New observations of amphibians and reptiles in Morocco, with a special emphasis on the eastern region

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ABSTRACT - This study reports the observations of 54 species of amphibians and reptiles obtained during four field surveys to Morocco, including the southern and southeastern regions. Our records reveal a notable expansion of the current distribution range for several species especially in the eastern part of the country, highlighting the need for more intensive sampling within this region.

MOROCCO is one of the most biodiverse regions in north Africa (Bons & Geniez, 1996). It covers a total area of more than 450,000 km^2 (Schlüter, 2006) and has a Mediterranean and sub-saharan climate with mean annual precipitation ranging from 300 to 600 mm (Michard et al., 2008). Morocco shares similar topographic characteristics with Algeria and Tunisia and together they constitute the western Maghreb. However, Morocco differs by its greater geological complexity and higher elevation (Michard et al., 2008), with several mountain systems reaching more than 3000 m ASL, including the highest peak in north Africa (Jbel Toubkal, 4.167 m ASL). Moreover, its proximity to Europe (separated by only 14 km) and its contact during the Messinian stage of the late Miocene (5-6 Mya, Hsü et al., 1973) is fundamental in explaining the richness of amphibians and reptiles of both African and European origins and its high number of endemisms (Bons & Geniez, 1996). In 2006, 12 species of amphibians and 95 species of non-marine reptiles were recognized (Cox et al., 2006). Although this country is one of the best sampled areas of the western Maghreb (Bons & Geniez, 1996; Real et al., 1997; Fahd & Pleguezuelos, 2001; Brito, 2003; Crochet et al., 2004; Guzmán et al., 2007; Harris et al., 2008; Pleguezuelos et al., 2008; García-Muñoz et al., 2009; Ceacero et al., 2010, Harris et al., 2010), there are still some regions in south and southeastern Morocco that have been

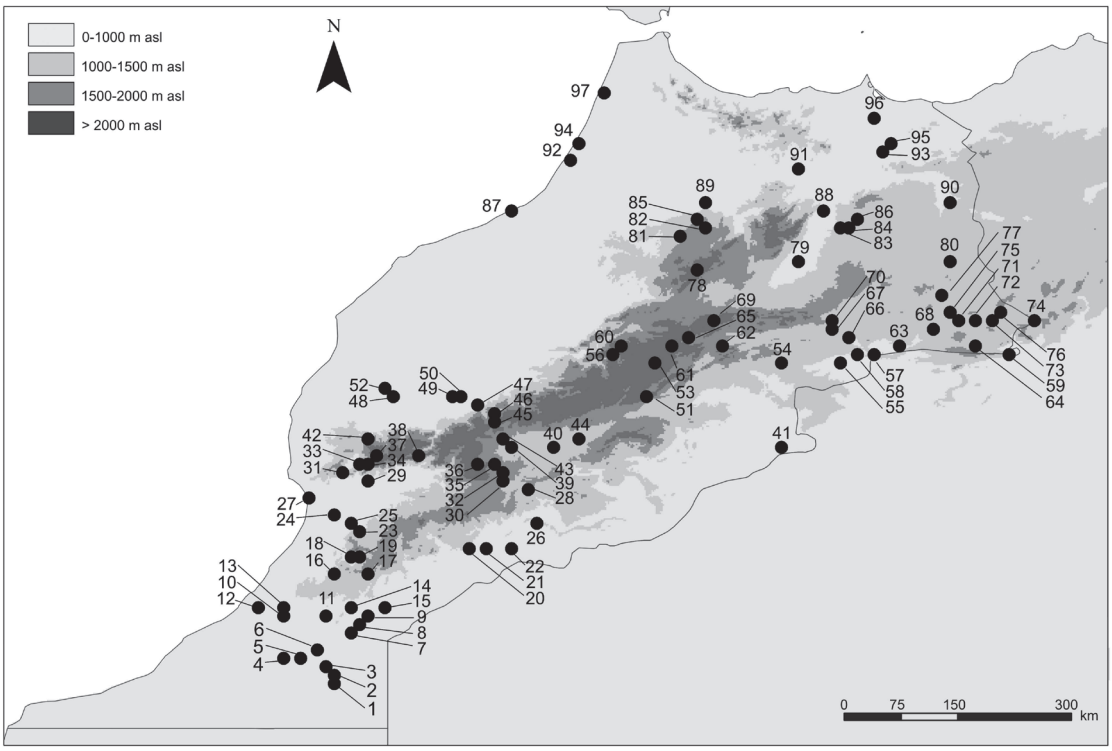

Figure 1. Map of Morocco with the distribution of the sampling localities presented in this study.

poorly surveyed (Bons & Geniez, 1996).

This study compiles the records from three surveys performed in May 2008 and May and July 2009 in central and western Morocco, and one survey in September 2009 in southern (Souss-Massa-Drâ and Guelmim-Es Mara) and southeastern (Oriental and Méknes-Tafilalet) provinces. In total, 342 records of 54 species of amphibians and reptiles from 97 localities were reported (Fig. 1). All specimens found were located with GPS and were identified using morphological characteristics and using the most updated taxonomy. Detailed information on species per locality is given in Table 1 (Appendix) and those species with records of particular interest or that have been subject to recent taxonomical changes are discussed.

