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A contribution to the atlas of the terrestrial herpetofauna of Sardinia

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Abstract. Here we report on the combined observations of 10 years of opportunistic field work conducted during short visits to Sardinia, from 1999 to 2012. A total amount of 433 distribution records of 27 species were collected from 187 different localities covering 52 unique UTM squares. We report species presence in 157 new UTM squares and additionally reconfirm previous reported presence in 150 UTM squares. Overall, we produce a remarkable increase in the knowledge of the Sardinian herpetofauna. Notes and observations on ecology, taxonomy and conservation are provided.

Keywords. Italy, amphibian, reptile, endemism, conservation, distribution atlas.

Introduction

Due to its large size (24.090 km²) and long separate geological history, the Italian island of Sardinia hosts a herpetofauna characterised by a relatively high degree of endemism. The total number of herpetofauna species on Sardinia depends on the number of recent alien species that is included (Table 1). Including all well-established, long-lasting introductions as well as those confirmed in recent times and omitting a limited number of unconfirmed sightings (but see Bassu et al., 2008) of Aesculapian Snake (*Zamenis* sp.), we list 29 species level taxa. Twelve species (41%) are restricted to Sardinia, the northerly neighbouring island Corsica and (in several cases) a number of islands in the wider Tyrrhenian Sea area, thus referred to as Tyrrhenian endemics. Six of those (21% of total number) only occur on Sardinia. The remainder of the species consists largely of species which have been (either deliberately or not) introduced by man during ancient or more recent times (ca. 13 species – 45% of total number). A limited number of species are of uncertain origin, meaning that their presence also possibly results from (ancient) introductions. As noted by Sindaco et al. (2006) and Salvi and Bombi (2010), data on the distribution of the Sardinian herpetofauna is relatively scarce. The most comprehensive contemporary overview has been provided by Sindaco et al. (2006) while a distribution

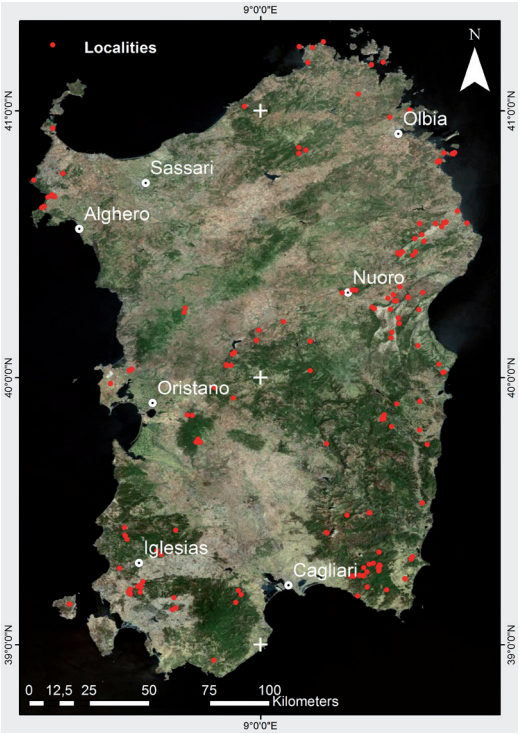

Figure 1. The study region on the Italian island Sardinia with an indication of all the sampling localities reported and the main cities.

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Table 1. Overview of endemism and origin of the Sardinian herpetofauna.

	Species	Tyrrhenian endemism	Sardinian endemism	Subspecies endemism	Introduced
1	*Euproctus platycephalus*	x	x		
2	*Speleomantes flavus*	x	x		
3	*Speleomantes genei*	x	x		
4	*Speleomantes imperialis*	x	x		
5	*Speleomantes sarrabusensis*	x	x		
6	*Speleomantes supramontis*	x	x		
7	*Speleomantes sarrabusensis*	x	x		
8	*Discoglossus sardus*	x			
9	*Bufo viridis*				
10	*Hyla sarda*	x			
11	*Pelophylax* cf. *ridibundus*				x
12	*Pelophylax* cf. kl. *esculentus*				x
13	*Testudo graeca*				x
14	*Testudo hermanni*				x
15	*Testudo marginata*				x
16	*Emys orbicularis*			x	
17	*Trachemys scripta elegans*				x
18	*Euleptes europaea*	x			
19	*Hemidactylus turcicus*				x
20	*Tarentola mauritanica*				x
21	*Algyroides fitzingeri*	x			
22	*Archaeolacerta bedriagae*	x		x	
23	*Podarcis siculus*				
24	*Podarcis tiliguerta*	x			
25	*Chalcides chalcides*			x	x
26	*Chalcides ocellatus*				x
27	*Natrix maura*				x
28	*Natrix natrix*			x	
29	*Hemorrhois hippocrepis*				x
30	*Hierophis viridiflavus*				
	? *Zamenis* sp.				?

update focused on reptile species was given by Salvi and Bombi (2010). Bassu et al. (2008, 2010) provided a considerable number of new distribution records, but these publications lacked precise locality information and maps making their usefulness limited. As a result, the obvious sizable gaps in the distribution of even the most abundant and widespread species (e.g. *Hyla sarda*, *Podarcis siculus*) clearly suggest the need for additional and continued mapping effort. It remains currently unclear whether several species which have been reported as rather common on Corsica (Delaguerre and Cheylan, 1992) do indeed have a more restricted distribution on Sardinia (e.g. *Euleptes europaea*, *Archaeolacerta bedriagae*), albeit the opposite might sometimes be true as well (e.g. *Algyroides fitzingeri*). Additionally, Bovero et al. (2008) and Bielby et al. (2009) recently reported on cases of lethal chytridiomycosis caused by the pathogen *Batrachochytrium dendrobatidis* in Sardinian populations of respectively *Euproctus platycephalus* and *Discoglossus sardus*. Due to the fact that these records constitute only the second and third confirmed cases of *B. dendrobatidis* associated amphibian mortality in Europe, and the high degree of endemism amongst Sardinia's amphibian species, a contemporary distribution overview is highly preferred. As a result, here we report on the combined observations of 10 years of opportunistic field work conducted during short visits to Sardinia, from 1999 to 2012.

