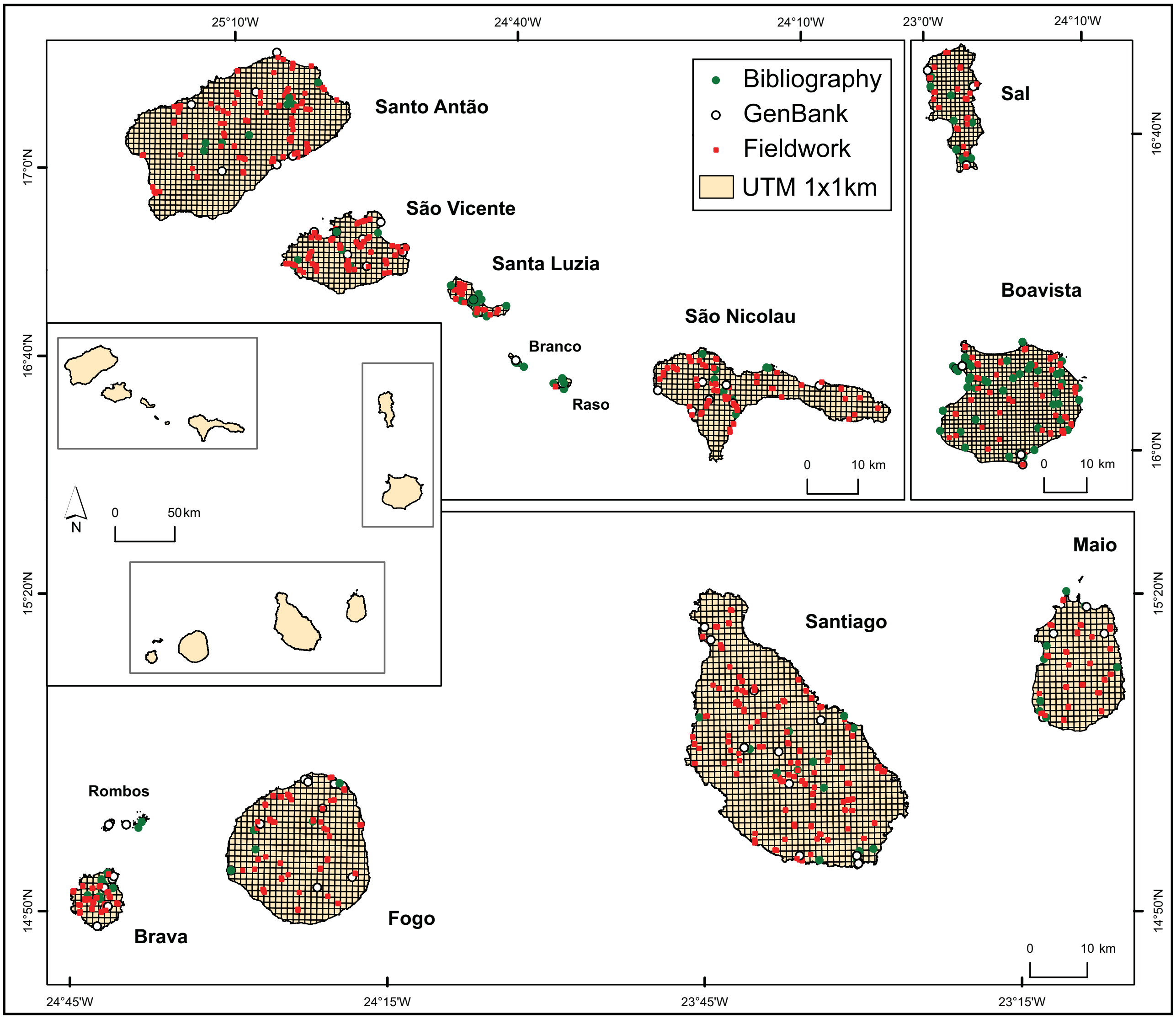
Review of the distribution and conservation status of the terrestrial reptiles of the Cape Verde Islands

Raquel Vasconcelos, José Carlos Brito, Salvador Carranza and D. James Harris

Appendix 1 Distribution of stations sampled during fieldwork and localities for which data were obtained from *GenBank* or the literature. The UTM sampling grid is in 1×1 km² cells.



© 2013 Fauna & Flora International, *Oryx*, 47(1), 1–13 doi:10.1017/S0030605311001438