AMPHIBIA

ANURA

Bufonidae

Bufo mauritanicus Schlegel 1841 was reported in 17 localities (17, 26, 31, 33, 37, 39, 43, 46, 47, 49, 50, 51, 58, 65, 74, 86 and 97, Table 1). Although considered incertae sedis by Frost et al. (2006), it clearly belongs to the *Amietophrynus* clade (Harris & Perera, 2009). This species, one of the most abundant in Morocco (Bons & Geniez, 1996), was reported in 17 localities mostly associated to wet central regions. However, the finding of individuals further south, in Foum Zguid (locality 26), Bouanane (locality 58) and Ich (locality 74), confirms the existence of isolated populations in the fringes of the Sahara (Bons & Geniez, 1996; Schleich et al., 1996; Brito, 2003; Guzmán et al., 2007). Despite its wide distribution, *B. mauritanicus* exhibits low levels of genetic variation, indicating a recent post-glacial expansion into this region (Harris & Perera, 2009).

Pseudepidalea viridis (Laurenti 1768). Localities 24, 25, 29, 56, 59 and 64 (Table 1). Historically included as a member of the genus *Bufo* prior to Frost et al. (2006), and considered by some authors as *P. boulengeri* (Stöck et al., 2008 but see

Speybroeck et al., 2010), this species is abundant and widespread (Bons & Geniez, 1996), being able to penetrate more than other toads into desert areas.

Ranidae

Pelophylax saharicus (Boulenger 1913). Localities 4, 17, 19, 26, 31, 51, 65 and 66 (Table 1). Previously considered *Rana saharica*, but recently reassigned to the genus *Pelophylax* (Frost et al., 2006; Speybroeck et al., 2010), it displays enormous morphological variation (Bons & Geniez, 1996; Schleich et al., 1996) but minimal mtDNA sequence variation within Morocco (Harris et al., 2003a).

REPTILIA

TESTUDINES

Geoemydidae

Mauremys leprosa (Schweigger 1812). Localities 52 and 95 (Table 1). The study published by Fritz et al. (2006) proposes a reduction in the number of existing subspecies to two, *M. l. leprosa* (Schweigger 1812) and *M. l. saharica* Schleich 1996 distributed across north and south of Morocco respectively and separated by the Atlas mountains.

SQUAMATA

Agamidae

Trapelus mutabilis Merrem 1820. Localities 1, 3, 5, 6, 7, 9, 14, 20 and 73. All localities reported belong to the southern province of Guelmim-Es-Mara with the exception of a single individual found in the Oriental province (locality 73).

Uromastyx acanthinura Bell 1825. Localities 2, 3, 4, 6, 7, 8, 9, 10, 11, 15, 21, 28, 57, 75 and 76. This species, endemic to north Africa was reported in two new localities in the Oriental province, expanding northwards the distribution of the species in the area (localities 57, 75 and 76).

Chamaeleonidae

Chamaeleo chamaeleon (L. 1758). Localities: 33, 42 and 66. Individuals found in Ksar Morhel (locality 66) indicate, for the first time, the presence of this species in the southern area of the Oriental province (Bons & Geniez, 1996). In total, three individuals, a male and two females (one of them gravid) were found. With the finding of an eastern Mediterranean haplotype in Tunisia and other distinct haplotypes in western Morocco, Dimaki et al. (2008) suggest the existence of a phylogeographic break in northwestern Africa.

Phyllodactylidae

Tarentola mauritanica (L. 1758). Localities 34 and 52. Recent molecular studies show the complexity of this group, with multiple highly divergent genetic lineages across Morocco (Harris et al., 2004; Rato et al., 2010) that do not match current subspecific taxonomy.

Tarentola deserti Boulenger 1891. Localities 57, 58, 59, 71 and 76 (Table 1 and Fig. 2A). Fieldwork in the Oriental province resulted in new locations (localities 57, 58, 71 and 76) linking the two known distribution areas for this species in Morocco: the triangle Tinerhir-Boudenib-Taouz, that holds the bulk of the distribution (Bons & Geniez, 1996) and the isolated localities in Figuig (locality 59 and Bons & Geniez, 1996). All specimens were confirmed genetically (Perera, pers. comm.).

Ptyodactylus oudrii Lataste 1880. Localities 30, 57 and 65. A recent study concerning the genetic variation of the fan-footed gecko in Morocco reported very high divergence levels among the populations from eastern Atlas, western Atlas and Antiatlas, suggestive of cryptic species (Perera & Harris, 2010). New records in Beni Yatti (locality 57) expand its distribution more than 50 km eastwards.

Sphaerodactylidae

Quedenfeldtia trachyblepharus (Boettger 1874). Locality 35. This Moroccan endemism can be found at altitudes up to 4000 m (Bons & Geniez, 1996). Individuals from Jbel Siroua region, considered as "indeterminated" by Bons & Geniez (1996) were confirmed as *Q. trachyblepharus* (Locality 35).

Quedenfeldtia moerens (Chabanaud 1916). Localities 12, 34, 37, 38, 53 and 61. This endemic, not so restricted to high altitudes as *Q. trachyblepharus* (10-2700 m altitude), is widely distributed across the High Atlas, Antiatlas, Jbel

Ouarkik and near the Middle Atlas, reaching coastal habitats (Bons & Geniez, 1996). "Indeterminated" individuals from Agoudal (Bons & Geniez, 1996) were identified as *Q. moerens* (locality 53).

Stenodactylus sthenodactylus (Lichtenstein 1823). Locality 64 (Table 1 and Fig. 2B). The finding of two individuals in Jboub Zoulai, more than 150 km from other known localities in Morocco (Bons & Geniez, 1996) suggest a possible relationship with the closer Algerian populations (Sindaco & Jeremcenko, 2008).

Saurodactylus mauritanicus (Duméril & Bibron 1836). Localities 91 and 96 (Table 1). This small gecko is distributed across northeast Morocco and north of Algeria (Sindaco & Jeremcenko, 2008). The finding of an individual near Irhoudane (Locality 91) expands 70 km southwest the current known distribution for *S. mauritanicus* in Morocco.

