threats ⁶
Endemic species								
<i>Geochelone atlantica</i> † López-Jurado et al. (1998)	NO	?	0	0	0 (2)	NE		
Genus <i>Hemidactylus</i> Oken, 1817								
<i>H. bouvieri</i> (Bocourt, 1870)	34	?	7	8 (10)	5 (7)	CR	B1ab(i,ii,iii,iv,v)c(iii,iv)+2ab(i,ii,iii,iv,v)c(iii,iv)	1,2,7,9,12
<i>H. bouvieri bouvieri</i> (Bocourt, 1870)	7	?	1*	2 (4)*	2 (4)	CR	B1ab(i,ii,iii,iv,v)c(iii)+2ab(i,ii,iii,iv,v)c(iii); C1+2a(ii)	1,2,7,9,12
<i>H. bouvieri</i> ssp., São Nicolau	5	?	2*	2*	1	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C1+2a(ii)	1,2,7,9,12
<i>H. bouvieri razoensis</i> Gruber & Schleich (1982)	22	?	4*	4*	2	CR	B1ab(i,ii,iii,iv,v)c(i,ii,iii,iv)+2ab(i,ii,iii,iv,v)c(i,ii,iii,iv); C1+2a(i,ii)b; D	1,2,7,9,12
<i>H. boavistensis</i> Boulenger (1906)	91	723	47	14	4	LC		1,2,7
<i>H. lopezjuradoi</i> Arnold et al. (2008)	3	?	1*	1*	1	CR	B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C1+2a(ii)	1,2,7,9,12
Genus <i>Tarentola</i> Gray, 1825								
<i>T. boavistensis</i> Joger (1993)	39	458	27	7	2	VU	C1; D1	7,9
<i>T. bocagei</i> Vasconcelos et al. (2012)	20	43	9*	7	1	VU	D2	9
<i>T. fogoensis</i> Vasconcelos et al. (2012)	44	341	20	8	1	LC		7
<i>T. darwini</i> Joger (1984b)	152	839	65	9	2	LC		0
<i>T. substituta</i> Joger (1984b)	160	151	45	8	1 ⁷	LC		7
<i>T. raziana</i> Schleich (1984)	84	28	22	8	3	VU	B1ab(v)+2ab(v); C1	1,2,7
<i>T. caboverdiana</i> Schleich (1984)	89	545	37	7	1	LC		0
<i>T. nicolauensis</i> Schleich (1984)	111	198	41	10	1 ⁷	LC		0
<i>T. gigas</i> (Bocage, 1875)	74	<10	6*	4*	2	EN	B1ac(iv)+2ac(iv)	7,8,9,10
<i>T. gigas gigas</i> (Bocage, 1875)	39	<3	3*	2*	1	EN	B1ac(iv)+2ac(iv)	7,8,9,10
<i>T. gigas brancoensis</i> Schleich (1984)	35	<6	3*	2*	1	EN	B1ac(iv)+2ac(iv)	7,8,9,10
<i>T. rudis</i> Boulenger (1906)	43	254	22	7	2	VU	D1	8
<i>T. protogigas</i> Joger (1984b)	75	75	22	11	4			7,9,12
<i>T. protogigas protogigas</i> Joger (1984b)	13	31	4*	3*	1	CR	B1ab(i,ii,v)+2ab(i,ii,v); C2a(ii)	7,9,12
<i>T. protogigas hartogi</i> Joger (1993)	62	45	18*	8	3	VU	D2	7
<i>T. maioensis</i> Schleich (1984)	57	195	22	6	1	LC		7
Genus <i>Chioninia</i> (Gray, 1845)								
<i>C. vaillanti</i> (Boulenger, 1887)	43	446	20	11	3	EN	D2	7,9
<i>C. vaillanti vaillanti</i> (Boulenger, 1887)	19	317	12*	5*	1	EN	D1+2	9
<i>C. vaillanti xanthotis</i> Miralles et al. (2010)	24	129	8*	6	2	EN	D1+2	7,9
<i>C. delalandii</i> (Duméril & Bibron, 1839)	341	1,134	141	37	7 ⁷	LC		7
<i>C. nicolauensis</i> (Schleich, 1987)	43	183	21	9	1	LC		7
<i>C. fogoensis</i> (O'Shaughnessy, 1874)	95	344	46	9	1	LC		2
<i>C. stangeri</i> (Gray, 1845)	122	101	28	23	4	EN	B1ab(i,ii,iii,v)+2ab(i,ii,iii,v); C1+2a(ii)	2,7
<i>C. coctei</i> (Duméril & Bibron, 1839)	49	6	7*	3*	3 (5)	EX		1,2,3,7,9
<i>C. spinalis</i> (Boulenger, 1906)	297	2,035	129	34	9	LC		0,7,9
<i>C. spinalis salensis</i> (Angel, 1935)	39	142	17*	6	1	VU	D2	7,9
<i>C. spinalis santiagoensis</i> Miralles et al. (2010)	67	790	31	6	3	LC		0
<i>C. spinalis spinalis</i> (Boulenger, 1906)	37	295	14 ⁸	8	1	LC		7