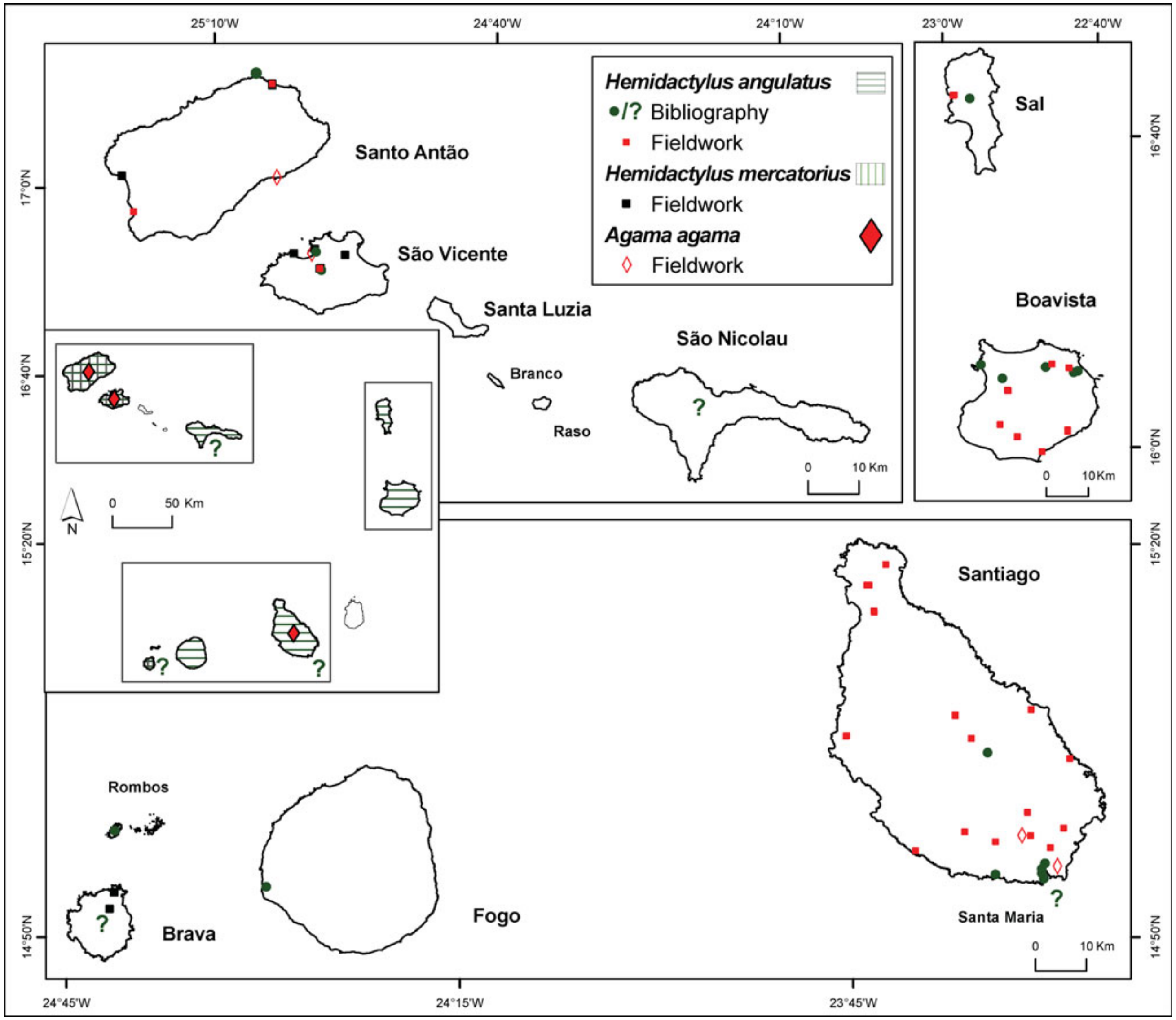
APPENDIX 2 Types and total number of habitats present (●) on each island or islet in the Cape Verde archipelago (Fig. 1; adapted from Diniz & Matos, 1986, 1987, 1988 a,b, 1993, 1994, 1999 a,b,c).

Habitat type	São Vicente	Santa Luzia	Raso	Branco	Santo Antão	São Nicolau	Brava	Rombos	Maio	Fogo	Santiago	Santa Maria	Sal	Boavista
Beaches	●	●			●	●			●	●	●		●	●
Dunes & sandy areas	●	●							●				●	●
Recent lavas										●				
Very arid flat areas	●	●	●		●	●			●	●			●	●
Very arid & hilly areas	●	●	●	●	●	●							●	●
Very arid & mountain areas	●	●	●	●		●								
Arid & flat areas						●	●	●		●	●	●		
Arid & hilly areas	●				●	●	●	●	●		●			
Arid & mountain areas	●				●						●			
Semi-arid & flat areas						●	●			●	●			
Semi-arid & hilly areas					●	●	●			●	●			
Semi-arid & mountain areas	●				●	●					●			
Sub-humid & flat areas										●				
Sub-humid & hilly areas					●		●			●	●			
Sub-humid & mountain areas	●				●	●	●			●	●			
Humid & mountain areas					●	●	●			●	●			
Water lines & floodplain areas	●	●			●	●	●		●		●		●	●
Coastal-salty lowland areas	●								●				●	●
Cliffs										●	●			
Urban areas	●				●	●	●		●	●	●		●	●
Total number	12	6	3	2	12	13	9	2	7	12	13	1	7	7

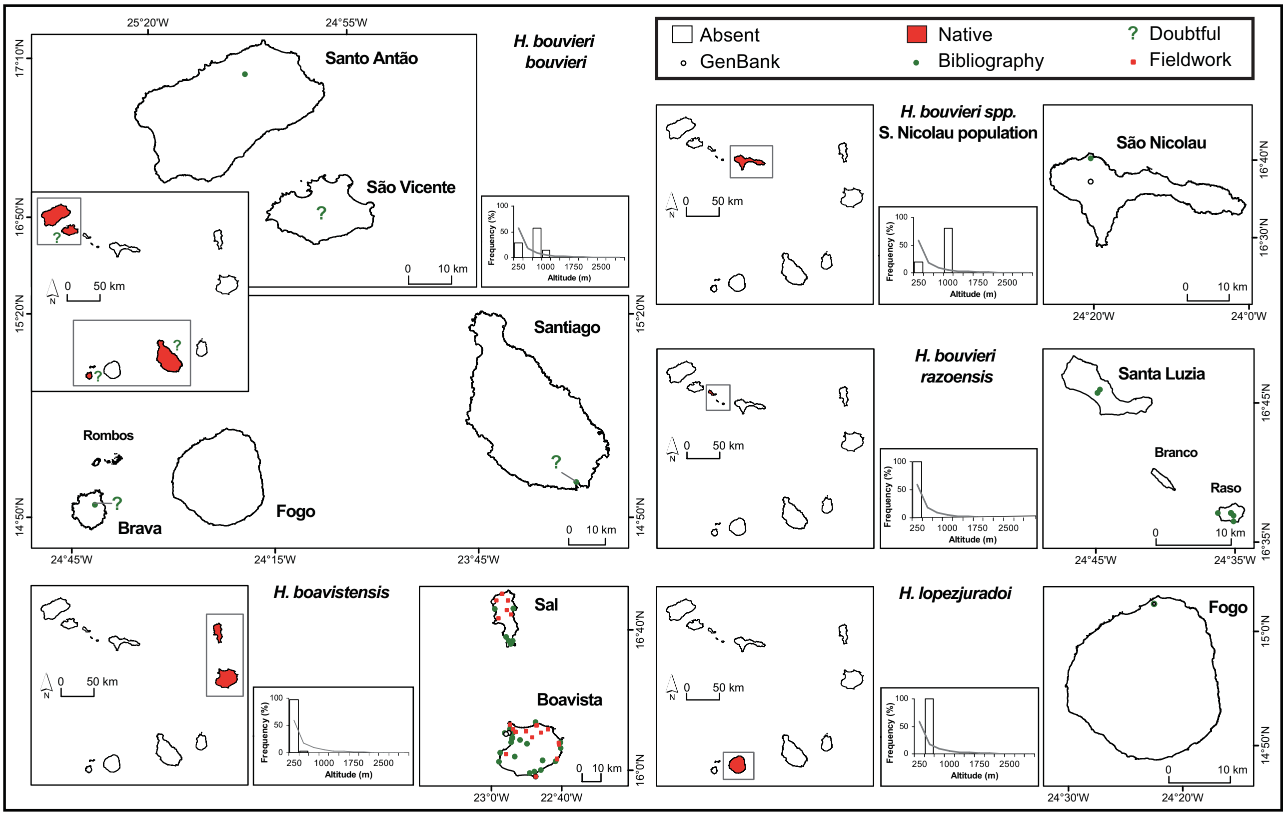
Appendix 3 Major threats affecting the reptiles of Cape Verde (Fig. 1), assessed using the categorization of threats in IUCN Standards and Petitions Subcommittee (2010), where further details of the subcategories of each threat can be found.