Saurodactylus fasciatus Werner 1931. Locality 89 (Table 1). This endemic, associated to stony areas in north and west of the Atlas system and southwest of the Rif, has a distribution limited to fewer than 40 localities across its range (Bons & Geniez, 1996; Harris et al., 2008; Harris et al., in press). This new observation expands south the distribution of the eastern populations by 20 km.

Lacertidae

Scelarcis perspicillata (Duméril & Bibron 1839). Localities 34 and 78. This climbing lizard extends across the middle and high Atlas regions, mostly associated with water sources and abundance of cliffs or rocks. Although there are three described subspecies (*S. p. perspicillata* (Duméril & Bibron 1839), *S. p. chabanaudi* (Werner 1931) and *S. p. pellegrini* (Werner 1929)) recognisable by their colour pattern, molecular studies do not show direct congruence between external pattern and genetic lineages (Harris et al., 2003b; Perera et al., 2007). The finding of individuals identified morphologically as *S. p. pellegrini* in Tasguint (locality 34) expands its current known distribution 40 km westwards in the High Atlas. The species was found coexisting with *Q. moerens* and *T. mauritanica.*

Acanthodactylus erythrurus lineomaculatus Duméril & Bibron 1839. Localities 94 and 97. Recent molecular analyses do not support the specific differentiation of *A. e. lineomaculatus* (Schinz, 1838) and *A. e. belli* Gray 1845, indicating that both morphotypes are probably ecotypical adaptations to different habitats (Fonseca et al., 2009).

Acanthodactylus boskianus (Daudin 1802). Localities: 1, 2, 64, 66, 70 and 73. This survey to the Oriental recorded two new localities, Jboub Zoulai (locality 64) and Bouarfa (locality 73).

Acanthodactylus pardalis complex: Localities 24 and 71. Two new localities for this group were found, one locality with several individuals identified as *A. busacki* Salvador 1982 in Imi Mqoum (locality 24) and another in Bouarfa (locality 71) where individuals were identified as *A. pardalis* Lichtenstein 1823, although this appears genetically to be a species complex (Fonseca et al., 2008).

Scincidae

Chalcides ocellatus (Forskål 1775). Localities 4, 72, 74, 77, 80, 88 and 90 (Table 1 and Fig. 2C). Individuals from the south were identified as *C. o. ocellatus* (Forskål 1775) (locality 4), although specimens observed in the Oriental Province (localities 72, 74, 77 and 80) could not be identified as belonging to the subspecies *C. o. tiligugu* (Gmelin 1789) or *C. o. subtypicus* Werner 1931. Recent studies show high genetic divergences between the southern and northern subspecies (Kornilios et al., 2010), although more studies are needed to confirm this differentiation.

Chalcides manueli Werner 1931. Locality 35. The range of this endemic skink, known only from 8 different localities (Bons & Geniez 1996), four of them near Essaouira, was considerably extended to the east with its recent finding in Jbel Siroua (Harris et al., 2010). Locality 35 confirms the existence of the species in the area. The specimens found were first identified as *C. montanus* (also reported for this area) because of the striped coloration, very different from the homogeneous pattern

