

## Rapid Communication

**Alien but not that one: a molecular reassessment of the Alborán Island's *Saurodactylus* Fitzinger, 1846 gecko**Catarina Rato<sup>1,2,\*</sup>, Lekshmi B. Sreelatha<sup>1,2,3</sup>, José A. Mateo<sup>4</sup> and Miguel A. Carretero<sup>1,2,3</sup><sup>1</sup>CIBIO – Research Centre in Biodiversity and Genetic Resources, Universidade do Porto, Campus de Vairão, Rua Padre Armando Quintas 7, 4485-661 Vila do Conde, Portugal<sup>2</sup>BIOPOLIS Program in Genomics, Biodiversity and Land Planning, CIBIO, Campus de Vairão, 4485-661 Vairão, Portugal<sup>3</sup>Department of Biology, Faculty of Sciences of the University of Porto, Rua do Campo Alegre, 4169-007 Porto, Portugal<sup>4</sup>Black Market. Cl. Paraires, 23. 07001 Palma de Mallorca, Spain

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**Citation:** Rato C, Sreelatha LB, Mateo JA, Carretero MA (2023) Alien but not that one: a molecular reassessment of the Alborán Island's *Saurodactylus* Fitzinger, 1846 gecko. *BioInvasions Records* 12(1): 313–320, <https://doi.org/10.3391/bir.2023.12.1.28>

**Received:** 24 March 2022**Accepted:** 6 August 2022**Published:** 21 November 2022**Handling editor:** Yik Hei Sung**Thematic editor:** Tim Adriaens**Copyright:** © Rato et al.

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**Abstract**

Alborán Island is located in the centre of the Alboran Sea in the Western Mediterranean, between the Iberian Peninsula and North Africa. Due to its geostrategic position and rich fishing grounds, this island has been frequently visited by humans throughout history from both coasts of the Alborán Sea, leading to the accidental introduction of many reptile species. However, during one field expedition a few specimens morphologically identified as *Saurodactylus mauritanicus* geckos were found at several areas of the island and considered as native to the region. This classification carried several nomenclature and conservation consequences to both species and Alborán Island. To clarify the taxonomic identification of the specimens found in Alborán and to evaluate its alien status in the island, we assessed its phylogenetic relationships among all *Saurodactylus* taxa under a mitochondrial genetic approach. We found that the sequenced specimen from Alborán, clusters with individuals of the *S. fasciatus* clade, instead of *S. mauritanicus*. Hence, this study does not support the proposed nomenclature change, neither the species nor the island's conservation status based solely on *S. fasciatus* from Alborán.

**Key words:** phylogeny, conservation, mtDNA, reptile, human introduction**Introduction**

The deliberate or accidental introduction of new species to areas outside their native range has been taking place over millennia. The reshuffling of species ranges is in some cases so great, that it becomes uncertain what is the geographic origin of the introduced taxa. Fortunately, the routine procedure of molecular tools has led to a shift from a purely phenotypic approach to the inclusion of molecular characters in the investigation of the evolutionary history, and invasion pathways of taxa (e.g., Rato et al. 2021a, b; Silva-Rocha et al. 2015).

The Mediterranean region, in particular, has one of the longest histories of human settlements and trade, as well as of interaction between humans and biodiversity, with multiple biological introductions occurring over

thousands of years (Blondel et al. 2010). In that sense, and at least for reptiles, humans have been key drivers for their dispersal on Mediterranean islands (Silva-Rocha et al. 2019). However, their distributions are determined by a complex interplay between human activities, geographic factors and species features (Silva-Rocha et al. 2019).

Although largely sedentary, reptiles are frequently introduced by humans during transport of building material, soil or cultivated plants (Kraus 2009). Islands, in particular, are not hosting a large number of alien reptiles (Pitt et al. 2005), which are among the most successful and abundant vertebrates in small islands (Novosolov et al. 2016). Moreover, small islands appear to be more prone to be successfully invaded than larger land masses (references in Kraus 2009). Besides, insular regions where biota have evolved within simplified ecosystems with few biological interactions, are especially prone to appearance and extinction of endemic taxa, while invasion episodes are often repeated (Whittaker and Fernández-Palacios 2007).