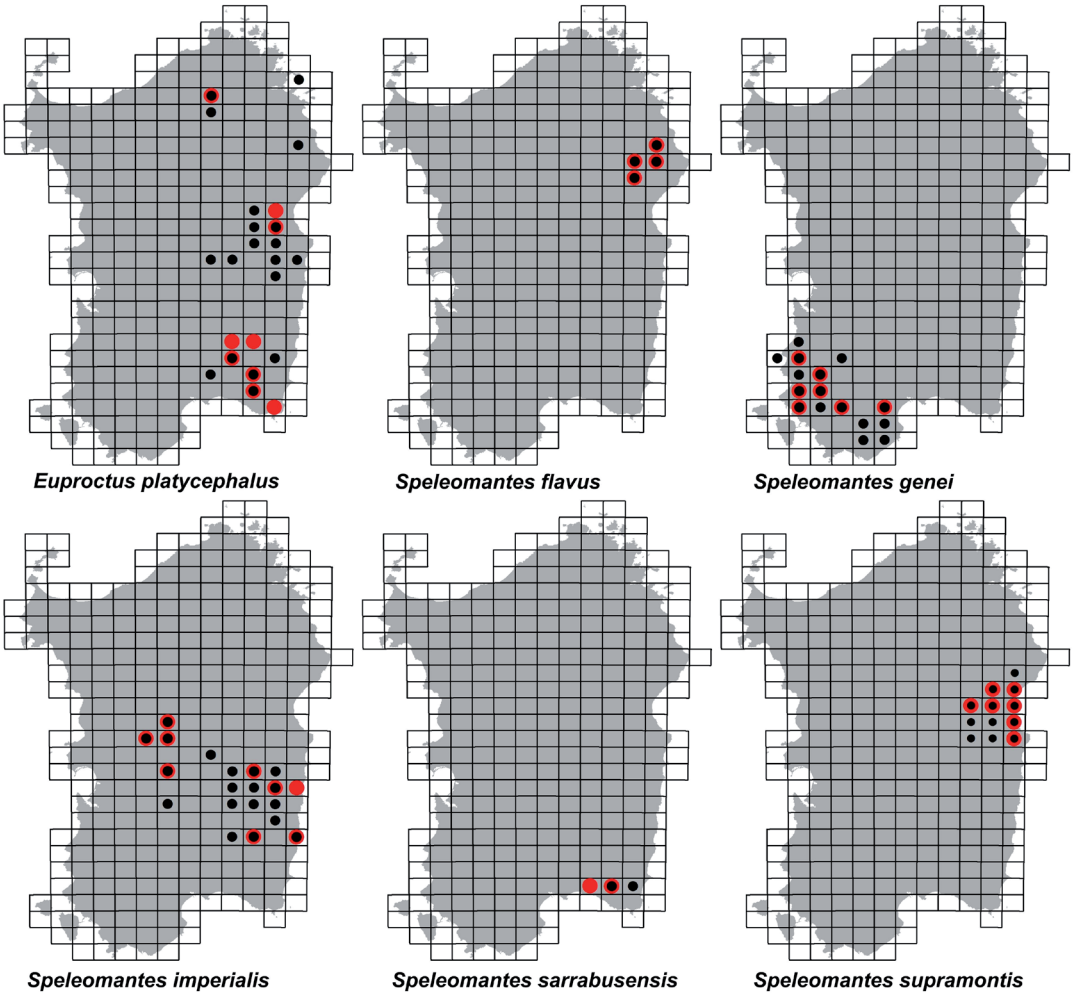

Figure 2. Distribution maps for six endemic Sardinian amphibian species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

Materials and Methods

A total of 14 field trips comprising 103 days were conducted between 1999 and 2012, of which 87 within the months October–March, and 16 in April-May. A total of 187 different localities in 72 unique UTM squares were prospected (Fig. 1). In all cases, opportunistic prospection was used to locate reptile and amphibian species. For all observations we marked site coordinates using GPS devices. The collected locality data was subsequently transformed into 10x10 km UTM grid format and compared to the most recent Italian atlas (Sindaco et al., 2006), the Sardinian update on reptile distribution (Salvi and Bombi, 2010), Bassu et al. (2008), and occasional species-specific literature (see species accounts). As systematics and/or nomenclature of a few species is still unresolved, we follow Speybroeck, Beukema and Crochet (2010). We classified species at the species level because subspecific taxonomy of several species is unclear (see e.g. Harris et al., 2005; Salvi et al., 2010). To contribute in an optimal fashion to the continued build-up of knowledge on the unique Sardinian herpetofauna, we have contributed all our data to the database of the Italian herpetological society, Societas Herpetologica Italica..

Results

A total of 433 observations of amphibian and reptile species were recorded. We observed 27 out of the 29 species that are present on Sardinia. An updated species richness map is provided in Fig. 11.

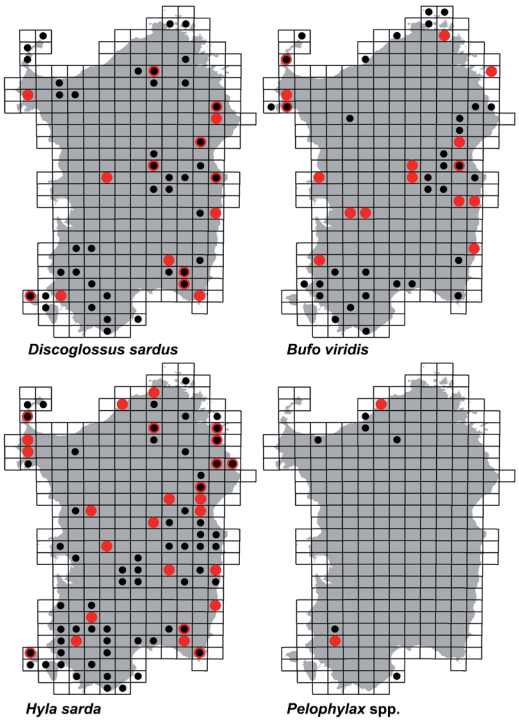

Figure 3. Distribution maps for four Sardinian amphibian species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