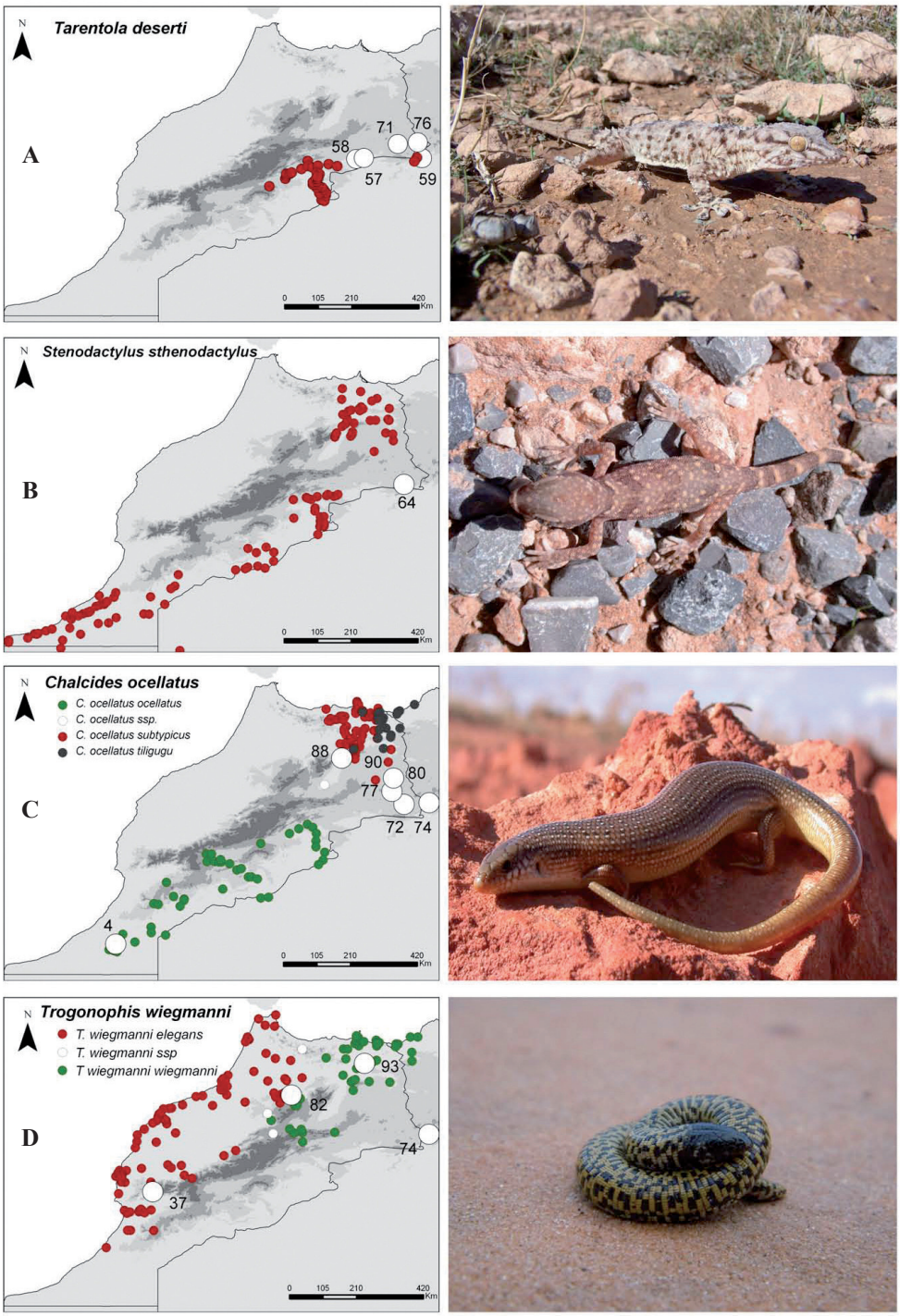

Figure 2. Distribution map and photographs of A) *Tarentola deserti*, B) *Stenodactylus sthenodactylus*, C) *Chalcides ocellatus,* D) *Trogonophis wiegmanni.* Color dots represent published observations (Bons and Geniez, 1996; Guzmán et al., 2007; Harris et al., 2008; Harris et al., 2010) and white dots show new localities included in this study.

typical for *C. manueli* (Bons & Geniez, 1996). However, despite the morphological patterns observed, individuals were confirmed genetically as *C. manueli* using DNA sequencing (Barata, pers. comm.).

Trogonophidae

Trogonophis wiegmanni Kaup 1830. Localities 37, 74, 82 and 93 (Table 1 and Fig. 2D). This endemic to the Maghreb is distributed across the humid, semihumid, arid and semiarid climates (Bons & Geniez, 1996) previously suggested to not exceed 1900 m altitude (Bons & Geniez, 1996). Two subspecies are recognized, *T. w. wiegmanni* (Kaup 1830) in the western, and *T. w. elegans* (Gervais 1835) in the eastern region, morphologically distinguishable and genetically distinct (Mendonça & Harris, 2007). The finding of an adult in Jbel Aoulime (locality 37), at 2084 m altitude, represents a new high altitude register for this species. On the other side, the finding of an individual in Ich oasis (locality 74) indicates for the first time the presence of this species in the south of the Oriental province geographically well separated from other Moroccan populations, but close to western Algerian ones (Sindaco & Jeremcenko, 2008).

Leptotyphlopidae

Leptotyphlops macrorhynchus (Jan 1861). Locality 57 (Fig. 3A). With only 11 localities reported for this species in Morocco, this is one of the rarest snakes in the country. An individual was found in Beni Yatti, 65 km northeast of the previous known distribution range (Bons & Geniez, 1996).

Colubridae

Scutophis moilensis (Reuss 1834). Localities 6, 43, 54, 55, 63 and 68 (Table 1 and Fig. 3F). New localities extend the range across the south of the Oriental province, being found between Boudenib and Figuig where it was previously thought to be absent (Bons & Geniez, 1996).

Psammophis schokari (Forskål 1775). Localities 2, 6, 19, 36, 55, 58, 79, 83 and 84. Although various colour patterns exist (Bons & Geniez, 1996) these do not show corresponding mtDNA genetic differentiation within Morocco (Rato et al., 2007).

Spalerosophis dolichospilus (Werner 1923). Localities 67 and 71 (Fig. 3C). This snake is restricted to the pre-Saharan regions of Morocco, Algeria and Tunisia (Pasteur 1967; Bons & Geniez, 1996). Two new records in Ait Yakoub (locality 67) and Bouarfa (locality 71) represent the first two observations of this species on the oriental province and expand its known distribution considerably in Morocco.

Telescopus tripolitanus (Werner 1909). Locality 59 (Fig. 3D). Previously named *Telescopus dhara* (Crochet et al., 2008) it was discovered for the first time in Morocco only in 1989 (Böhme et al., 1989). It remains one of the least reported snakes in Morocco, with only 5 known localities restricted to the Moroccan pre-Sahara (Bons & Geniez, 1996). One individual, with black head and light brownish/orange colour and darker bands across its body (Fig. 3D) was found in Figuig during a crepuscular survey.

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REFERENCES

Böhme,W., Schmitz, G. & Messer, J. (1989). Erster nachweis der gattung *Telescopus* für die schlangenfauna Marokkos. *Salamandra* **25**, 73-76.

Bons, J. & Geniez, P. (1996). *Anfibios y Reptiles de Marruecos (incluido el Sahara Occidental): Atlas biogeográfico – Amphibiens et Reptiles du Maroc (Sahara Occidental Compris)*. Barcelona: Asociación Herpetológica Española.

Brito, J.C. (2003). Observations of amphibians and reptiles from north and west Africa - Morocco, Mauritania and Senegal. *Bol. Asoc. Herp. Esp.* **14**, 2-6.

Ceacero, F., García-Muñoz, E., Pedrajas, L., Perera, A. & Carretero, M.A. (2010). *Tarentola* and other gekkonid records from Djbel Ouarkziz (Morocco). *Acta Herpetol.* **5**, 13-17.