The Alborán Island (35°56'24"N; 3°02'04"W) is located in the centre of the Alborán Sea Western Mediterranean, 85 km from Punta Entinas (Spain) and 55.5 km from Cabo Tres Forcas (Morocco), the two closest continental shores in the enclave (Figure 1). This small volcanic island is only 7.12 ha, with 15 m of maximum altitude, 605 m long and 265 m wide. The emerged part of the island is from the late Early Pleistocene (800,000 years) but the volcanic base is from the Middle-Late Miocene (7–18 Mya). It is surrounded by sea depths of 1,000–2,000 m and has not been connected to the mainland since the Messinian Salinity Crisis, 5–6 Mya (Yus et al. 2013).

Due to its geostrategic position and rich fishing grounds, this island has been frequently visited throughout history by fishermen, pirates, explorers and travellers from both coasts of the Alborán Sea. Hence, the island has maintained an intermittent human presence. Since 1936, the human presence in Alborán has been mainly military and, after several periods of absence (1939–1941, 1964–1967 and 1992–1997), the Alborán Military Detachment became permanent on the island since 1997. However, during the last absence period there were assiduous visits, dockings and repeated landings of ships coming, among other places, from North Africa (Paracuellos et al. 2005; Rubio 2001). Furthermore, in 1997 the enclave became protected as a Marine Reserve and Fishing Reserve, and since 2003 as Natural Area. Such events have meant that, to this day, there are constant movements of cargo shipments between Alborán and, mainly, the south of the Iberian Peninsula transporting personnel, building materials and equipment (Acosta 1996; Cano et al. 2006; Rubio 2001; Salvator 1898; Sola et al. 2006). Not surprisingly, a recent molecular study identified southern Iberia as the source area of the introduced lizard populations of *Tarentola mauritanica*, *Hemidactylus turcicus* and *Podarcis vaucheri* in Alborán Island (Rato et al. 2021a).

Prior to the finding of these introduced reptile species, a few specimens, morphologically identified as the gecko *Saurodactylus mauritanicus*, were recorded under rocks at the northern and southern parts of the island (Barbadillo et al. 1999; Mateo 2002a). These records occurred in 1997 coinciding with the final of the last period when Alborán Island was unoccupied and frequently visited by boats coming from North Africa, suggesting that the introduction was recent (Paracuellos et al. 2005). However, the authors responsible for the discovery of these specimens (1) considered it as native to the island; (2) classified it as threatened and vulnerable to extinction in Andalucía; (3) proposed a change of its common name from “Maghreb gecko” to “Alborán gecko”; and, finally (4) classified Alborán as an important conservation area in Spain, given that it is the only place in Europe where this reptile species is present (Mateo 2001, 2002a, b). Currently, *Saurodactylus* is considered extinct due to the lack of observations during all the intensive and numerous surveys of the island before and after 1997 to date, which instead detected other alien lizards (Paracuellos et al. 2005; M. Paracuellos *pers. com.*).

Geckos of the genus *Saurodactylus*, an extremely old taxon belonging to the Family Sphaerodactylidae (Gamble et al. 2011), are endemic to the Western Maghreb region, encompassing Morocco and Algeria (Figure 1). Before the study from Javanmardi et al. (2019), the genus was composed of three species: *S. mauritanicus* (Duméril and Bribon, 1836), *S. fasciatus* Werner, 1931 and *S. brosetti* Bons and Pasteurs, 1957. However, based on molecular markers and colouration Javanmardi et al. (2019) split the later into five species: *S. brosetti*, *S. elmoudenii*, *S. slimanii*, *S. harrisii*, and *S. splendidus*, resolving the *S. brosetti* species complex. *Saurodactylus mauritanicus* occurs in North-East Morocco and Western Algeria, while all remaining species of the genus have an endemic Moroccan and Western Sahara distribution (Bons and Geniez 1996).