Taxa	0. 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	11/12. Other/ Unknown
H. bouvieri bouvieri		1.1.1.2, 1.5	2.1, 2.2		7.1		9.5, 9.9		12
H. b. spp., São Nicolau		1.1.1.2, 1.5	2.1, 2.2		7.1		9.5, 9.9		12
H. b. razoensis		1.5	2.1, 2.2		7.1		9.5, 9.9		12
H. boavistensis		1.4, 1.5	2.1		7.1				
H. lopezjuradoi		1.1.1.2, 1.5	2.1, 2.2		7.1, 7.5		9.5, 9.9		12
T. boavistensis					7.1		9.5		
T. bocagei							9.9		
T. fogoensis					7.5				
T. darwini	0								
T. substituta					7.1				
T. raziana		1.5	2.1, 2.2		7.1				
T. caboverdiana	0								
T. nicolauensis	0								
T. gigas gigas					7.1	8.3	9.9	10.6	
T. g. brancoensis					7.1	8.3	9.9	10.6	
T. rudis						8.4			
T. protogigas protogigas					7.5		9.5, 9.9		12
T. p. hartogi					7.1, 7.7				
T. maioensis					7.1				
C. vaillanti vaillanti							9.5, 9.7, 9.9		
C. v. xanthotis					7.5		9.5, 9.7, 9.9		
C. delalandii					7.1				
C. nicolauensis					7.1				
C. fogoensis			2.5						
C. stangeri			2.2		7.1				
C. coctei		1.5	2.2	3.1.1, 3.2.1, 3.4.1, 3.5.3	7.1		9.2, 9.7, 9.9		
C. spinalis salensis					7.1		9.9		
C. s. santiagoensis	0								
C. s. spinalis					7.5				
C. s. maioensis					7.1				
C. s. boavistensis					7.1				
Total	2	7	9	1	23	3	13	2	5

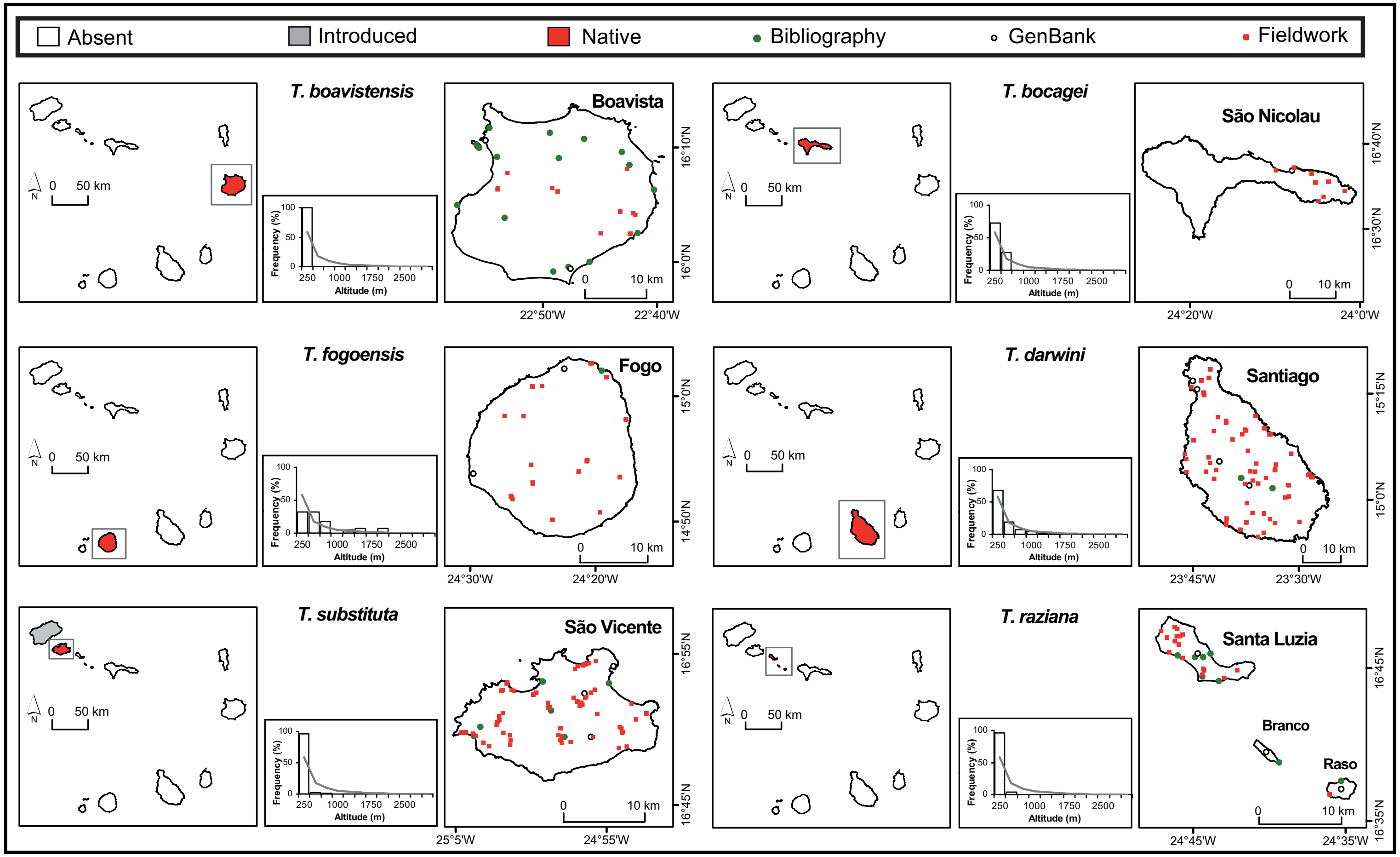
Appendix 4 Distribution of introduced reptiles in the Cape Verde Islands. Islands of occurrence of each taxon are highlighted with taxon-specific shading. Doubtful records are indicated by question marks (a single question mark within an island indicates the locality of occurrence is unknown).