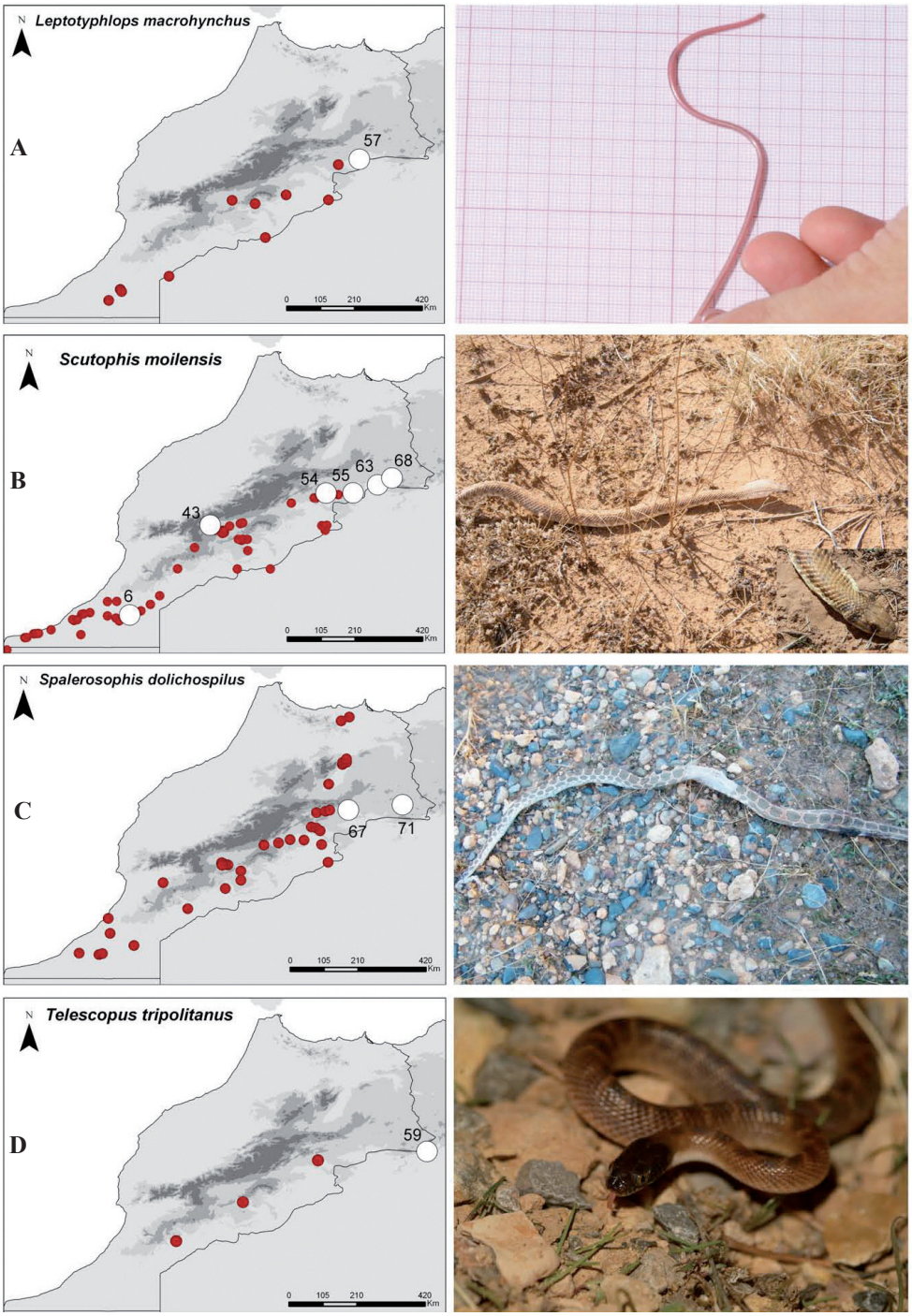

Figure 3. Distribution map and photographs of A) *Leptotyphlops macrohynchus*, B). *Scutophis moilensis*, C) *Spalerosophis dolichospilus*, D) *Telescopus tripolinanus*. Colour dots represent published observations (Bons & Geniez, 1996; Guzmán et al., 2007; Harris et al., 2008; Harris et al., 2010) and white dots show new localities included in this study.

Cox, N., Chanson, J. & Stuart, S. (Compilers) (2006). *The Status and Distribution of Reptiles and Amphibians of the Mediterranean Basin*. Switzerland and Cambridge: IUCN, Gland.

Crochet, P.-A., Sweet, S.S. & Mateo, J.A. (2004). Recent records of the rare *Psammodromus microdactylus* (Boettger, 1881) in Morocco. *Herpetozoa* **17**, 184-186.

Crochet, P.-A., Rasmussen, J.B., Wilms, T., Geniez, P., Trape, J.-F. & Böhme, W. (2008). Systematic status and correct nomen of the western north African cat snake: *Telescopus tripolitanus* (Werner, 1909) (Serpentes: Colubridae), with comments on the other taxa in the dhara-obtusus group. *Zootaxa* **1703**, 25-46.

Dimaki, M., Hundsdörfer, A.K. & Fritz, U. (2008). Eastern Mediterranean chameleons (*Chamaeleo chamaeleon,* Ch. *africanus*) are distinct. *Amphibia-Reptilia* **29**, 535-540.

Fahd, S. & Pleguezuelos, J.M. (2001). Los reptiles del Rif (Norte de Marruecos), II : anfisbenios y ofidios. Comentarios sobre la biogeografía del grupo. *Rev. Esp. Herp*. **15**, 13-36.

Fonseca, M.M., Brito, J.C., Paulo, O.S., Carretero, M.A. & Harris, D.J. (2009). Systematic and phylogeographical assessment of the *Acanthodactylus erythrurus* group (Reptilia: Lacertidae) based on phylogenetic analyses of mitochondrial and nuclear DNA. *Mol. Phylogenet. Evol.* **51**, 131-142.