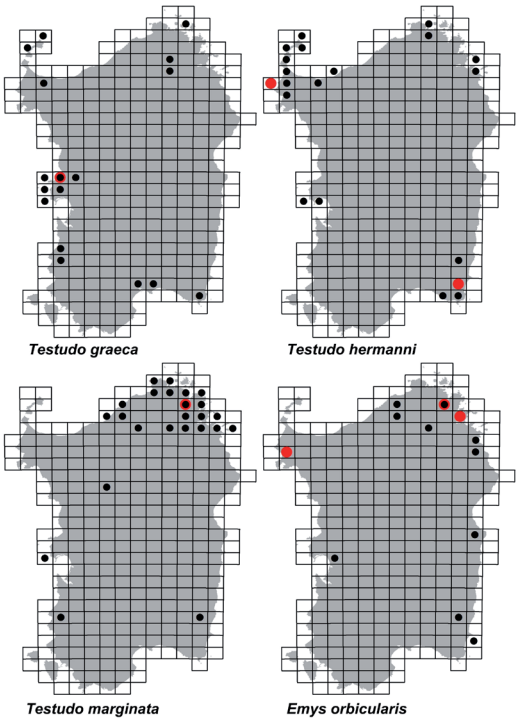

Figure 4. Distribution maps for four Sardinian reptile species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

Class Amphibia

Order Caudata

Euproctus platycephalus (Gravenhorst, 1829)
– Sardinian Brook Newt

The distribution map (Fig. 2) is composed of records presented by Sindaco et al. (2006). While Sindaco et al. (2006) reported 19 sites, this species has been recently observed in 46 sites increasing the distribution by 41.2% (Sotgiu et al., 2010). We observed *E. platycephalus* in 9 sites (4 new UTM squares) and reconfirmed the presence in 5 UTM squares. It is likely that *E. platycephalus* has a broader distribution in the mountainous regions than currently known, due to low detectability and specific survey methods required (Sotgiu et al., 2010).

On three occasions, specimens with malformations of toes and/or lower jaw were encountered. It is unclear if this might indicate locally elevated predation levels, genetic erosion, or rather be related to disease such as chytrid fungus infection (Fig. 9A).

Speleomantes flavus (Stefani, 1969)
– Monte Albo Cave Salamander

The distribution map (Fig. 2) is composed of records extracted from Lanza et al. (2005), Sindaco et al. (2006) and Chiari et al. (2012). We observed *S. flavus* in 14 sites and reconfirm the species' presence in all UTM squares that have previously been reported in literature (Lanza et al., 2005; Sindaco et al., 2009; Chiari et al., 2012). The distribution of *S. flavus* remains limited to the Monte Albo chain and nearby hills north of Siniscola, but south of the Posada River Basin.

Speleomantes genei (Temminck and Schlegel, 1838)
– Gené's Cave Salamander

The distribution map (Fig. 2) shows a current range composed of 16 UTM squares, based on the observations of Lanza et al. (2005), Sindaco et al. (2006) and Chiari et al. (2012). We have reconfirmed the presence of *S. genei* in 7 UTM squares. *Speleomantes genei* appears to be localised but widespread throughout south-western Sardinia. Due to the inhospitable nature of

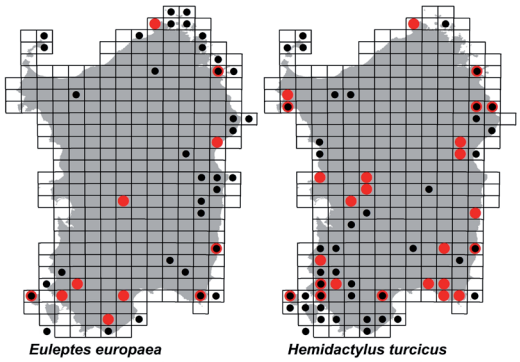

Figure 5. Distribution maps for four Sardinian reptile species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

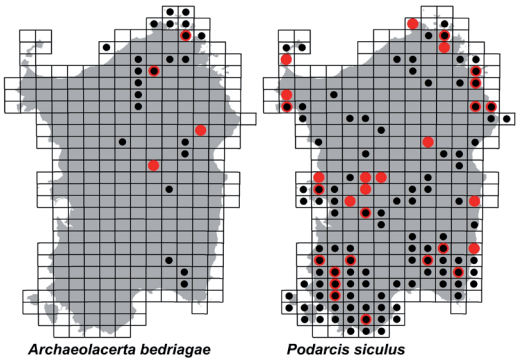

Figure 6. Distribution maps for four Sardinian reptile species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

the southern mountainous Sulcis, future discovery of additional populations can be expected, likely to reflect a rather continuous distribution pattern. This species has previously been partitioned into the nominal taxon and an undescribed taxon (*S. genei* 'B', Lanza et al., 2005). However, Chiari et al. (2012) recently showed intraspecific mtDNA and nuclear variation among these entities to fall within the variation observed in other Sardinian *Speleomantes*. Conversely, populations from the north-western part of the distribution show much deeper divergence in respect to all other populations (Chiari et al., 2012).

Speleomantes imperialis (Stefani, 1969)
– Imperial or Odorous Cave Salamander

The distribution map (Fig. 2) is composed of records from Lanza et al. (2005), Sindaco et al. (2006) and Chiari et al. (2012). We have observed *S. imperialis* in a single new UTM square and reconfirmed the presence in 8 UTM squares. The distribution of *S. imperialis* is partially disjunct as a result of post-Pleistocene climate warming. This is mirrored by considerable intraspecific divergence (Chiari et al., 2012), both at mtDNA and nuclear level. Despite the relatively recent discovery of *S. imperialis* around Lago Omodeo (Mucceda, 2005) we found the species to be locally abundant in the western part of its distribution. Occurrence in the Monte Arci can be expected as suitable looking habitat is present. Based on allozyme data, Cimmaruta et al. (1997) identified a population of *S. imperialis* introgressed by *S. supramontis* northwest of Lago Omodeo. It remains unknown whether the distribution of these species currently overlaps in the Barbagia Ololai between Lago Omodeo and the Sopramonte, or that the observed pattern of introgression represents historical contact.