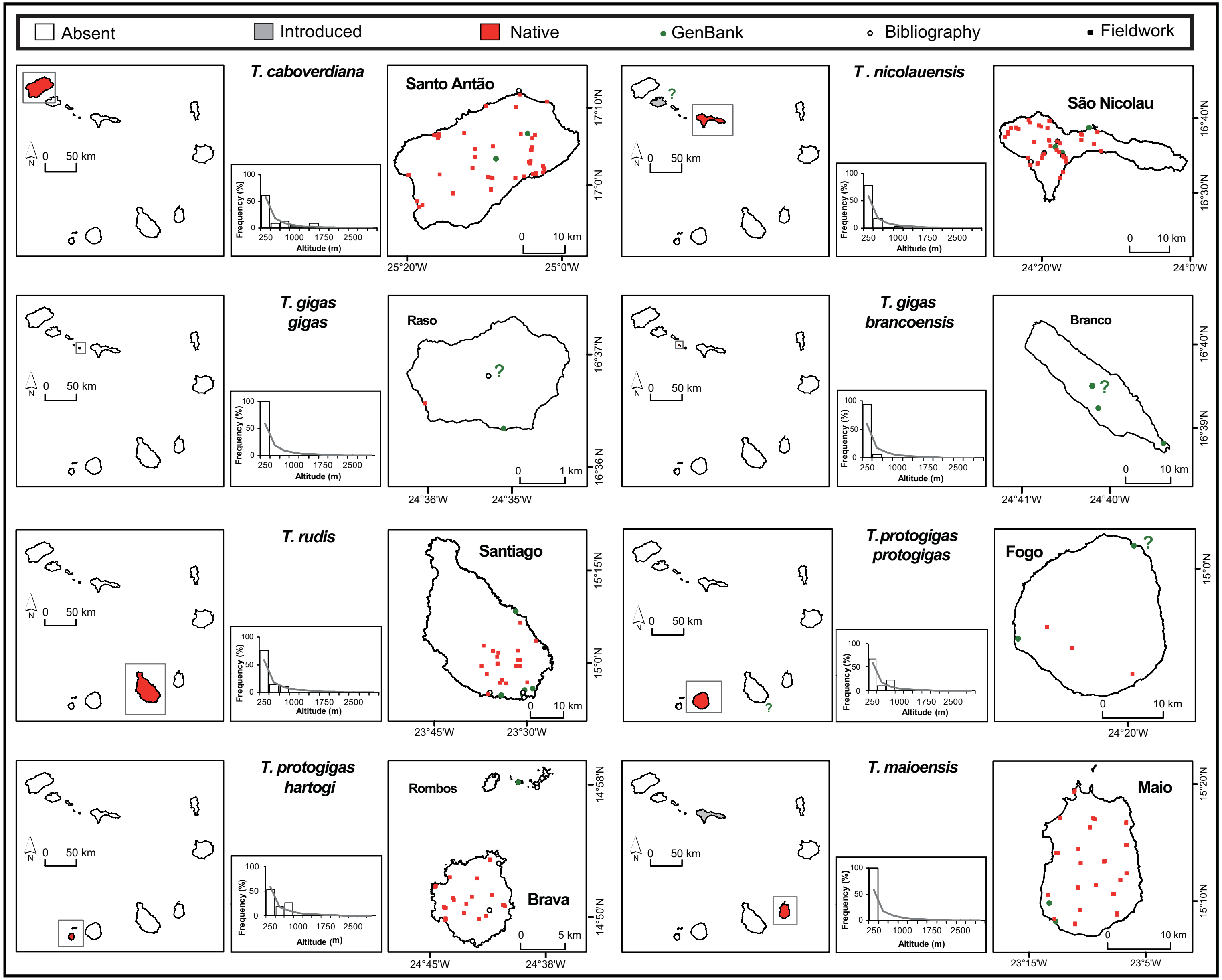
Appendix 5 Distribution of *Hemidactylus* reptiles in the Cape Verde Islands. Islands of occurrence of each taxon are highlighted in red. Doubtful records are indicated by question marks (a single question mark within an island indicates the locality of occurrence is unknown). The histograms represent the altitudinal distribution of each taxon.