Fonseca, M.M., Brito, J.C., Rebelo, H., Kalboussi, M., Larbes, S., Carretero, M.A. & Harris, D.J. (2008). Genetic variation among spiny-footed lizards in the *Acanthodactylus pardalis* group from north Africa. *Afr. Zool.* **43**, 8-15.

Fritz, U., Barata, M., Busack, S.D., Fritzsch, G. & Castilho, R. (2006). Impact of mountain chains, sea straits and peripheral populations on genetic and taxonomic structure of a freshwater turtle, *Mauremys leprosa* (Reptilia, Testudines, Geomydidae). *Zool. Scr.* **35**, 97-108.

Frost, D., Grant, T., Faivovich, J., Bain, R., Haas, A., Haddad, C., De Sá, R., Channing, A., Wilkinson, M., Donellan, S.C., Raxworthy, C.J., Campbell, J.A., Blotto, B.L., Moler, P., Drewes, R.C., Nussbaum, R.A., Lynch, J.D., Green, D.M. & Wheeler, W.C. (2006). The amphibian tree of life. *Bull. Am. Mus. Nat. Hist.* **297**, 1-291.

García-Muñoz, E., Ceacero, F. & Pedrajas, L. (2009). Notes on the reproductive biology and conservation of *Pseudoepidalea brongersmai. Herpetol. Notes* **2**, 231-233.

Guzmán, J., Ceacero, F. & García-Muñoz, E. (2007). Nuevas citas de anfibios y reptiles en Marruecos. *Munibe* **25**, 82-87.

Harris, D.J. & Perera, A. (2009). Phylogeography and genetic relationships of north African *Bufo mauritanicus* Schlegel, 1841 estimated from mitochondrial DNA sequences. *Biologia* **64**, 356-360.

Harris, D.J., Batista, V. & Carretero, M.A. (2003a). Diversity of 12s mitochondrial DNA sequences in Iberian and north-west African water frogs across predicted geographic barriers. *Herpetozoa* **16**, 81-83.

Harris, D.J., Batista, V., Carretero, M.A. & Ferrand, N. (2004). Variation in *Tarentola mauritanica* (Reptilia: Gekkonidae) across the Strait of Gibraltar. *Amphibia-Reptilia* **25**, 451-459.

Harris, D.J., Carretero, M.A., Brito, J.C., Kaliontzopoulou, A., Pinho, C., Perera, A., Vasconcelos, R., Barata, M., Barbosa, D., Batista, V., Carvalho, S., Fonseca, M.M., Pérez-Lanuza, G. & Rato, C. (2008). Data on the distribution of the terrestrial herpetofauna of Morocco: records from 2001-2006. *Herpetol. Bull.* **103**, 19-28.

Harris, D.J., Carretero, M.A., Perera, A. & Ferrand, N. (2003b). Complex patterns of genetic diversity within *Lacerta* (*Teira*) *perspicillata*: Preliminary evidence from 12S rRNA sequence data. *Amphibia-Reptilia* **24**, 386-390.

Harris, D.J., Perera, A., Barata, M., Tarroso, P. & Salvi, D. (2010). New distribution notes for terrestrial herpetofauna from Morocco. *North-West J. Zool.* **6**, 309-315.

Hsü, K.J., Ryan, W.B.F. & Cita, M.B. (1973). Late Miocene desiccation of the Mediterranean. *Nature* **242**, 240–244.

Kornilios, P., Kyriazi, P., Poulakakis, N., Kumlutaş, Y., Ilgaz, C., Mylonas, M. & Limberakis, P. (2010). Phylogeography of the ocellated skink *Chalcides ocellatus* (Squamata, Scincidae), with

the use of mtDNA sequences: a hitch-hiker's guide to the Mediterranean. *Mol. Phylogenet. Evol.* **54**, 445-456.

Mendonça, B. & Harris, D.J. (2007). Genetic variation within *Trogonophis wiegmanni* Kaup 1830. *Belg. J. Zool.* **137**, 239-242.

Michard, A., Saddiqi, O., Chalouan, A. & Frizon de Lamotte, D. (2008). *Continental Evolution: the Geology of Morocco. Structure, Stratigraphy, and Tectonics of the African-Atlantic-Mediterranean Triple Junction.* Berlin Heidelberg: Springer.

Pasteur, G. (1967). Un serpent endémique du Maghreb: *Spalerosophis dolichospilus* (Werner), Colubridé. *Bull. Mus. Nat. Hist. Nat. Paris 39*, 444-451.

Perera, A. & Harris, D.J. (2010). Genetic variability within the Oudri's fan-footed gecko *Ptyodactylus oudrii* in north Africa assessed using mitochondrial and nuclear DNA sequences. *Mol. Phylogenet. Evol.* **54**, 634-639.

Perera, A., Vasconcelos, R., Harris, D.J., Brown, R.P., Carretero, M.A. & Pérez-Mellado, V. (2007). Complex patterns of morphological and mtDNA variation in *Lacerta perspicillata* (Reptilia; Lacertidae). *Biol. J. Linn. Soc.* **90**, 479-490.

Pleguezuelos, J.M., Fahd, S. & Carranza, S. (2008). El papel del Estrecho de Gibraltar en la conformación de la actual fauna de anfibios y reptiles en el Mediterráneo Occidental. *Bol. Asoc. Herp. Esp.* **19**, 2-17.

Rato, C., Brito, J.C., Carretero, M.A., Larbes, S., Shacham, B. & Harris, D.J. (2007). Phylogeography and genetic diversity of *Psammophis schokari* (Serpentes) in north Africa based on mitochondrial DNA sequences. *Afr. Zool.* **42**,112-117.