Speleomantes sarrabusensis Lanza, Leo, Forti, Cimmaruta, Caputo and Nascetti, 2001
– Sette Fratelli Cave Salamander

The distribution map (Fig. 2) is composed of records from Lanza et al. (2005), Sindaco et al. (2006) and Chiari et al. (2012) who reported the species' presence

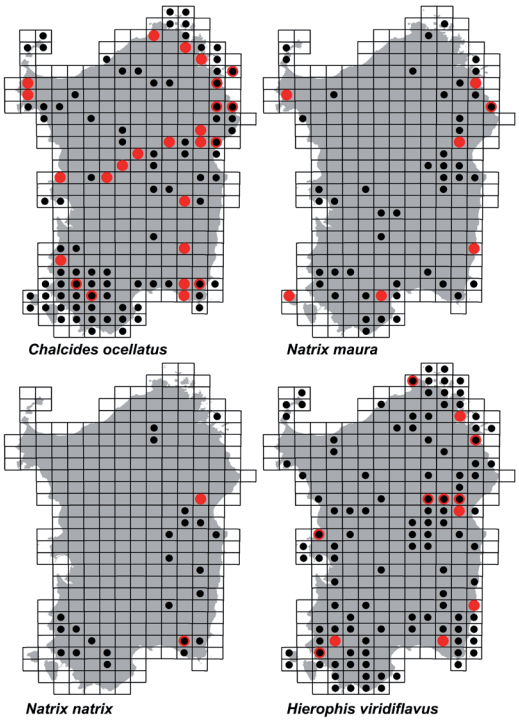

Figure 7. Distribution maps for four Sardinian reptile species. Red circles indicate presence in new UTM squares, red and black circles indicate confirmations and black circles indicate presence reported in literature.

in 2 UTM squares. We here report presence in a new UTM square within the western Sette Fratteli Massif (Fig. 9B). Although the distribution of *S. sarrabusensis* initially seemed highly localized (e.g. Lanza et al., 2005), this seems partially due to the largely inhospitable terrain it inhabits, in combination with its highly cryptic behaviour. The occurrence of *S. sarrabusensis* can be expected at higher elevations (> 500 m) throughout the Sette Fratteli Massif. The northern distribution limit remains unknown.

Speleomantes supramontis (Lanza, Nascetti and Bullini, 1986) – Sopramonte Cave Salamander

The distribution map (Fig. 2) is compiled of records from Lanza et al. (2005), Sindaco et al. (2006) and Chiari et al. (2012). *Speleomantes supramontis* is known from 12 UTM squares of which we reconfirm the species presence in seven. The distribution of *S. supramontis* is partially fragmented and comprises the wider Sopramonte Massif and the isolated Monte Tuttavista. The western distribution limit is not known (see comment under *S. imperialis*). *Speleomantes supramontis* is listed by the IUCN as endangered, due to an alleged continuing decline in occupied distribution area and/or quality, as well as a continuing decline in the number of reproducing individuals (B1ab(iii,v)) (Temple and Cox, 2009). Yet, it is unclear to us what data suggests that this species' status should deserve a different assessment than any of the other *Speleomantes* species. Our personal, yet opportunistic observations throughout the distribution do not corroborate this assessment. While we lack quantitative data, we recorded this species at numerous sites, of which several seemed to hold healthy numbers.

Order Anura

Discoglossus sardus Tschudi in: Otth, 1837 – Tyrrhenian Painted Frog

The distribution map (Fig. 3) is composed of records presented by Sindaco et al. (2006) and Bielby et al. (2009). We have observed the species in 7 new UTM squares and reconfirmed presence in 8 UTM squares. The species is relatively widespread in the mountainous regions, whereas it is seems to be absent from the central western coastal region, likely as a result of its cryptic habits and a lack of investigation in this area. Thus, the distribution map quite surely still underestimates the actual distribution of *D. sardus*. Introduction of alien water frog species (*Pelophylax* spp.) might, however, result in competition.

Bufo viridis Laurenti, 1768 – Green Toad

The distribution map (Fig. 3) is composed of records presented by Sindaco et al. (2006). *Bufo viridis* was observed in 13 new UTM squares while its presence was reconfirmed in 3 UTM squares. The new records largely fill in gaps in the central west of Sardinia. The species seems to be clearly more widespread than on Corsica (Delaguerre and Cheylan, 1992). *Bufo viridis* mostly reproduces in temporary ponds or puddles and can be found far from water bodies outside of the breeding season. On Sardinia this species commonly occurs in lowland coastal sites, but has also been recorded in various mountainous regions such as the Monte Arci (Fig. 9D), Gennargentu Massif and the Iglesiente. Stöck et al. (2006) attributed Sardinian populations to *B. balearicus* Boettger, 1881 solely based on mtDNA divergence. We follow Speybroeck, Beukema and Crochet (2010) in retaining Sardinian populations as part of *B. viridis,* pending additional evidence.