TABLE 1 (Continued)

Taxa ¹	N ²	EOO ³ (km ²)	AOO ⁴ (km ²)	No. of localities ⁴	No. of subpopulations	Red List category ⁵	Criteria	Threats ⁶
<i>C. spinalis maioensis</i> (Mertens, 1955)	57	210	29	7	1	LC		7
<i>C. spinalis boavistensis</i> Miralles et al. (2010)	97	598	52	7	3	LC		7
Exotic								
<i>Pelusios</i> sp. Wagler, 1830	NO	?	0	0	0 (2)	NE		
<i>Lygodactylus</i> sp. Gray, 1864	NO	?	0	0	0 (1)	NE		
<i>Hemidactylus angulatus</i> Hallowell, 1852	60	1,140	41	>6	8 (10)	NE		
<i>Hemidactylus mercatorius</i> (Gray, 1842)	12	8	7	3	3	NE		
<i>Agama agama</i> (Linnaeus, 1758)	4	?	4	4	3	NE		
<i>Psammophis sibilans</i> (Linnaeus, 1758)	NO	?	0	0	0 (1)	NE		

¹†, Fossil

²NO, Not observed

³?, Unknown

⁴Endemic taxa with a restricted range (i.e. AOO < 20 km² or number of localities of occurrence ≤ 5) are indicated with an *

⁵CR, Critically Endangered; VU, Vulnerable; EN, Endangered; LC, Least Concern; EX, Extinct; NE, Not Evaluated

⁶0, None; 1, Habitat loss; 2, Invasive alien species; 3, Harvesting; 7, Natural disasters; 8, Changes in native species dynamics; 9, Intrinsic factors; 10, Human disturbance; 11, Other; 12, Unknown

⁷See Presence data section in Results for further details

⁸See Methods for further details

in response to global warming are highly uncertain (Biasutti et al., 2008). If droughts become more pronounced this could compromise the viability of some reptile populations, and thus increased conservation efforts are needed to ensure a secure future for the herpetofauna of Cape Verde.

National laws to protect all threatened taxa are needed as current legislation is inadequate in the face of recent taxonomic changes and new distribution data. In addition, education campaigns are required to increase awareness and capacity-building so that Cape Verdeans can protect the endemic reptiles of the archipelago better. Particular attention should be paid to new legislation to protect *H. bouvieri*, *H. lopezjuradoi* and *T. p. protogigas*, which have restricted AOO, are Critically Endangered and for which there are few records. Management plans are required to prevent the extinction of these taxa. Research and policy-based action, accompanied by species-based actions, such as control and eradication of invasive and potential competing species, are imperative to ensure the viability of the endemic *Hemidactylus*. This also applies to the subspecies of *T. gigas*, for which improved annual estimates of the abundance of mature individuals are needed because demographic fluctuations are likely to occur within their extremely restricted ranges (both occur on small islets) as a result of cyclic droughts and variation in the numbers of birds with which both subspecies have trophic relationships. The Endangered *C. vaillanti* also requires a management plan as its range has probably already been reduced by increasing aridity, as suggested by the finding of subfossil records on Boavista and Maio, where the species is no longer found (Carranza et al., 2001). In addition, *C. stangeri* on São Vicente deserves particular attention because of its small range. Removal of introduced mammals from Santa Luzia is needed to conserve the threatened *C. stangeri* and *T. raziana*.

Currently, only four of the 46 terrestrial protected areas on Cape Verde have been legally gazetted, and it is important to guarantee that protected areas will encompass all reptile taxa and evolutionarily significant units (Miralles et al., 2010; Vasconcelos et al., 2010). At present this is not the case because, for example, there are no protected areas planned for Brava, where the largest population of *T. p. hartogi* occurs. The opportunity to optimize the design and location of such areas for reptiles needs to be taken, following the recommendations of Vasconcelos et al. (2012a).

In general little is known about the biology and demography of the threatened reptiles of Cape Verde; further ecological studies and quantification of the major threats affecting these taxa are required. The new data on distribution and conservation status presented here may improve the options for assessing conservation priorities for this group. The findings of this research will be passed to the Cape Verde governmental authorities, which have shown

great interest in this work and, considering their budgetary constraints, have provided considerable assistance and support. Ultimately, the effective protection of the biodiversity of Cape Verde is dependent on the necessary funds becoming available to support the implementation and management of the protected area network and future conservation action plans.

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Appendices 1–9

The appendices for this article are available online at <http://journals.cambridge.org>

Biographical sketches

RAQUEL VASCONCELOS studied the herpetofauna of the Cape Verde Islands, combining geographical information systems and molecular tools, and is now studying the reptiles of the Socotra archipelago. JOSÉ CARLOS BRITO is interested in geographical patterns of biodiversity and is the principal investigator of the BIODESERTS (Biodiversity of Deserts and Arid Regions) group. SALVADOR CARRANZA has a long-standing interest in the herpetofauna of the Mediterranean Basin, Old World deserts and oceanic islands. D. JAMES HARRIS is interested in phylogenetics, especially of reptiles, and leads several projects on the genetic and morphological variation of reptiles of the Mediterranean Basin and other areas.