Rato, C., Carranza, S., Perera, A., Carretero, M.A. & Harris, D.J. (2010). Conflicting patterns of nucleotide diversity between mtDNA and nDNA in the Moorish gecko, *Tarentola mauritanica. Mol. Phylogenet. Evol.* **56**, 962-971.

Real, R., Pleguezuelos, J.M. & Fahd, S. (1997). The distribution patterns of reptiles in the Riff region, northern Morocco. *Afr. J. Ecol.* **35**, 312-325.

Schleich, H.H., Kästle, W. & Kabisch, K. (1996). *Amphibians and Reptiles of North Africa.* Koenigstein: Koeltz Scientific Books.

Schlüter, T. (2006). Geological Atlas of Africa: with Notes on Stratigraphy, Tectonics, Economic Geology, Geohazards and Geosites of each Country. Berlin: Springer.

Sindaco, R. & Jeremcenko, V.K. (2008). The reptiles of the Western Palearctic. 1. Annotated checklist and distributional atlas of the turtles, crocodiles, amphisbaenians and lizards of Europe, north Africa, Middle East and central Asia. Belvedere & Societas Herpetologica Italica.

Speybroeck, J., Beukema, W. & Crochet, P. (2010). A tentative species list of the European herpetofauna (Amphibia and Reptilia) - an update. *Zootaxa* **2492**, 1-27.

Stöck, M., Sicilia, A., Belfiore, N., Buckley, D., Lo Brutto, S., Lo Valvo, M. & Arculeo, M. (2008). Post-Messinian evolutionary relationships across the Sicilian channel: mitochondrial and nuclear markers link a new green toad from Sicily to African relatives. *BMC Evol. Biol.* **8**, 56.

APPENDIX

Table 1. Localities sampled in this study. For each locality, GPS coordinates (WGS84 decimal degrees) and list of the species found is given.

Local nº	Locality	Lat.	Long.	Species found
1	20 km north Zag	28.21	-9.30	*A. boskianus, T. mutabilis*
2	5 km south Tistguezzemtz	28.29	-9.34	*A. boskianus, C. cerastes, P. schokari, U. acanthinura*
3	Tistguezzemtz	28.41	-9.41	*A. impalearis, C. cerastes, T. mutabilis, U. acanthinura*
4	Aouinet Torkoz	28.53	-9.86	*C. ocellatus, H. algirus, M. guttulata, P. saharicus, S. boulengeri, U. acanthinura*

5	Between Aouinet Torkoz/Tadachacht	28.49	-9.65	*T. mutabilis*
6	Near Assa	28.57	-9.50	*A. impalearis, C. cerastes, S. moilensis, P. schokari, T. mutabilis, U. acanthinura*
7	Near Tanezida	28.77	-9.11	*T. mutabilis, U. acanthinura*
8	Between Tanezida	28.89	-8.99	*U. acanthinura*
9	Foum el Hassane	28.99	-8.91	*T. mutabilis, U. acanthinura*
10	5 km north Taourirt Doubiane	28.98	-9.90	*U. acanthinura*
11	Nr. Taghjicht/ Bouizakarne	29.05	-9.35	*U. acanthinura*
12	Gorges nr Guelmin	29.07	-10.25	*E. algeriensis, Q. moerens*
13	N1 Ouaoutelt	29.09	-9.89	*S. brosseti*
14	Bouizakarne	29.11	-9.14	*T. mutabilis*
15	Between Tizgui/Icht	29.07	-8.70	*U. acanthinura*
16	Kerdous	29.55	-9.33	*A. impalearis*
17	10 km north Aguerd Imelal	29.54	-8.87	*B. mauritanicus, P. saharicus*
18	Near Aimou road	29.65	-9.06	*A. impalearis*
19	3 km north Ayerd	29.67	-8.96	*A. impalearis, P. schokari, P. saharicus, S. brosseti*
20	2 km west Akka Iguirene	29.76	-7.73	*T. mutabilis*
21	Kasba El Joua	29.85	-7.47	*A. impalearis, U. acanthinura*
22	N12 Mrimina	29.81	-7.20	*N. maura*
23	4 km north Ifrhel	29.96	-9.01	*A. impalearis, S. brosseti*
24	4 km n.Imi Mqoum	30.18	-9.28	*A. busacki, P. viridis, S. brosseti, S. sphenopsiformis*
25	Ait Baha Barragem	30.06	-9.12	*A. impalearis, P. viridis*
26	Foum Zguid	30.09	-6.88	*B. mauritanicus, P. saharicus, T. boehmei*
27	Agadir	30.42	-9.61	*A. aureus, S. sphenopsiformis*
28	North Foum Zguid	30.49	-7.00	*U. acanthinura*
29	Taurodant-Tasguint	30.63	-8.91	*P. viridis*
30	Tazenakht	30.63	-7.27	*P. oudrii*
31	10 km sth Argana	30.74	-9.18	*B. mauritanicus, P. saharicus*
32	N10 to Anezal	30.71	-7.29	*M. mauritanica*
33	Near Argana	30.84	-8.99	*B. mauritanicus, C. chamaeleon*
34	Tasguint	30.78	-8.86	*Q. moerens, S. perspicillata, T. mauritanica*
35	Road to Jbel Siroua	30.79	-7.59	*H. meridionalis, A. erythrurus, C. manueli, A. andreanskyi, T. tangitanus, P. vaucheri, Q. trachyblepharus*
36	West Anezal	30.78	-7.37	*P. schokari*
37	Jbel Aoulime	30.89	-8.81	*A. impalearis, B. mauritanicus, Q. moerens, T. wiegmanni*
38	Tasguint	30.91	-8.31	*Q. moerens*
39	Near Agadir	30.97	-7.22	*B. mauritanicus, C. cerastes, M. mauritanica*
40	N10 n. Ouarzazate	30.98	-6.74	*M. guttulata*
41	Jboub Zoulal	31.01	-4.00	*M. rubropunctata*
42	Talaint N8	31.10	-8.94	*C. chamaeleon, S. brosseti*
43	Afela n'lsly	31.07	-7.26	*B. mauritanicus, S. moilensis*
44	Skoura N10	31.10	-6.43	*M. cucullatus*
45	Taddert	31.30	-7.41	*A. andreanskyi, P. vaucheri*
46	N9-Ait Mannsour	31.39	-7.40	*B. mauritanicus*
47	Tasrhimout	31.55	-7.60	*B. mauritanicus*
48	Mzouda N8	31.58	-8.55	*A. erythrurus, C. mionecton, S. brosseti*
49	N9 s. Marrakech	31.59	-7.92	*B. mauritanicus*
50	Oulad el Guern	31.58	-7.82	*B. mauritanicus*
51	Gorges du Todra	31.59	-5.59	*B. mauritanicus, P. saharicus*
52	Near Sidi-Chikér	31.75	-8.74	*C. polylepis, M. leprosa, S. brosseti, T. mauritanica*
53	Agoudal	31.97	-5.49	*A. erythrurus, T. tangitanus, P. vaucheri, Q. moerens*
54	Near Tazzouguert	31.97	-4.02	*S. moilensis*
55	Belibilia	31.98	-3.27	*S. moilensis, P. schokari*