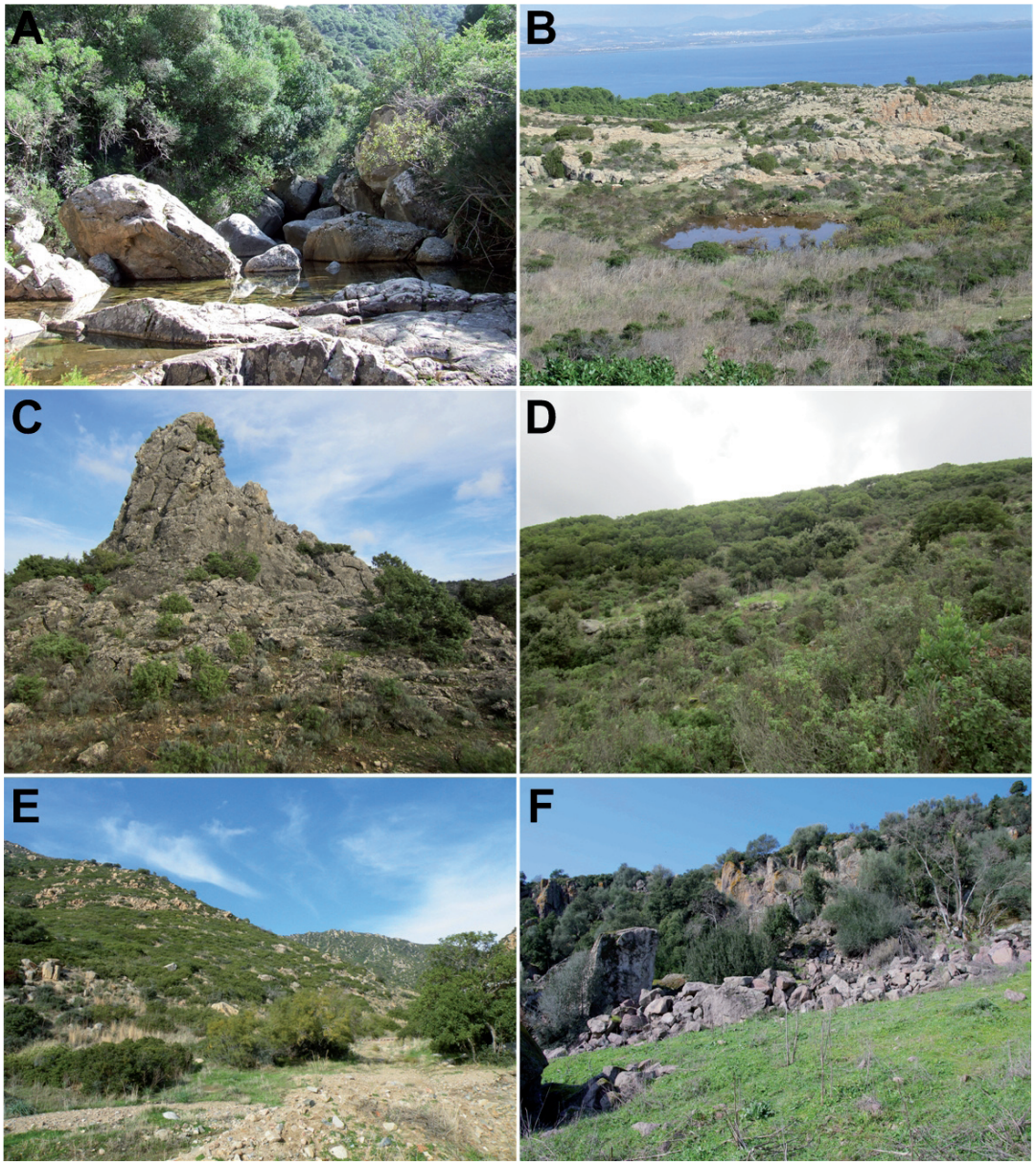

Figure 8. Herpetofauna habitat on the Italian island Sardinia: (A) Stream habitat of *E. platycephalus*, *D. sardus, H. sarda* and *P. tiliguerta* in the Sette Fratelli natural park, (B) Habitat of *D. sardus, E. europaea*, *H. turcicus*, *P. tiliguerta*, *P. siculus* and *N. maura* on central San Pietro Island, (C) Habitat of *S. supramontis* and *P. tiliguerta*, (D) Habitat of *S. sarrabusensis* and *A. fitzingeri* at new locality and UTM square in the western Sette Fratelli: (E), Habitat of *T. hermanni*, *C. ocellatus* and *T. mauritanica* at a new locality in southwest Sardinia, and (F) Habitat of *S. imperialis*, *C. ocellatus* and *C. chalcides* north of Lago Omodeo.

Hyla sarda (De Betta, 1857) – Tyrrhenian Tree Frog

The distribution map (Fig. 3) is composed of Sindaco et al. (2006), Bisconti, Canestrelli and Nascetti, (2011) and Bisconti et al. (2011). We have observed *H. sarda* in 16 new UTM squares and reconfirmed the presence in 9 UTM squares. *Hyla sarda* seems to be the most euryoecious anuran on Sardinia, occupying a broad variety of habitats ranging from coastal marshes to fast-flowing mountain streams. The current distribution map most likely underestimates the occurrence of *H. sarda,* which can be expected to occur almost continuously throughout Sardinia. Indeed, Bisconti et al. (2011)

