Moroccan herpetofauna: distribution updates

Geographical exploration is crucial to fully catalog the extent of biodiversity. It is an indispensable tool for achieving a more complete sampling of species and to correctly quantify species richness, while also aiding a better understanding on how this connects with the ecological requirements of the different species and their interactions in an ecosystem. Without this knowledge, conservation efforts are likely to be ineffective. Many conservationists focus their attention in the preservation of areas with high levels of biodiversity. The Mediterranean Basin is considered one of the Global Biodiversity Hotspots (MYERS et al. 2000; MITTERMEIER et al. 2004), with the south European Peninsulas and the western Maghreb comprising most of the species richness (MÉDAIL & QUÉZEL 1999).

Morocco is a country located in the western part of the Maghreb region, with an area of 446,550 km^2 (excluding the Western Sahara region). It is a unique area of Africa, given the conjunction of the influences of both the Mediterranean Sea and the Atlantic Ocean. Its particular location associated with the heterogeneity of the landscape creates an exceptional combination of climactic and biological features, which lead to high levels of richness and endemism in the herpetofauna. The distribution of the Moroccan amphibians and reptiles is well documented by BONS & GENIEZ (1996). Since then, researchers have tried to enhance the sampling coverage particularly in less explored regions (HARRIS et al. 2008, 2010; BARNESTEIN et al. 2010; BARATA et al. 2011). A recent review has greatly improved knowledge concerning the distribution of amphibians (BEUKEMA et al. 2013). New species location records are constantly being added to the known species' ranges, indicating that the full distribution of many of them is still unknown.

In the present study, the authors compile the records of an expedition carried out

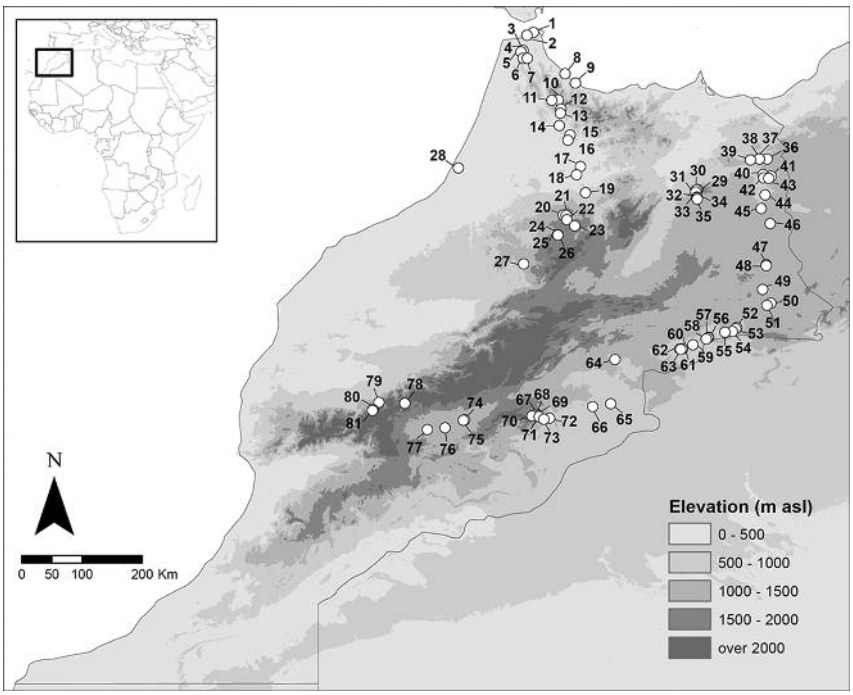

Fig. 1: Map of Morocco, including the sampled localities. For more details, see Table1.