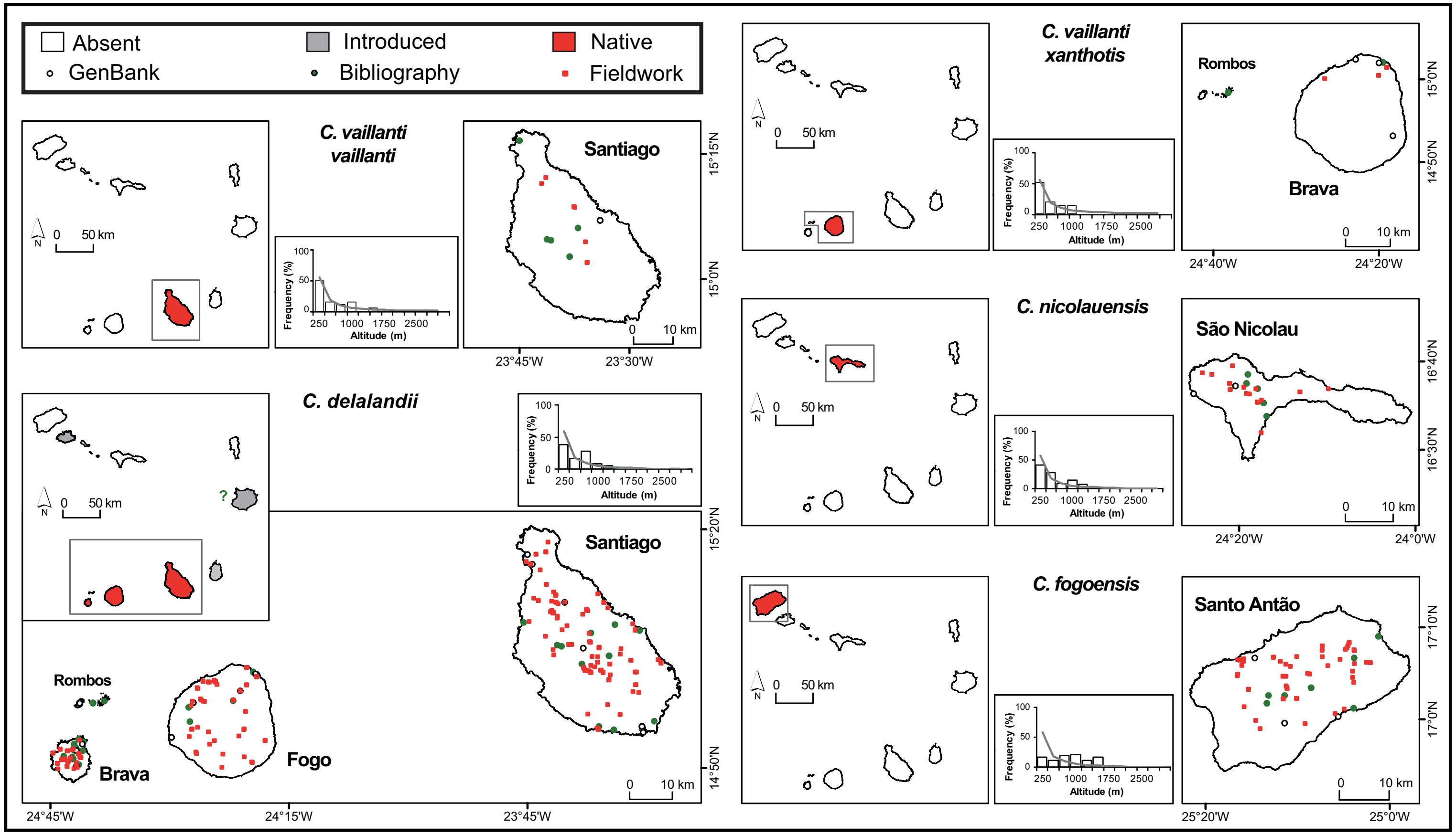
Appendix 6 Distribution of *Tarentola* reptiles in the Cape Verde Islands. Islands of occurrence of each taxon are highlighted in light grey if they result from an introduction and in red if native. Doubtful records are indicated by question marks (a single question mark within an island indicates the locality of occurrence is unknown). The histograms represent the altitudinal distribution of each taxon.



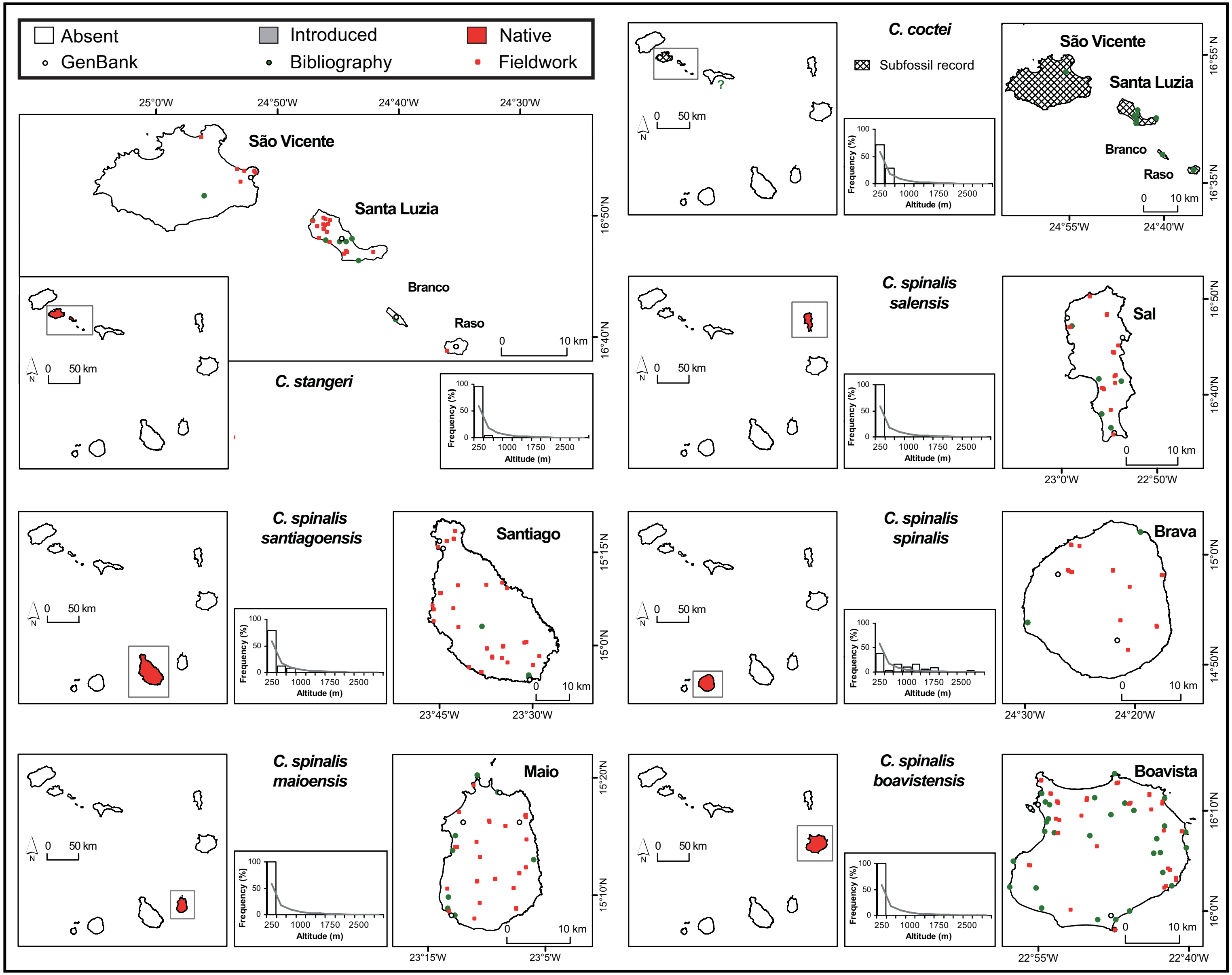
Appendix 6 (Continued)