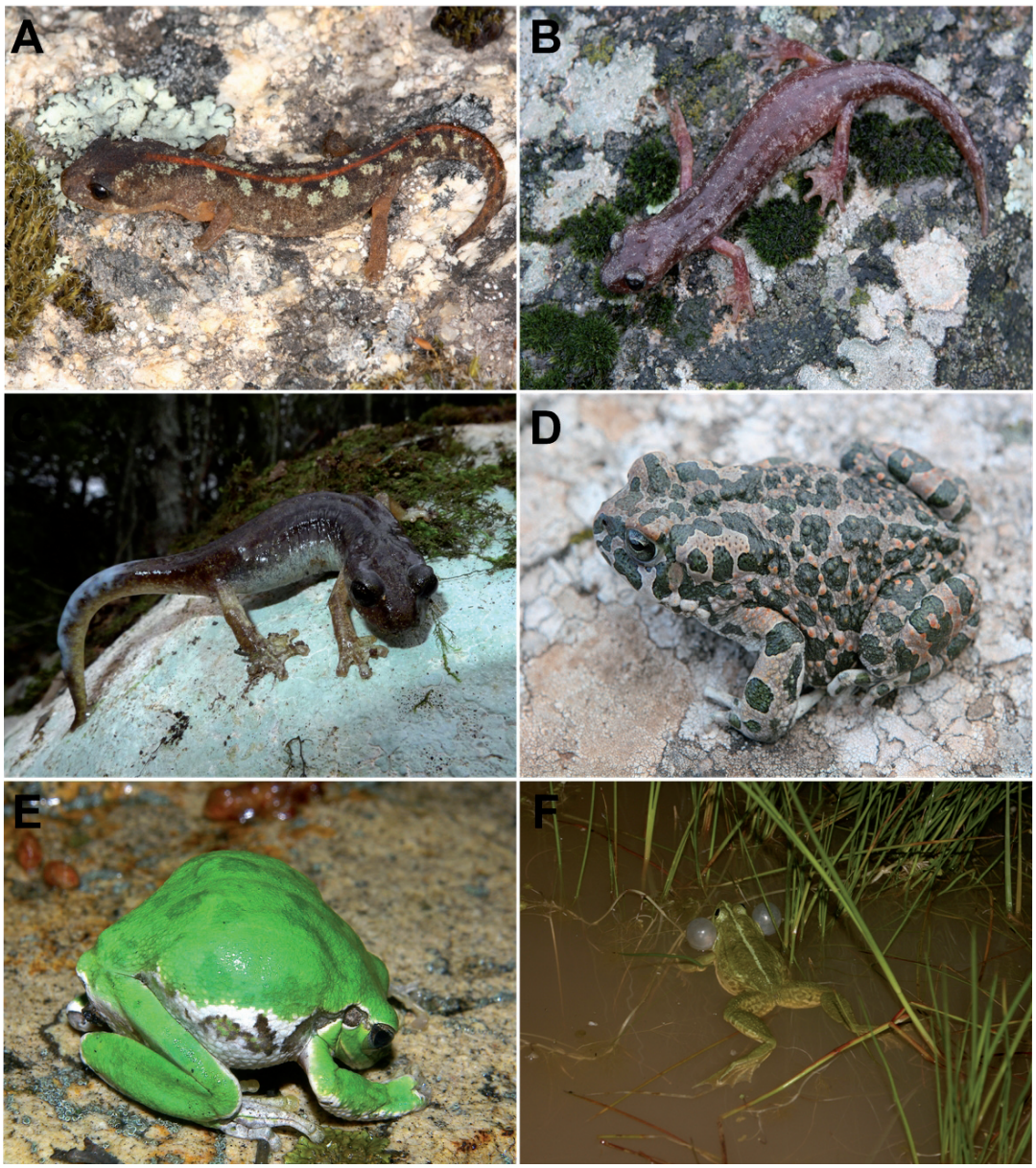

Figure 9. Sardinian amphibian observations: (A) A malformated juvenile *E. platycephalus* that was found in an ants nest, (B) Female *S. sarrabusensis* from a new locality and UTM square in the western Sette Fratelli, (C) A *S. supramontis* displaying defensive behaviour, (D) *B. viridis* from the Monte Arci, (E) *H. sarda* displaying defensive behaviour, and (F) *Pelophylax sp.* from the north of the island, calling like *P. ridibundus*, but with pale vocal pouches.

suggested relatively rapid expansion of *H. sarda* populations on both Sardinia and Corsica after the Last Glacial Maximum.

Pelophylax spp. – water frogs indet.

The distribution map (Fig. 3) is composed of Mutz (2002), Sindaco et al. (2006) and Li Vigni, Licata and Anza (2011). While Sindaco et al. (2006) reported members of this complex from 2 UTM squares, Mutz (2002) observed *Pelophylax* spp. in 3 new UTM squares in the north. Subsequently, Li Vigni, Licata and Anza (2011) reported occurrence of the species from a new site in south-western Sardinia. Here, we report the observation of frogs belonging to the genus

Figure 10. Sardinian reptile observations: (A) *E. orbicularis* from new locality in the northwest of the island, (B) *A. bedriagae* from new locality on Monte Albo, (C) Typical *C. chalcides*, (D) A very large and dark coloured specimen of *C. ocellatus*, (E) Newly discovered *N. maura* on San Pietro Island, and (F) *Natrix natrix cetti* from Sette Fratelli.

Pelophylax (Fig. 9F) from 2 UTM squares adjacent to the ones reported by Mutz (2002) and Li Vigni, Licata and Anza (2011), resulting in 8 occupied UTM squares on Sardinia. The identity of the species remains unclear and requires further genetic study. Auditive observations, however, allowed us to identify at least two different taxa being present on the island – with calls from a northern location largely resembling those of the *Pelophylax ridibundus* species group, whereas those of a southern site where reminiscent of those of *Pelophylax* kl. *esculentus*.

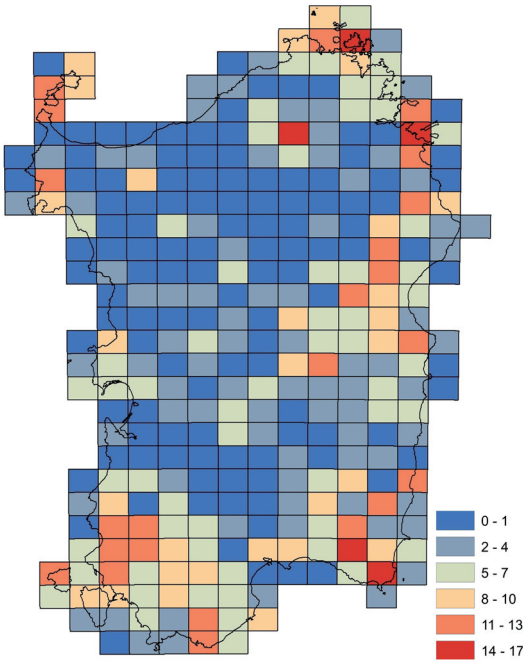

Figure 11. An updated species richness map of the Sardinian herpetofauna.

Class Reptilia

Order Testudines

Testudo graeca Linnaeus, 1758 – Spur-thighed Tortoise

The distribution map (Fig. 4) is composed of Sindaco et al. (2006), Bassu et al. (2010) and Salvi and Bombi (2010). We reconfirm the presence in 1 UTM square in the Sinis Peninsula. Fritz et al. (2009), using cytochrome b, showed that the Sardinian populations of *T. graeca* belong to the western North African lineage A, which matches the range of *T. g. nabeulensis*. More recently, Vamberger et al. (2011) showed that Sardinian populations resulted from prehistoric or historic introduction from the western Maghreb, what is now Tunisia and Algeria.

Testudo hermanni Gmelin, 1789 – Hermann's Tortoise

The distribution map (Fig. 4) is composed of Sindaco et al. (2006), Bassu et al. (2010) and Salvi and Bombi (2010). We have observed *T. hermanni* in 2 new UTM squares and reconfirmed the presence in 3 UTM squares. Fritz et al. (2006) analysed the range-wide phylogeography of *T. hermanni*, and showed Sardinian populations to be weakly differentiated. Subsequently, Vamberger et al. (2011) argued that the extant populations of *T. hermanni* are not native and likely originate from human introduction. This species seems to be the more widespread tortoise on the island.