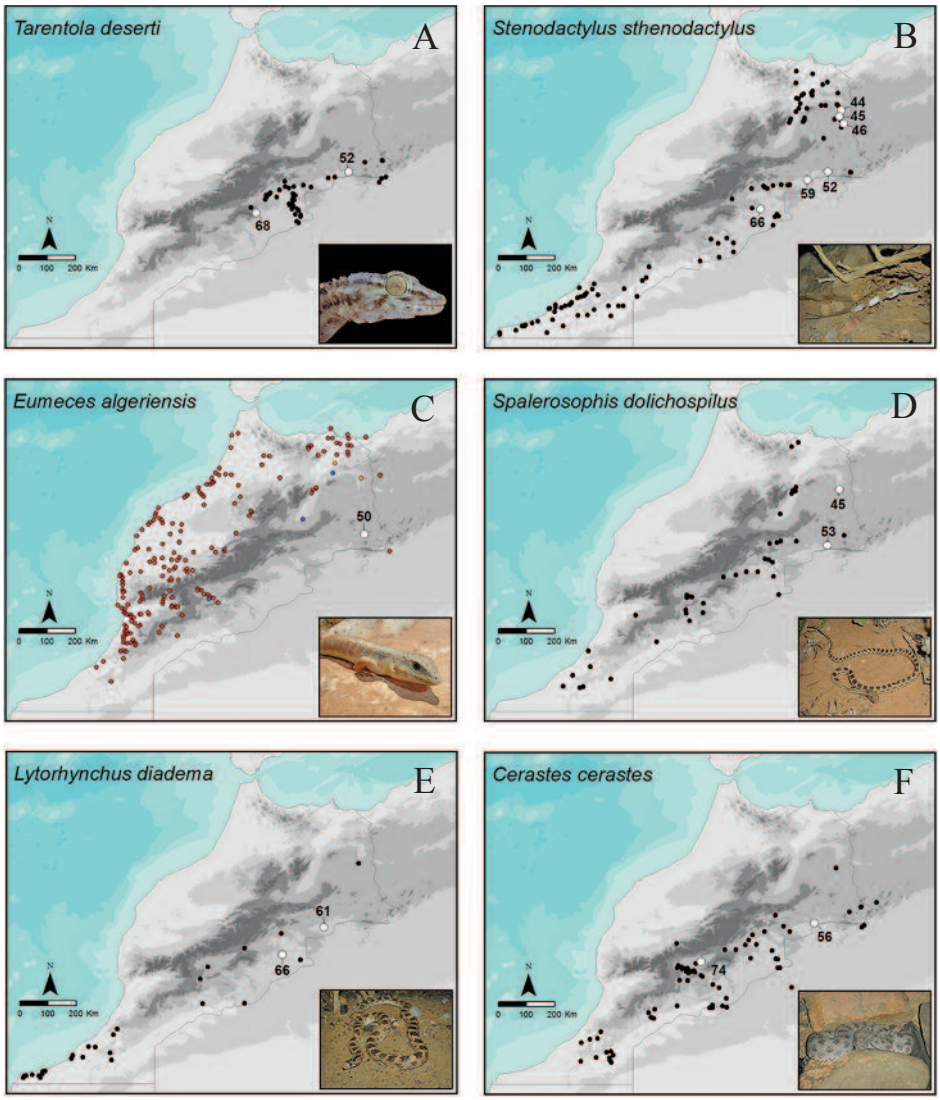

Fig. 2: Distribution maps of the species with the more relevant new records. White circles represent the new localities; black or colored circles represent previously published records (Bons & Geniez 1996; Harris et al. 2008, 2010; Barnestein et al. 2010; Barata et al. 2011). In the map of *Eumeces algeriensis*, the different color circles stand for distinct forms, red circles: "*algeriensis* form", blue circles: "*meridionalis* form", and yellow circles: "intermediate form". All photographs by D. Salvi.

over three weeks during May 2012 that covered an extensive area of northern and central Morocco (Fig. 1), crossing very different types of habitat. In total, specimens of four amphibian and 37 reptile species were found from 81 localities. GPS coordinates and a detailed listing of species per location are given in Table 1. Photographs of most animals are available on request from the authors. Species distributions were compared with previous literature (see references above) and, for species whose new

records hold particular interest, additional information is provided in the text that follows. More recent taxonomic changes are addressed to facilitate comparison with preceding publications. Some reptile species were found in new locations often linking previously known populations, especially in the eastern part of northern Morocco. These results highlight the need for further exploration of this area, despite several recent herpetological expeditions.

Ranidae – *Pelophylax saharicus* (Boulenger, 1913). Localities 4, 5, 7, 9, 15, 17, 31, 33, 55, 64, 65, 69, 71, 72, and 81. Previously named *Rana saharica*, this species is now assigned to the genus *Pelophylax* after Frost et al. (2006). Along with other less notable locations, a new one (locality 55) is added to the eastern part of its Moroccan range, showing a probable connectivity with the populations around Figuig, near the Algerian border.

Agamidae – *Trapelus boehmei* Wagner et al., 2011. Localities 58, 62, and 63. *Trapelus mutabilis* (Merrem, 1820) was recently identified as a complex of species with all populations from Morocco assigned to *T. boehmei* (Wagner et al. 2011). This desert species is widely dispersed south of the Atlas Mountains. The three new records are in the Oriental province and locality 58 is more than 45 km from previous records.