Appendix 7 Distribution of *Chioninia* reptiles in the Cape Verde Islands. Islands of occurrence of each taxon are highlighted in light grey if they result from an introduction and in red if native. Doubtful records are indicated by question marks (a single question mark within an island indicates the locality of occurrence is unknown). The histograms represent the altitudinal distribution of each taxon.



APPENDIX 7 (Continued)



APPENDIX 8 Uncertain occurrences of endemic and exotic taxa in the Cape Verde Islands.

Exotic taxa

Serpa Pinto (1896) mentioned a 'tortoise' on São Vicente. Nevertheless, Bocage (1896) doubted the presence of a terrestrial chelonian in the archipelago. Given that the common name in Creole (cágado) is applied to the marine turtle *Eretmochelys imbricata*, common in the archipelago, it is probable that a misunderstanding of common names occurred. The old references for *Pelusios* on Santa Maria islet (Angel, 1935, 1937) were never confirmed.

An unknown species of *Lygodactylus* gecko was observed on Santiago and mentioned on the National Red List (Schleich, 1996) as Data Deficient but has not been recorded since. The presence of *H. angulatus* on Maio is referred to by Schleich (1982b), citing Angel (1935, 1937), but no such reference exists in the original papers. Schleich (1987) cites *H. angulatus* on Santa Maria islet but with uncertainty. The presence of *H. angulatus* on Brava, at an unknown location, was referred to first by Mertens (1955) and cited later by others (Naurois, 1994; Schleich, 1982b, 1987, 1996). On São Nicolau specimens were collected by Jesus et al. (2001) at an unknown location. However, no other individuals have been observed on either island since then, including during our surveys. Later authors doubted the occurrence of *H. angulatus* on São Nicolau (González & López-Jurado, 2004) and excluded it from the preliminary list of species of Cape Verde (López-Jurado et al., 2005). Hence, the present occurrence of the taxon on those two islands is doubtful.

Regarding the *A. agama* specimen seen on São Antão, after intensive sampling throughout the island at 71 sites with at least two observers, no other agamids were found. However, it is possible that some individuals remain in the wild (for details see Vasconcelos et al., 2009).

There is an old reference to the snake *Psammophis sibilians* on Sal by Deykeyser & Villiers (1951) that, according to the author was an accidental introduction from Guinea-Bissau that has never been recorded again.

Endemic taxa

Chevalier, in the 1930s, referred to fossil records of *Testudo calcarata* in Pedra Lume crater, on Sal (in López-Jurado, 1998). Later on, it was described as *Geochelone atlantica* López-Jurado 1998. Also Bebiano (1932) referred subfossil eggs from Maio to this terrestrial turtle but their identification has been questioned (Hazevoet, 1995). Nevertheless, this species probably went extinct after the end of the humid phase of the Quaternary, as ecological conditions no longer could sustain its presence, as confirmed by its absence from more recent historical records (López-Jurado, 1998).

The present occurrence of *Hemidactylus bouvieri* on Santiago and Brava is doubtful, since the most recent records are 50 and 110 years ago, respectively (Mertens, 1954; Andreone, 2000). It is unknown if these records are of this species or another as no molecular studies could be performed. For the accepted current distribution for the *Hemidactylus* species see Arnold et al. (2008).

The occurrence of *Tarentola* on Sal (Angel, 1935, 1937) is uncertain. Its possible presence is based on only one specimen sent by Professor Chevalier in 1934 that might have been incorrectly assigned to Sal. All the following authors refer to this record based on Angel (Mertens, 1955; Schleich, 1982b). Sal is a relatively small and almost flat island where the species' presence should be relatively easy to detect but subsequent expeditions failed to record it, including ours. For this reason Carranza et al. (2000) consider that Sal apparently has no *Tarentola* at the moment. Therefore we considered that occurrence to be doubtful.

The presence of *T. substituta* on Santa Luzia and Branco islet is mentioned by López-Jurado et al. (2005). This was the first record for the species on those islands and it is strange that there was no reference to this fact. Even more so considering that references for that study were based on earlier literature. Possibly it is a typographical error, as it is missing the reference for the same islands for *T. raziana* in the table where this doubtful record occurs. Thus, the presence of *T. substituta* on those islands is considered in this study as erroneous.

There is a reference for the occurrence of *T. nicolauensis* in Mindelo, São Vicente Island (Jesus et al., 2002) that could be interpreted as a recent introduction because of high genetic similarity to the samples from São Nicolau Island. However, its presence has been doubted (González & López-Jurado, 2004) and the record excluded from the preliminary list of species of Cape Verde (López-Jurado et al., 2005). Unless its presence is confirmed we consider it doubtful.

The possible presence of *T. darwini* on Sal Island (Joger, 1984a) was criticised by Schleich (1987) who stated that it was speculative, and mentioned the poorly preserved state of the specimen and that the identification was based only on the high number of dorsal tubercles. Later, in 1993, Joger assumed its presence on São Nicolau and not on Sal and thus we do not consider the occurrence of *T. darwini* on the latter island valid.