56	Road to Imilchil	32.10	-5.95	*P. viridis*
57	Beni Yatti	32.09	-3.10	*L. macrorhynchus, P. oudrii, T. deserti, U. acanthinura*
58	Near Bouanane	32.11	-2.88	*B. mauritanicus, P. schokari, T. deserti, T. tripolitanus*
59	Figuig	32.11	-1.25	*P. viridis, T. deserti, T. tripolitanus* (*T. dhara*)
60	Jebel Morrik	32.18	-5.88	*P. vaucheri*
61	Road Imilchil-Rich	32.17	-5.34	*P. vaucheri, Q. moerens*
62	Rich	32.22	-4.68	*H. hippocrepis*
63	Near Ain Chair	32.20	-2.59	*S. moilensis*
64	Jboub Zoulai	32.24	-1.72	*A. boskianus, P. viridis, S. sthenodactylus*
65	Jbel Aderdouz	32.26	-5.15	*B. mauritanicus, H. hippocrepis, N. maura, P. algirus, P. oudrii, P. saharicus*
66	Ksar Morhel	32.25	-3.18	*A. boskianus, C. chamaeleon, P. saharicus*
67	Ait Yakoub	32.36	-3.44	*S. dolichospilus*
68	N10 to Mengoub	32.39	-2.19	*S. moilensis*
69	Cirque de Jafar	32.54	-4.79	*A. andreanskyi*
70	Talsint	32.49	-3.41	*A. boskianus, A. impalearis, N. maura*
71	N17 to Bouarfa	32.51	-1.93	*A. pardalis, S. dolichospilus, T. deserti*
72	N17-Jboub Zoulai	32.48	-1.72	*C. ocellatus*
73	N17 to Bouarfa	32.51	-1.50	*A. boskianus, T. mutabilis*
74	Ich	32.52	-1.01	*A. impalearis, B. mauritanicus, C. ocellatus, T. wiegmanni*
75	Bouarfa	32.57	-2.02	*A. impalearis, U. acanthinura*
76	N18 to El Mlalih	32.56	-1.37	*C. cerastes, T. deserti, U. acanthinura*
77	Bouarfa	32.84	-2.07	*C. ocellatus*
78	Lake Aguelmame Sidi Ali	33.07	-5.01	*T. tangitanus, N. maura, P. vaucheri, S. perspicillata*
79	Teggour	33.24	-3.83	*P. schokari*
80	N17 to Tendara	33.21	-2.02	*C. ocellatus*
81	R707 to Ifrane	33.54	-5.16	*C. lanzai*
82	Imouzzer Kandar	33.63	-4.90	*A. erythrurus, T. tangitanus, P. vaucheri, P. algirus, T.wiegmanni*
83	Bouloutane	33.58	-3.33	*A. impalearis, P. schokari*
84	Bouloutane	33.57	-3.21	*P. schokari*
85	Imouzzer Kandar	33.66	-5.04	*T. tangitanus, P. vaucheri*
86	El Hamar	33.71	-3.05	*B. mauritanicus*
87	Between Casablanca/ Rabat	33.78	-7.23	*E. algeriensis, N. maura*
88	N15 to Zerzaia	33.78	-3.48	*C. ocellatus, E. algeriensis*
89	Sefrou	33.85	-4.86	*S. fasciatus, T. graeca*
90	Near Ain Benimathar	33.89	-2.02	*C. ocellatus*
91	N6 to Irhoudane	34.25	-3.85	*S. mauritanicus*
92	A1 to Akbate	34.43	-6.52	*H. hippocrepis*
93	N6-Moulay Bagdad	34.52	-2.84	*T. wiegmanni*
94	El Behara	34.65	-6.41	*A. e. lineomaculatus*
95	N7-Moulay Bagdad	34.57	-2.73	*M. leprosa*
96	N19-Oulad Bouihia	34.94	-2.88	*S. mauritanicus*
97	Larache	35.17	-6.12	*A. e. lineomaculatus, B. tingitanus, B. mauritanicus, M. cucullatus, T. graeca*