Gekkonidae – *Tropiocolotes algericus* Loveridge, 1947. Localities 51 and 66. Previously considered as a subspecies of *T. tripolitanus* Peters, 1880, Baha El Din (2001) classified it as a full species. This gecko is found in rocky habitats across the south half of Morocco. Locality 51 is situated near Bouarfa and is an additional record in an area with fewer observation points. Moreover, it corresponds to the northernmost know location for this species.

Lacertidae – *Ophisops occidentalis* Boulenger, 1887. Locality 36. Only one specimen was found within this poorly prospected region of Morocco. It represents the northernmost *Ophisops* record for the country, suggesting that the Moroccan populations may not be as isolated from the Algerian populations as seems in the map by Bons & Geniez (1996).

Scelarcis perspicillata (Duméril & Bibron, 1839). Localities 18, 21, 26, 29, and 81. The authors recorded two individuals, tentatively assigned to the subspecies *S. p. chabanaudi* (Werner, 1931) (spotted morphotype: localities 26, 29, 81), and *S. p. pellegrini* (Werner, 1929) (striped morphotype: localities 18, 21). However, this species needs a taxonomic revision due to the incongruence between morphological and genetic patterns (Harris et al. 2003; Perera et al. 2007).

Phyllodactylidae – *Ptyodactylus oudrii* Lataste, 1880. Localities 57, 68, 69, and 73. This taxon encompasses almost certainly a species complex (Perera & Harris 2010) with multiple distinct genetic lineages within Morocco. Although *P. oudrii* presents a scattered distribution pattern with a relatively low number of records, four more occurrence points were identified during this trip. One of these expands the distribution of this species 20 km to the east (locality 57).

Tarentola deserti Boulenger, 1891. Localities 52, and 68 (Fig. 2A). This species has a distribution restricted to the south of the Oriental and Meknes-Tafilalet provinces. Apart from one prior observation, location 68 is separated more than 50 km from other previous records. Therefore, it might be expected that future prospecting in this area should result in new findings for this species. Also, the second locality (52) represents a geographic link between two distant populations, suggesting *T. deserti* may have a more continuous distribution along the Algerian border in this zone.

Scincidae – *Eumeces algeriensis* Peters, 1864. Locality 50 (Fig. 2C). A commonly found skink in the Mediterranean and temperate habitats of north and west Morocco. In the southern portion of eastern Morocco there are far fewer records, generally assigned to the form "*meridionalis*", which is variously considered a subspecies of *E. algeriensis*, a subspecies of *E. schneideri* (Daudin, 1802), or a full species (see Eiselt 1940; Bons & Geniez1996; and Schleich et al. 1996). The individual recorded in Locality 50, near the town of Bouarfa, was morphologically intermediate between *E. algeriensis* and the "*meridionalis*" form, but genetically similar (Salvi et al., unpublished mtDNA data) to the southern

Table 1: List of the sampled localities (numbers in column L correspond to numbers in Figure 1) along with the correspondent species records. Coordinates are given in the WGS84 coordinate system.