Testudo marginata Schoepff, 1792
– Marginated Tortoise

The distribution map (Fig. 4) is composed of Sindaco et al. (2006), Bassu et al. (2010) and Salvi and Bombi (2010). We reconfirm the presence in 1 UTM square. While formerly tentatively described as belonging to the endemic subspecies *T. m. sarda*, the Sardinian populations of *T. marginata* have been shown to originate from Greece and constitute a fairly recent human mediated introduction (Fritz et al., 2005; Perez et al., 2011; Vamberger et al., 2011).

Emys orbicularis (Linnaeus, 1758)
– European Pond Terrapin

The distribution map (Fig. 4) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *E. orbicularis* in 2 new UTM squares and reconfirmed the presence in 1 UTM square. The observation in the northwest near Alghero constitutes a significant extension of the species' range on Sardinia. Pedall et al. (2011) showed that extant Sardinian populations of *E. orbicularis* are undifferentiated from the nearest continental subspecies *E. o. galloitalica* based on mitochondrial and microsatellite markers. As the fossil record argues for a Middle-Pleistocene presence of the species on Sardinia, Pedall et al. (2011) suggested a scenario of extinction and later introduction by prehistoric settlers (see also Vamberger et al., 2011). Subsequently, the Sardinian endemic subspecies *E. o. capolongoi* should be considered invalid. Sardinian terrapin populations, as any throughout the Mediterranean Basin, face a potential threat from introduced species like Red-Eared Slider (*Trachemys scripta elegans*).

Order Squamata

Suborder Sauria

Euleptes europaea (Gené, 1839) – Leaf-toed Gecko

The distribution map (Fig. 5) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *E. europaea* in 7 new UTM squares and reconfirmed the presence in 3 UTM squares. The new record in central Sardinia near Ruinas might indicate a wider distribution of this difficult to observe species, especially in the interior of the island. Our coastal records

Table 2. Overview of the number of UTM squares provided in the literature and the present study.

Species	Literature	New UTM	Confirmed UTM	Total UTM
Euproctus platycephalus	19	4	5	23
Speleomantes flavus	4	0	4	4
Speleomantes genei	16	0	7	16
Speleomantes imperialis	19	1	8	20
Speleomantes sarrabusensis	2	1	1	3
Speleomantes supramontis	12	0	7	12
Discoglossus sardus	41	7	8	48
Bufo viridis	34	13	3	47
Hyla sarda	63	16	9	79
Pelophylax ssp.	6	2	0	8
Testudo graeca	17	0	1	17
Testudo hermanni	18	2	3	20
Testudo marginata	24	0	1	24
Emys orbicularis	10	2	1	12
Euleptes europeae	35	7	3	42
Hemidactylus turcicus	43	16	9	59
Tarentola mauritanica	33	12	7	45
Algyroides fitzingeri	74	10	13	84
Archaeolacerta bedriagae	23	2	2	25
Podarcis siculus	106	12	17	118
Podarcis tiliguerta	122	13	23	135
Chalcides chalcides	34	8	1	42
Chalcides ocellatus	86	17	8	103
Natrix maura	46	6	1	52
Natrix natrix	23	1	1	24
Hemorrhois hippocrepis	15	0	0	15
Hierophis viridiflavus	109	5	7	114
Total	1034	157	151	

slightly devaluate the assumption that the species would be less widespread or less common on Sardinian than on Corsica (Delaguerre and Cheylan, 1992).

Hemidactylus turcicus (Linnaeus, 1758)
– Turkish Gecko

The distribution map (Fig. 5) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *H. turcicus* in 16 new UTM squares and reconfirmed the presence in 9 UTM squares. Rato, Carranza and Harris (2011) studied the phylogeography of *H. turcicus* and showed that the Sardinian specimens belong to two widespread distinct mitochondrial lineages characterized by low differentiation and genetic diversity. An origin based on human-mediated introduction seems likely.

Tarentola mauritanica (Linnaeus, 1758)
– Moorish Gecko

The distribution map (Fig. 5) is composed of records from Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *T. mauritanica* in 19 new UTM squares and reconfirmed the presence in 7 UTM squares. *Tarentola mauritanica* is most often found in areas characterized by significant rock debris. As we found individuals of this species both on coastal sites and further inland on rocky outcrops a much wider distribution on Sardinia can be expected. Several studies have shown that *T. mauritanica* represents a cryptic species complex with a rather complicated and difficult to interpret evolutionary history, likely resulting from a selective sweep process as well as recent colonisations and introductions (Harris et al., 2004; Rato et al., 2010; Rato et al., 2012). Recently, Rato et al. (2012) showed that Sardinian specimens belong to Clade III which is widespread in Europe and North Africa.

Algyroides fitzingeri (Wiegmann, 1834)
– Tyrrhenian Algyroides

The distribution map (Fig. 5) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *A. fitzingeri* in 10 new UTM squares and reconfirmed the presence in 13 UTM squares. The new records fill in gaps in the central western part of Sardinia. The Corso-Sardinian endemic *A. fitzingeri* is a relatively widespread species on Sardinia, whereas it has been surprisingly seldom recorded from Corsica (Delaguerre and Cheylan, 1992). The new distribution records in central western Sardinia further extend the distribution of this species. Recently, Salvi et al. (2011) investigated mitochondrial genetic variation and showed quite high genetic diversity which is geographically, although shallowly, structured. Salvi et al. (2011) provided only a preliminary results and a more thorough assessment with a broader sampling needs to be undertaken in order to obtain a conclusive phylogeographic appraisal.

Archaeolacerta bedriagae (Camerano, 1885)
– Tyrrhenian Rock Lizard

The distribution map (Fig. 6) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *A. bedriagae* in 2 new UTM squares and reconfirmed the presence in 2 UTM squares. The lesser availability of both suitable mountain as well as coastal habitat in comparison with Corsica is a likely cause for the restricted distribution pattern on Sardinia. However, the two new UTM squares presented herein, located on the northern slopes of the Monte Albo and on the northern Gennargentu Massif suggest that *A. bedriagae* might occupy more yet to be prospected, but hard to explore mountain slopes.