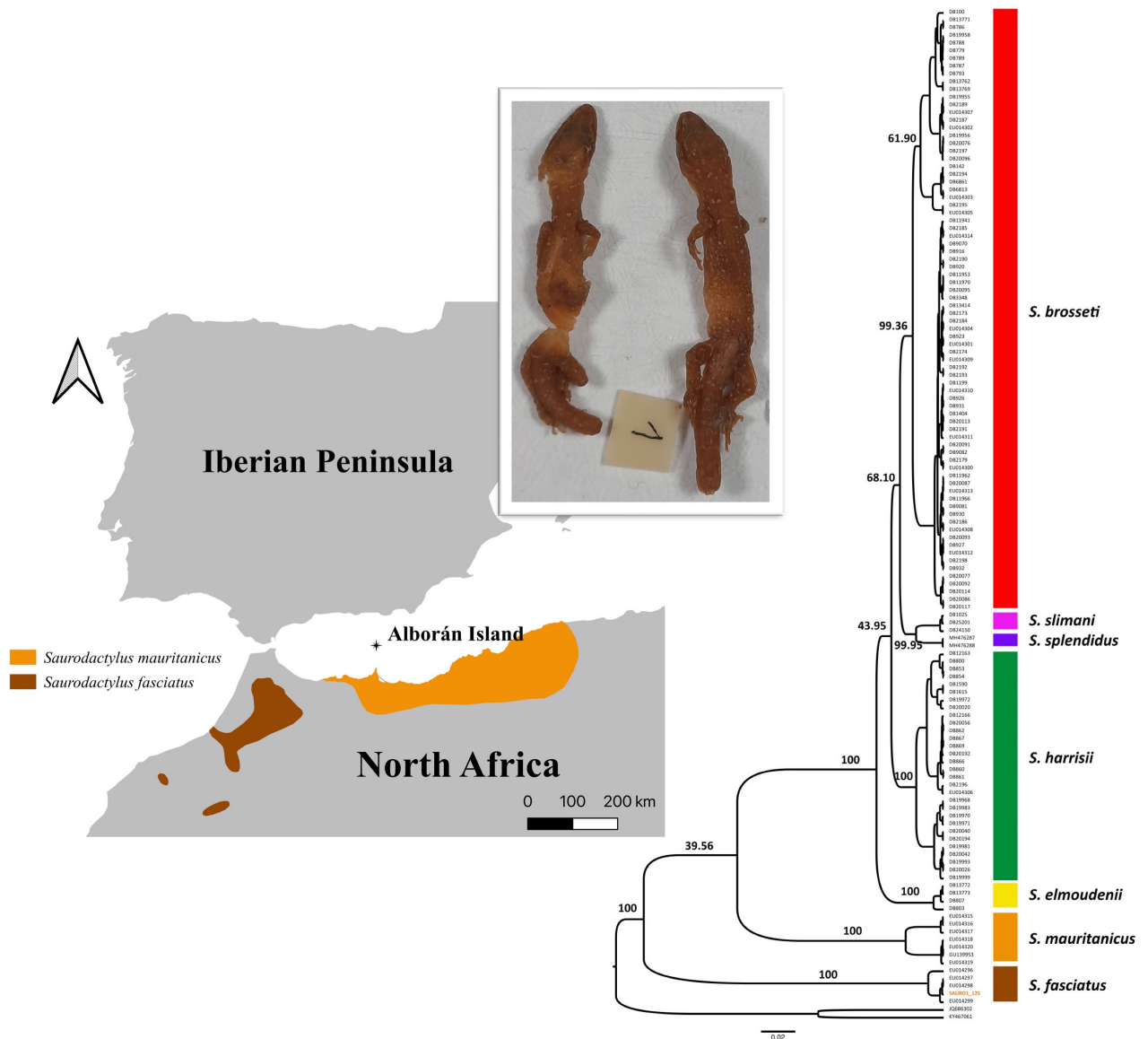
To clarify the taxonomic identification of the specimens found in Alborán Island and to evaluate the alien status in the island, we assessed its phylogenetic relationships among all *Saurodactylus* taxa using a genetic approach.