Some subfossil bones of an undetermined subspecies of *T. gigas* were recently found on Santa Luzia and São Vicente (Mateo et al., 2009) but without genetic confirmation it is difficult to assign them to subspecies. Therefore, we consider that the species had a wider range in the past, although this was not represented on either of the current distribution maps of the subspecies.

A specimen of *T. protogigas* (Museo Civico "G. Doria" di storia Naturale de Genova 28248) is recorded to have been found in Igreja (same as Mosteiros) on the northern part of Fogo in 1899 (Andreone, 2000) based on data collected by Fea. However, the much more abundant *T. fogoensis*, previously referred to *T. darwini* (Vasconcelos et al., 2012b) and also present on the island, was not described at the time. In this way, without genetic confirmation, this unique northern record is doubtful as it could represent *T. fogoensis*. Also, the fact that Joger (1984a) used this same specimen to describe the new subspecies of *T. 'rudis' protogigas* but stating its origin as São Filipe, Fogo Island, indicates that an error occurred in the capture locality. '*T. rudis* cf. *protogigas*' was also reported to occur on Santa Maria islet by Schleich (1987). However, no genetic analysis was performed and no vouchers were collected. It is possible that these animals could be *T. rudis* with some morphological variation from those from Santiago. The reference by the same author to the occurrence of *T. rudis* on Fogo (Schleich, 1984) is explained by the fact that when Boulenger (1906) described *T. rudis* (at the time *T. delalandii* var. *rudis*) he recognised Santiago and Fogo as its terra typica. Knowing that *T. 'rudis' protogigas* Joger, 1984 had not yet been described, this confusion is resolved. That is why the same specimen identified as *T. rudis* from Fogo in Schleich (1984) was used in the *T. protogigas* section in Schleich (1987). However, the error was later propagated (Schleich, 1987), probably due to a typographical error as the author does not refer to its occurrence on Fogo in the article, either in the table or in the subspecies description, but only in the 'Island by Island' section. In a later publication (Schleich, 1996) the occurrence of *T. rudis* on Fogo or *T. p. protogigas* on Santa Maria was not mentioned. Thus, the references until 1984 for *T. rudis* on Fogo were interpreted as referring to *T. p. protogigas*. This interpretation is also based on our intensive surveys and on the fact that after that date no other author referred to the occurrence of both taxa on the same island and this is supported by others (González & López-Jurado, 2004). For analogous reasons, all references to *Tarentola* on Brava and Maio until 1984 were referred to *T. p. hartogi* and *T. maioensis* Schleich, 1984, respectively, the only *Tarentola* proven to occur respectively on each of the islands.

T. gigas referred by Jesus et al. (2001) to occur on São Nicolau Island is actually *T. maioensis*, probably introduced on this island (Vasconcelos et al., 2010). Regarding *T. protogigas hartogi* (sensu Joger, 1993), it is genetically nearly identical to *T. protogigas* from Brava (Carranza et al., 2000). Moreover, differences in morphology are questionable as Joger's (1993) study did not present statistical support, being based on only five and nine specimens of each subspecies. Thus, in this study, *T. p. hartogi* was considered to occur on Brava and Rombos, following Vasconcelos et al. (2012b).

The past presence of *C. coctei* on other islands apart from the Desertas group is defended by some authors as possible on São Nicolau because of Pleistocene sea level falls and based on reports by fishermen (Greer, 1976; Schleich, 1982a). Also, on São Vicente, a fisherman (Schleich, 1982a), subfossil records (Mateo et al., 2005, 2009) and old museum specimens (Andreone, 2000) might indicate its presence, even though the localities of specimens can be considered doubtful (see also Miralles et al., 2010). The possible current presence on Santa Luzia Island is supported by the finding of an alleged mandible of a juvenile of this species in the faecal pellets of a cat (Mateo et al., 2005).

The presence of a subfossil record from Boavista and Maio, apparently conspecific with *C. vaillanti* (in Carranza et al., 2001), might indicate a larger species range in the past, although without genetic data or a detailed study of the subfossil material it is not possible to assign them to any subspecies. Considering that these fossils were much larger than the individuals from Fogo and Santiago, reaching 240 mm from snout to vent, it is possible that this would be a different and extinct form. The presence of *C. vaillanti* and *T. p. hartogi* on Brava Island, noted by Brehm et al. (2001) and Lopéz-Jurado et al. (2005), respectively, was interpreted as referring to the Rombos Islets, which lie north of this island, as both taxa were considered to be found exclusively on Rombos Islets before the taxonomical revision of Vasconcelos et al. (2012b). Moreover, Lopéz-Jurado et al. (2005) mentions in his introductory text the assignment of the presence records on islets to the island nearby. This study confirmed the introduction of *C. delalandii* on Maio, first referred to by Carranza et al. (2001) and López-Jurado et al. (2005) and refers its first occurrence on S. Vicente, Mindelo. This species is also recorded from São Nicolau by Fea in 1899 (Andreone, 2000) and Bocage (1902) but this is probably a error perpetuated from mislabelling (Andreone, 2000). The introduction of this species on Boavista, in Vila de Sal Rei (Schleich, 1987), occurred in the 1970s but its current presence is uncertain as some authors claim it is now extinct (Lopéz-Jurado *et. al*, 1999) or has not been found after intensive survey (Brown et al., 2001). Others have referred to its presence after the 1970s (Chadwick & Slater, 2005), although the photograph of the individual raises doubts. The current presence of this species on Boavista, also not confirmed during our surveys, is hence considered doubtful.

Chioninia geisthardti (Joger, 1993) and *C. fogoensis fogoensis* (O' Shaughnessy, 1874) were not considered valid taxa, following some authors (Carranza et al., 2001; González & López-Jurado, 2004; Naurois, 1994), and both are presently considered as synonyms of *C. fogoensis* from Santo Antão (Miralles et al., 2010). The record of *C. fogoensis* on São Vicente is also doubtful (Miralles et al., 2010).