Podarcis siculus (Rafinesque-Schmaltz, 1810)
– Italian Wall Lizard

The distribution map (Fig. 6) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *P. siculus* in 12 new UTM squares and reconfirmed the presence in 17 UTM squares, making it the second most widely spread species to occur in Sardinia. It is, however, very likely that the obtained distribution map still suffers from sampling bias, with the true presence of the species being more ample.

Podarcis tiliguerta (Gmelin, 1789)
– Tyrrhenian Wall Lizard

The distribution map (Fig. 6) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *P. tiliguerta* in 13 new UTM squares and reconfirmed the presence in 23 UTM squares, making it the most widely spread species to occur in Sardinia. As mentioned for *P. siculus*, this species also is likely to be even more widespread than current knowledge suggests. While often replaced by *P. siculus* in the more lush and -especially- anthropogenic habitats, the species is readily encountered in high abundance throughout the island.

Chalcides chalcides (Linnaeus, 1758)
– Italian Three-Toed Skink

The distribution map (Fig. 6) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *C. chalcides* in 8 new UTM squares and reconfirmed the presence in 1 UTM square. Due to sufficient presence of suitable habitat throughout the island, it is most likely that the available distribution records largely underestimate the actual presence of the species in many parts of the island. The Sardinian populations belong to the subspecies *C. c. vittatus* (Fig. 10C) which is likely to have been introduced from northern Tunisia (Carranza et al., 2008).

Chalcides ocellatus (Forskål, 1775) – Ocellated Skink

The distribution map (Fig. 7) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *C. ocellatus* in 17 new UTM squares and reconfirmed the presence in 8 UTM squares. While more records are available for this species in comparison with *C. chalcides*, its ubiquitous nature and occurrence in a wide range of both natural and man-made habitats suggests that its actual presence on Sardinia is much wider than currently reflected by the available data. The presence of *C. o. tiligugu* on Sardinia seems to be due to human introduction from northern Tunisia (Carranza et al., 2008).

Suborder Serpentes
Natrix maura (Linnaeus, 1758) – Viperine Snake

The distribution map (Fig. 7) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *N. maura* in 6 new UTM squares and reconfirmed the presence in 1 UTM square. The presence of the species on San Pietro Island is confirmed with the finding of a specimen west of Carloforte in 2010 (Fig. 10E). *Natrix maura* is widespread on Sardinia where the species occupies a variety of aquatic habitats. Guicking, Joger and Wink (2008) showed that the Sardinian populations belong to the Tunisian clade. An introduced origin might be the case.

Natrix natrix (Linnaeus, 1758) – Grass Snake

The distribution map (Fig. 7) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We observed *N. natrix* in 1 new UTM square and reconfirmed the presence in 1 UTM square. Thorpe (1979) showed the Sardinian subspecies *N. n. cetti* to be morphologically clearly differentiated. Recently, Fritz, Corti and Päckert (2012) provided genetic evidence against full species status. This is one of the most rarely recorded species of the Sardinian herpetofauna. Its contemporary distribution is poorly known, which has been attributed to its nocturnal habits (Capula, Rugiero and Luiselli, 1994). In contrast, the only two specimens we recorded were found basking during daytime (Fig. 10F). *Natrix natrix* is most commonly found in the vicinity of small water bodies or streams in Sardinia's mountainous regions.

Hemorrhois hippocrepis (Linnaeus, 1758) – Horseshoe Whip Snake

Please refer to Salvi and Bombi (2010) for a distribution map. We have not observed this locally endangered species of introduced origin.

Hierophis viridiflavus (Lacépède, 1789) – Western Whip Snake

The distribution map (Fig. 7) is composed of Sindaco et al. (2006) and Salvi and Bombi (2010). We have observed *H. viridiflavus* in 5 new UTM squares and reconfirmed the presence in 7 UTM squares, making it the third most widely distributed species to occur in Sardinia. Rato et al. (2009) showed that Sardinian populations belong to the "western" clade, which may likely result from a recent colonization.

Conclusions

Our opportunistically collected data provide a sizable and noteworthy addition to the available data on the distribution of the Sardinian herpetofauna. As noted before, the majority of the observations presented herein have been made between the months October – April. Moreover, most search sites were located in mountainous regions, due to the partial focus on *Speleomantes* sp., while large areas of the central and southern Sardinian lowlands were not visited (Fig. 1). A considerable degree of observation bias therefore has to be taken into account, which results in the fact that the distribution pattern of several species (e.g. *Podarcis* spp, *Chalcides* spp.) which were characterized by a lack of distribution data (Sindaco et al., 2006; Salvi and Bombi, 2010) remains largely unchanged. Lack of data therefore still exists for large sections of the island. The distribution records presented by Bassu et al. (2008, 2010), however, might partly cover some of the remaining gaps. Additionally, several of the new distribution records presented in this study might already have been included in Bassu et al. (2008, 2010). Combining all the available distribution records will ultimately result in the realisation of an updated atlas of the Sardinian herpetofauna.

Until now, it is hard to assess the conservation status of the amphibians and reptiles of the island, both due to a lack of data and the occasional confusing systematic history of several taxa. While some actual threats have been observed (e.g. Voesenek et al., 1987; Bovero et al., 2008; Bielby et al., 2009), recent decisions on the conservation status of several species have been based on expert judgement rather than solid data (Temple and Cox, 2009). These conclusions do, as noted before, not always correspond to our personal observations. As we have shown it is fairly easy to collect new distribution data. At least six endemic amphibian species occur on Sardinia. All are listed on Annexes II and IV of the EU Natural Habitats Directive (Directive 92/43/EEC). Therefore, they are in need of strict protection and monitoring, to establish the requirements of the directive. Only then it is possible to establish a favourable conservation status for those species. Only with sufficient knowledge on the actual presence and abundance, truth-based goals can be set for conservation and monitoring of trends.

It has to be noted that although the validity of several previously endemic taxa has been recently questioned (e.g. Salvi et al., 2010; Pedall et al., 2011; Vamberger et al., 2011; Chiari et al., 2012; Fritz, Corti and Päckert, 2012) some of these do show considerable genetic intraspecific divergence or morphological differentiation in comparison with continental populations (Thorpe, 1979; Salvi et al., 2010; Chiari et al., 2012). The presence of such insular variation and the existence of evolutionary significant units should be taken into account for conservation measures.

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