## Materials and methods

### *DNA extraction, amplification and sequencing*

Two adult specimens identified in the field as *Saurodactylus mauritanicus*, collected in 1997 in Alborán Island (Figure 1) and preserved in 96% ethanol, were examined. Because of the importance of these findings, voucher specimens are currently deposited in loan in the herpetological collection of CIBIO-InBIO, available for examination.

Considering the age of the preserved specimens, genomic DNA was extracted from tail muscle using the DNAeasy Qiagen® extraction kit, following the manufacturer's protocol.



**Figure 1.** Inset map depicting the geographic location of Alborán Island, and the distribution range of both *Saurodactylus mauritanicus* and *S. fasciatus*. The figure with the two specimens corresponds to the original *Saurodactylus* sp. individuals collected in the island in 1997 (Carlos Bazaga Miras leg.), used in this study. On the right is represented the 12SrRNA mitochondrial phylogenetic topology under a Bayesian inference approach (BEAST), using *Quedenfeldtia moerens* as outgroup. The *Saurodactylus* specimen used in this study is highlighted in orange nesting within the *S. fasciatus* clade. Values next to the nodes correspond to posterior probabilities.

This was followed by the amplification of the 12SrRNA gene fragment by Polymerase Chain Reaction (PCR), using the primers 12Sa/12Sb from Kocher et al. (1989). PCR conditions were the same as those described in Harris et al. (1998). After several repeated trials, Sanger amplification was only successful for one of the specimens, which will be the one used in the following analyses (GenBank accession number will be provided after acceptance of the manuscript).

#### Gene genealogies

Additional 12S fragments assigned as *S. mauritanicus*, *S. brosetti* sensu lato and *S. fasciatus* were downloaded from GenBank (Javanmardi et al. 2019;

Rato and Harris 2008; Rosado et al. 2017), as well as two 12S sequences from *Quedenfeldtia moerens*, another member of the Sphaerodactylidae family (Barata et al. 2012; Harris et al. 2017). The obtained sequences were imported into the software Geneious Prime v.2022.0.1 (<https://www.geneious.com>) where alignment was performed with MAFFT v.7.017 (Katoh and Standley 2013), under the default parameters (auto algorithm; scoring matrix = 200PAM/k = 2; gap open penalty = 1.53; and offset value = 0.123).

To determine the genetic affinity of Alborán's *Saurodactylus* specimen, a phylogenetic analysis was carried out under a Bayesian Inference (BI) methodology. To build this genealogy, the sequences of *Q. moerens*, were used as outgroup.

To determine the best fitting nucleotide model to be applied in the BI analysis, the software PartitionFinder v.1.1 was used (Lanfear et al. 2012). Parameters used were *branchlengths* = linked and *modelselection* = BIC.

The BI analysis was performed with the software BEAST v.1.10.4 (Suchard et al. 2018), running the dataset twice for  $10 \times 10^6$  generations with a sampling frequency of 1,000 generations. Models and prior specifications applied were as follows (otherwise by default): GTR substitution model; Strict Clock; Coalescent with Constant Population Size; random starting tree. Convergence for all model parameters was assessed by examining trace plots and histograms in Tracer v.1.7.1 (Rambaut et al. 2018) after obtaining an effective sample size (ESS) > 200. The initial 10% of samples were discarded as burn-in. Runs were combined using LogCombiner, and maximum credibility trees with divergence time means and 95% highest probability densities (HPDs) were produced using Tree Annotator (both part of the BEAST package). Trees were visualized using FigTree v.1.4.4 (Rambaut 2009).

## Results and discussion

The specimen found and collected in Alborán island clusters with the *S. fasciatus* clade (Figure 1), matching in 100% with the closest sequences (EU014297, EU014298) in terms of nucleotide base pairs.