L	Latitude	Longitude	Sampled species
1	35.87981	-5.46898	*Tarentola mauritanica*
2	35.84769	-5.56204	*Tarentola mauritanica*
3	35.66590	-5.63411	*Amietophrynus mauritanicus*, *Tarentola mauritanica*, *Timon tangitanus*
4	35.66320	-5.62317	*Blanus tingitanus*, *Hyla meridionalis*, *Pelophylax saharicus*, *Podarcis vaucheri*, *Natrix maura*
5	35.64439	-5.65377	*Pelophylax saharicus*
6	35.56917	-5.62423	*Agama impalearis*
7	35.56669	-5.55873	*Blanus tingitanus*, *Pelophylax saharicus*, *Podarcis vaucheri*
8	35.37960	-4.99471	*Psammodromus algirus*
9	35.26684	-4.84243	*Pelophylax saharicus*, *Podarcis vaucheri*, *Natrix maura*
10	35.06430	-5.09989	*Podarcis vaucheri*, *Psammodromus algirus*, *Tarentola mauritanica*
11	35.05962	-5.19378	*Podarcis vaucheri*
12	34.95202	-5.05846	*Psammodromus algirus*
13	34.90027	-5.06451	*Amietophrynus mauritanicus*
14	34.74982	-5.08356	*Amietophrynus mauritanicus*, *Blanus tingitanus*
15	34.63909	-4.92240	*Amietophrynus mauritanicus*, *Pelophylax saharicus*
16	34.57196	-4.95671	*Amietophrynus mauritanicus*
17	34.25108	-4.76486	*Pelophylax saharicus*
18	34.14850	-4.82867	*Saurodactylus fasciatus*, *Scelarcis perspicillata*, *Tarentola mauritanica*
19	33.92488	-4.69164	*Agama impalearis*
20	33.65217	-5.02266	*Psammodromus algirus*
21	33.64656	-4.97959	*Amietophrynus mauritanicus*, *Bufotes boulengeri*, *Podarcis vaucheri*, *Scelarcis perspicillata*, *Timon tangitanus*
22	33.59543	-4.96836	*Psammodromus algirus*
23	33.51809	-4.85335	*Podarcis vaucheri*, *Trogonophis wiegmanni*
24	33.40851	-5.10825	*Acanthodactylus erythrurus*, *Timon tangitanus*
25	33.40556	-5.10297	*Bufotes boulengeri*, *Malpolon monspessulanus*, *Natrix maura*, *Hyalosaurus koellikeri*, *Podarcis vaucheri*, *Psammodromus algirus*, *Tarentola mauritanica*, *Timon tangitanus*
26	33.40364	-5.10158	*Bufotes boulengeri*, *Malpolon monspessulanus*, *Podarcis vaucheri*, *Scelarcis perspicillata*, *Tarentola mauritanica*, *Timon tangitanus*
27	33.04503	-5.61190	*Mauremys leprosa*
28	34.23080	-6.58596	*Tarentola mauritanica*
29	33.96737	-3.02681	*Agama impalearis*, *Chalcides pseudostriatus*, *Podarcis vaucheri*, *Scelarcis perspicillata*
30	33.96446	-3.04089	*Chalcides ocellatus*, *Podarcis vaucheri*, *Tarentola mauritanica*
31	33.93699	-3.05380	*Chalcides ocellatus*, *Hyla meridionalis*, *Pelophylax saharicus*, *Podarcis vaucheri*
32	33.87299	-3.03860	*Chalcides ocellatus*, *Hyla meridionalis*, *Natrix maura*, *Tarentola mauritanica*
33	33.87069	-3.03667	*Pelophylax saharicus*
34	33.86531	-3.03239	*Acanthodactylus erythrurus*, *Chalcides ocellatus*, *Natrix maura*, *Psammodromus algirus*
35	33.84780	-3.03053	*Tarentola mauritanica*
36	34.34239	-1.98905	*Chamaeleo chamaeleon*, *Ophisops occidentalis*, *Trogonophis wiegmanni*
37	34.34252	-2.10870	*Agama impalearis*, *Testudo graeca*
38	34.34210	-2.10808	*Trogonophis wiegmanni*
39	34.32827	-2.24108	*Testudo graeca*
40	34.15185	-2.05613	*Amietophrynus mauritanicus*
41	34.13204	-1.93334	*Chalcides ocellatus*
42	34.10919	-2.04447	*Hemorrhois hippocrepis*
43	34.10223	-1.96761	*Amietophrynus mauritanicus*
44	33.89849	-2.01957	*Chalcides ocellatus*, *Stenodactylus sthenodactylus*
45	33.73235	-2.07838	*Spalerosophis dolichospilus*, *Stenodactylus sthenodactylus*
46	33.54277	-1.94482	*Stenodactylus sthenodactylus*
47	33.03361	-2.00432	*Agama impalearis*
48	33.02259	-2.00667	*Malpolon insignitus*
49	32.72496	-2.06050	*Uromastyx nigriventris*
50	32.55655	-1.93517	*Eumeces algeriensis*
51	32.52714	-1.99750	*Tropiocolotes algericus*
52	32.24888	-2.44608	*Acanthodactylus boskianus*, *Stenodactylus sthenodactylus*, *Tarentola deserti*
53	32.23612	-2.45979	*Spalerosophis dolichospilus*
54	32.20004	-2.50865	*Amietophrynus mauritanicus*

Table 1 (continued): List of the sampled localities (numbers in column L correspond to numbers in Figure 1) along with the correspondent species records. Coordinates are given in the WGS84 coordinate system.