Chioninia spinalis spinalis is referred to São Nicolau by Fea in 1899 but it is again probably an error originating from a mislabelling (Andreone, 2000). Its presence on Sal is also mentioned by Angel (1935, 1937) even though he is the author responsible for the description of the new taxa *C. salensis* (Angel, 1935), now *C. spinalis salensis* following Miralles et al. (2010). This can be explained by the fact that *C. spinalis* was described by Boulenger (1905) as being present on Fogo and Sal. When Angel found differences in the few specimens analysed from Sal, he assumed the existence of the two taxa (*C. spinalis* and *C. salensis*) on the island. Only later, Mertens (1955) divided them into *C. stangeri spinalis* and *C. stangeri salensis*, which was confirmed by Schleich (1987) and by Joger (1993), who changed the taxonomy to *C. spinalis spinalis* and *C. spinalis salensis*, respectively. For this same reason, Angel (1937) referred to the presence of *C. stangeri* on Boavista as some authors referred to *C. spinalis* as *C. stangeri*, omitting the subspecific name, for example Bocage (1902), because the description of *C. spinalis* occurred only in 1906 by Boulenger. The reference for *C. stangeri* on São Nicolau (Bocage, 1902) is again an old error (González & López-Jurado, 2004), repeated in later citations. However, Pinheiro (1990) indicated it was recently introduced on this island and on Santiago, but there is no confirmation by any of the further surveys, including ours. Reference to this species on Brava and Sal is also made by Schleich (1982b) based on old references. Later, the same author considered those records and the presence of this taxon on Boavista as doubtful (Schleich, 1996). In this way, the presence of *C. stangeri* in these three islands is considered as probably erroneous. The hypothesis that they could be referring to *C. spinalis* in the case of Sal and Boavista islands, as mentioned above, is more plausible.

APPENDIX 9 Supplementary data on the distribution of native taxa

Several threatened Cape Verde taxa have restricted ranges, particular habitat associations or a very low number of records. For example, there are few presences of *H. bouvieri* on São Vicente, Santo Antão, São Nicolau, Santiago and possibly Brava, and of *H. lopezjuradoi*, known only from one site in the north of Fogo Island (Arnold et al., 2008). Rarity could be related to low population sizes and habitat specialization. Observations of endemic *Hemidactylus* were restricted to relatively humid places such as mountain tops and humid deep valleys (Arnold et al., 2008; Köhler et al., 2007a,b). Some individuals were found at 600–700 m, on Santo Antão on mountain tops, and on São Nicolau and Santa Luzia under bushes of the endemic *Euphorbia tuckeyana* (Arnold et al., 2008; R. Vasconcelos pers. obs.). Other specimens on São Nicolau and Fogo were found at 250–300 m under stones in humid deep valleys, under large rocks near water (Köhler et al., 2007b) and under stones with lots of vegetation (Arnold *et al.*, 2008). *H. b. razoensis* is also uncommon, occurring on Raso islet (Arnold et al., 2008) on dry inland streams with high vegetation density, or inside cavities in volcanic rock and holes made by roots and never on rocks or on the ground (Gruber & Schleich, 1982), and on Santa Luzia in mountain areas. Only five individuals of this subspecies were collected by Gruber & Schleich (1982), further four by Mateo et al. (1997) and one more was found by R. Vasconcelos and J. Oliveira in 2012. All these *Hemidactylus* are hence Critically Endangered.

Although not with a restricted range, the same sort of habitat associations are seen for other threatened taxa. The threatened *T. boavistensis* seems to avoid the dune areas that cross from north to south on western Boavista Island and is rare on the hyperarid flat areas on the south and northern coasts (López-Jurado et al., 1999), and the threatened *T. raziana* occurs only in the small and very arid Desertas group. Also threatened, *T. rudis* was only detected on the southern part of Santiago Island and on Santa Maria Islet (Schleich, 1987; Vasconcelos et al., 2012b), preferentially on rocky barren areas and dry woody shrubland (R. Vasconcelos, pers. obs.). Furthermore, it was confirmed that the Endangered *C. stangeri* mainly occurs, apart from Desertas, on eastern São Vicente and is absent between São Pedro and Mindelo (Schleich, 1987).

Most restricted range and threatened taxa occurred only on one island, such as *T. p. protogigas* with only four recent records (after 1980) on the southern part of Fogo Island (but see Appendix 8). Although more common, *T. bocagei* is also restricted to eastern São Nicolau Island. Individuals were found under rocks on rocky barren plain and arid areas and were less abundant in more humid or high areas. Concerning the skinks, the three extant taxa with restricted range are uncommon: *C. v. vaillanti* and *C. v. xanthotis* are restricted to inland Santiago, to the northern side of Fogo Island and Cima Islet, respectively, mainly on remains of agricultural stone walls and other rock walls with vegetation cover in sub-humid and humid areas such as in conifer and moist eucalyptus forests and near water tanks (R. Vasconcelos, pers. obs.). Similarly, *C. s. salensis* occurs only on Sal, generally under fallen palm trees, rock piles and calcareous plates in dunes and sandy areas (Schleich, 1987, 1996).

Some taxa are presently restricted to very small islets, such as *T. g. gigas* and *T. g. brancoensis* on Branco and Raso, respectively. The latter is more abundant on the lower parts of the islet near the coast (Schleich, 1982a), such as in the southern dunes (Schleich & Wuttke, 1983) and on high parts and small ravines on the southern side (Schleich, 1980) or in flat areas in the interior of the islet (Andreone, 2000). It is rare on the south-east peninsula because of the strong wind exposure (Schleich, 1982a). Wind-exposed vertical slopes and rough and fissured stone are usually avoided by these geckos (Schleich, 1980) as they are unable to use vertical surfaces (Schleich, 1987) because of their high body mass. Both subspecies are usually found on rocky shores under sandstone blocks and are commensal with sea birds, using them as a food source (dead young, eggs, regurgitations) and inhabiting the same crevices birds use to nest (Schleich, 1982a; Hazevoet, 1995). This species probably had a wider range in the past, occupying Santa Luzia Island and São Vicente, where subfossil bones have been found (Mateo et al., 2009). Thus, the present range of the species results from the natural fragmentation of the habitat after the Pleistocene sea-level fluctuations that joined São Vicente and the Desertas group, followed by the effect of human colonization and associated mammalian predators (Mateo et al., 2009; Appendix 8).