The obtained phylogenetic topology coincides almost entirely with the ones obtained in previous studies (Javanmardi et al. 2019; Rato and Harris 2008); *S. fasciatus* occupies a basal position, with *S. mauritanicus* and the remaining members of the *S. brosetti* species complex as sister taxa. As we only used a single mitochondrial gene fragment, the relationships among the *S. brosetti* species complex are different from Javanmardi et al. (2019), and some of the nodes not that highly supported: the splitting of *S. harrisi* (43.95), and the divergence of *S. slimani* and *S. splendidus* from the remaining taxa (68.10). Nevertheless, the assessment of the phylogenetic relationships within all the *Saurodactylus* genus is not the scope of this study, but the genetic assignment of the individuals found in Alborán island.



Considering the geographic range of each species, it is reasonable to think that the *Saurodactylus* specimens found in Alborán could belong to *S. mauritanicus* and were allochthonous. Moreover, apart from *S. brossei*, which clearly differs morphologically from the other species in terms of head shape, pholidosis and colour pattern, all remaining taxa have a considerable similar morphology (Bons and Geniez 1996; Schleich et al. 1996). Nevertheless, a morphological examination of the two specimens (in poor preservation state), indicates a temporal band with a white edge, apart from 48–50 scales between the eyes, which are both more compatible with *S. fasciatus* and not with *S. mauritanicus* (Schleich et al. 1996).

Moreover, the taxonomic result obtained in this study, raises the question that the discovered *Saurodactylus* specimens analysed here could have been collected from its natural distribution and then mislabelled. This is very unlikely, since the collector of the specimens (Carlos Bazaga, nationality Spanish) was a customs ship pilot, who had no jurisdiction to disembark in a foreign country, such as Morocco. Contacted by the authors, he declared he usually moved through the Alboran Sea, so apart from Alborán Island, the specimen could only have caught in either Melilla or Chafarinas, but in these islands, the recorded species is *Saurodactylus mauritanicus* (Mateo 1997; Vargas and Antúnez 1982). In the remote hypothetical case that the specimens were captured there, it would also be an introduced species.

Overall, the result obtained here is quite unexpected carrying with it conservation implications. When Barbadillo et al. (1999) reported the *Saurodactylus* specimens in Alborán island, apart from identifying it as *S. mauritanicus*, they interpreted the arrival of this species as ancient and naturally driven, considering it as native to the island. These assumptions led to a series of conservation and nomenclature proposals, such as the classification of the species as vulnerable in Spain and the change of the common name from “Maghreb gecko” to “Alborán gecko”, which in turn supported the consideration of Alborán Island as an important conservation area to the herpetology in Spain (Mateo 2001, 2002a, b).

According to the current genetic results, not only we confirm that the specimens from Alborán belong to *S. fasciatus*, but given the high genetic similarity with the closest genetic sequences, the possible arrival to the island is recent and likely human-mediated. Indeed, it could have taken place between 1992 and 1997 when Alborán was abandoned by the Spanish military detachment and illegal ship traffic was common between North Africa (Paracuellos et al. 2005; Rubio 2001).

Hence, this study does not support the proposed nomenclature change, neither the species nor the island's conservation status based solely on *S. fasciatus* from Alborán, something already proposed by Paracuellos et al. (2005). Whatever the case, this is another example suggesting that native, alien or absent biodiversity should be carefully evaluated based on multiple sources of evidence. Other doubtful findings in the biogeographically complex Mediterranean Basin may be still awaiting proper analysis.

## Acknowledgements

The authors would like to thank Carlos Bazaga Miras for assistance during field work and donation of the specimens, and also to the reviewers for their valuable comments to this manuscript.