L	Latitude	Longitude	Sampled species
55	32.18864	-2.62186	*Pelophylax saharicus*
56	32.12621	-2.86282	*Cerastes cerastes*
57	32.11620	-2.87504	*Ptyodactylus oudrii*
58	32.10176	-2.89838	*Trapelus boehmei*
59	32.03032	-3.09638	*Acanthodactylus boskianus*, *Stenodactylus sthenodactylus*
60	31.98316	-3.24879	*Uromastyx nigriventris*
61	31.98120	-3.25739	*Lytorhynchus diadema*
62	31.97732	-3.29199	*Trapelus boehmei*, *Varanus griseus*
63	31.97345	-3.27959	*Trapelus boehmei*
64	31.84697	-4.25545	*Pelophylax saharicus*
65	31.28650	-4.31999	*Natrix maura*, *Pelophylax saharicus*
66	31.24722	-4.58440	*Lytorhynchus diadema*, *Stenodactylus sthenodactylus*, *Tropiocolotes algericus*
67	31.15190	-5.42118	*Uromastyx nigriventris*
68	31.14187	-5.39574	*Ptyodactylus oudrii*, *Tarentola deserti*
69	31.13540	-5.39863	*Pelophylax saharicus*, *Ptyodactylus oudrii*
70	31.13250	-5.49071	*Quedenfeldtia moerens*
71	31.12180	-5.38044	*Pelophylax saharicus*
72	31.10227	-5.22929	*Pelophylax saharicus*
73	31.08759	-5.31111	*Ptyodactylus oudrii*
74	31.08033	-6.48831	*Cerastes cerastes*, *Uromastyx nigriventris*
75	31.07354	-6.50827	*Uromastyx acanthinura*
76	30.97855	-6.78016	*Uromastyx acanthinura*
77	30.95561	-7.04385	*Uromastyx acanthinura*
78	31.29064	-7.38161	*Podarcis vaucheri*
79	31.30215	-7.76305	*Amietophrynus mauritanicus*
80	31.20864	-7.85095	*Timon tangitanus*
81	31.20002	-7.85795	*Atlantolacerta andreanskyi*, *Hyla meridionalis*, *Natrix maura*, *Pelophylax saharicus*, *Podarcis vaucheri*, *Quedenfeldtia trachyblepharus*, *Scelarcis perspicillata*

lineage of *E. algeriensis* described in Perera et al. (2012).

Sphaerodactylidae – *Stenodactylus sthenodactylus* (Lichtenstein, 1823). Localities 44, 45, 46, 52, 59, and 66 (Fig. 2B). This is again a taxon that represents a complex of species (Metallinou et al., 2012). Although different lineages occur in Western Sahara, only one appears to be known from the region sampled in this expedition. The distribution of this species is further extended, with two new sample points (localities 52 and 59) showing connectivity between three populations, previously separated by more than 100 km.

Varanidae – *Varanus griseus* (Daudin, 1803). Locality 62. The Desert Monitor possesses a low abundance in Morocco, where it is found near the Algerian border and in southern regions, due to its preference for sandy areas and associated low human densities (Bons & Geniez 1996). The distance from the roadkilled individual located between Bouanane and Boudenib to the nearest previously published location is about 35 km, pointing to connectivity with the eastern populations.

Blanidae – *Blanus tingitanus* Busack, 1988. Localities 4, 7, and 14. Although it is hard to find, primarily due to its secretive habits, three specimens were recorded in separated places, within the province of Tangier-Tetuan. These points consolidate the extensive distribution of this species through this area.

Colubridae – *Lytorhynchus diadema* (Duméril, Bibron & Duméril, 1854). Localities 61 and 66 (Fig. 2E). Despite a higher number of observations in southern Morocco, this snake presents a contrasting pattern in more northern and central regions. The north-easternmost previously known presence was isolated from the southern populations by more than 300 km. With the addition of locality 61, this distance is cut by a third. Another observation point (locality 66) is located about 30 km west of Rissani.

Spalerosophis dolichospilus (Werner, 1923). Localities 45 and 53 (Fig. 2D). Both specimens were observed during night searches. One individual was found 130 km from a previously recorded localization, indicating the occurrence of the species near the Algerian frontier (locality 45). The second observation took place on the road to Figuig, between two distant known populations of the species. All the observations in the East were reported subsequent to Bons & Geniez (1996), highlighting the lack of knowledge regarding species distributions in this region.

Viperidae – *Cerastes cerastes* (Linnaeus, 1758). Localities 56 and 74 (Fig. 2F). One record, situated 20 km off Bouanane, indicates a probable continuation between the populations of central and north-east Morocco. These were separated by over 180 km, but locality 56 is located roughly in the middle of this distance.

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