## Funding declaration

CR is supported by a postdoctoral contract from Fundação para a Ciência e Tecnologia (FCT), Portugal (DL57/2016/CP1440/CT0005). LBS is supported by a doctoral grant from FCT (2021.06600.BD). This work was co-funded via national funds through FCT—Foundation for Science and Technology and EU funds European Regional Development Fund (ERDF) under the project PTDC/BIA-EVL/27958/2017 – POCI-01-0145-FEDER-027958 (to CR). The authors also acknowledge research support in lab work and analysis from the project PTDC/BIA-CBI/28014/2017 – POCI-01-0145-FEDER-028014 (to MAC), co-funded by FCT and FEDER. Moreover, the work was also co-funded by the project NORTE-01-0246-FEDER-000063, supported by Norte Portugal Regional Operational Programme (NORTE2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF).

## Authors' contribution

Catarina Rato: Conceptualization, Methodology, Software, Validation, Formal analysis, Writing – Original Draft, Writing – Review and Editing, Project administration, Funding acquisition. Lekshmi B Sreelatha: Laboratory Work, Writing – Review and Editing. José A. Mateo: Sample collection, Writing – Review and Editing. Miguel A. Carretero: Conceptualization, Writing – Review and Editing, Project administration, Funding acquisition.

## References

- Acosta F (1996) Isla de Alborán. In: Agero J (eds), Almería pueblo a pueblo. Agedime, Mediterráneo, Novotécnica, La Voz de Almería, Madrid, pp 17–24
- Barata M, Perera A, Martínez-Freiria F, Harris DJ (2012) Cryptic diversity within the Moroccan endemic day geckos *Quedenfeldtia* (Squamata: Gekkonidae): a multidisciplinary approach using genetic, morphological and ecological data. *Biological Journal of the Linnean Society* 106: 828–850, <https://doi.org/10.1111/j.1095-8312.2012.01903.x>
- Barbadillo LJ, Lacomba JI, Pérez-Mellado V, Sancho V, López-Jurado LF (1999) Anfibios y Reptiles de la Península Ibérica, Baleares y Canarias. GeoPlaneta, Barcelona, 419 pp
- Blondel J, Aronson J, Bodiou J-Y, Boeuf G (2010) The Mediterranean region: biological diversity in space and time. Oxford University Press, Oxford and New York, 376 pp
- Bons J, Geniez P (1996) Amphibiens et reptiles du Maroc (Sahara occidental compris): atlas biogéographique. Asociación Herpetológica Española, 319 pp
- Cano JA, Sola AJ, Jiménez-Sánchez ML, Pérez-García FJ, Rodríguez-Tamayo ML, Mota JF (2006) Capítulo III. Recorrido histórico: la presencia humana en la isla. In: Paracuellos M, Nevado JC, Mota JF (eds), Entre Africa y Europa. Historia Natural de la Isla de Alborán. RENPA, Consejería de Medio Ambiente, Junta de Andalucía, Sevilla, pp 47–58
- Gamble T, Bauer AM, Colli GR, Greenbaum E, Jackman TR, Vitt LJ, Simons AM (2011) Coming to America: multiple origins of New World geckos. *Journal of Evolutionary Biology* 24: 231–244, <https://doi.org/10.1111/j.1420-9101.2010.02184.x>
- Harris DJ, Arnold EN, Thomas RH (1998) Relationships of the lacertid lizards (Reptilia: Lacertidae) estimated from mitochondrial DNA sequences and morphology. *Proceedings of the Royal Society of London B* 265: 1939–1948, <https://doi.org/10.1098/rspb.1998.0524>
- Harris DJ, Rosado D, Xavier R, Salvi D (2017) New genetic lineages within Moroccan day geckos *Quedenfeldtia* (Sphaerodactylidae) revealed by mitochondrial and nuclear DNA sequence data. *Amphibia-Reptilia* 38: 97–101, <https://doi.org/10.1163/15685381-00003088>
- Javanmardi S, Vogler S, Joger U (2019) Phylogenetic differentiation and taxonomic consequences in the *Saurodactylus brossei* species complex (Squamata: Sphaerodactylidae), with description of four new species. *Zootaxa* 4674: 401–425, <https://doi.org/10.11646/zootaxa.4674.4.1>
- Katoh K, Standley DM (2013) MAFFT multiple sequence alignment software version 7: improvements in performance and usability. *Molecular Biology and Evolution* 30: 772–780, <https://doi.org/10.1093/molbev/mst010>
- Kocher TD, Thomas WK, Meyer A, Edwards SV, Pääbo S, Villablanca FX, Wilson AC (1989) Dynamics of mitochondrial DNA evolution in animals: amplification and sequencing with conserved primers. *Proceedings of the National Academy of Sciences USA* 86: 6196–6200, <https://doi.org/10.1073/pnas.86.16.6196>
- Kraus F (2009) Alien Reptiles and Amphibians: A scientific compendium and analysis. Springer, New York, 563 pp, <https://doi.org/10.1007/978-1-4020-8946-6>

- Lanfear R, Calcott B, Ho SYW, Guindon S (2012) PartitionFinder: combined selection of partitioning schemes and substitution models for phylogenetic analyses. *Molecular Biology and Evolution* 29: 1695–1701, <https://doi.org/10.1093/molbev/mss020>
- Mateo JA (1997) Los anfibios y reptiles de Ceuta, Melilla, Chafarinas y los peñones de Alhucemas y Vélez de la Gomera. In: Pleguezuelos JM (eds), *Distribución y Biogeografía de los Anfibios y Reptiles en España y Portugal*, Monografías de Herpetología. Universidad de Granada-Asociación Herpetológica Española, Granada, pp 451–464
- Mateo JA (2001) Geco Magrebi. *Saurodactylus mauritanicus* (Duméril y Bibron, 1836). In: Franco A, Rodríguez M (eds), *Libro Rojo de los vertebrados amenazados de Andalucía*. Consejería de Medio Ambiente (Junta de Andalucía). Sevilla, pp 67
- Mateo JA (2002a) *Saurodactylus mauritanicus* Duméril & Bibron, 1836. Geco de Alborán. In: Pleguezuelos JM, Márquez R, Lizana M (eds), *Atlas y Libro Rojo de los anfibios y reptiles de España*. Dirección General de Conservación de la Naturaleza, Asociación Herpetológica Española. Madrid, pp 175–176
- Mateo JA (2002b) Áreas importantes para la herpetofauna española. In: Pleguezuelos JM, Márquez R, Lizana M (eds), *Atlas y Libro Rojo de los anfibios y reptiles de España*. Dirección General de Conservación de la Naturaleza, Asociación Herpetológica Española, Madrid, pp 483–500
- Novosolov M, Rodda GH, Feldman A, Kadison AE, Dor R, Meiri S (2016) Power in numbers. Drivers of high population density in insular lizards. *Global Ecology and Biogeography* 25: 87–95, <https://doi.org/10.1111/geb.12390>
- Paracuellos M, González-Miras E, Rodríguez A, Alesina JJ, Nevado JC (2005) On the presence of geckos (Squamata: Gekkota: Gekkonidae) in the Alborán Island (Western Mediterranean). *Zoologica Baetica* 16: 141–146
- Pitt W, Vice D, Pitzler M (2005) Challenges of invasive reptiles and amphibians. In: Nolte DL, Fagerstone KA (eds), *Proceedings of the 11<sup>th</sup> Wildlife Damage Management Conference*. Paper 84, pp 112–119
- Rambaut A (2009) Figtree [Computer Software]. <http://tree.bio.ed.ac.uk/software/figtree/>
- Rambaut A, Drummond AJ, Xie D, Baele G, Suchard MA (2018) Posterior summarisation in Bayesian phylogenetics using Tracer 1.7. *Systematic Biology* syy032, <https://doi.org/10.1093/sysbio/syy032>
- Rato C, Harris DJ (2008) Genetic variation within *Saurodactylus* and its phylogenetic relationships within the Gekkonoidea estimated from mitochondrial and nuclear DNA sequences. *Amphibia-Reptilia* 29: 25–34, <https://doi.org/10.1163/156853808783431406>
- Rato C, Marques V, Paracuellos M, Tortolero J, Nevado JC, Carretero MA (2021a) Alborán Island, a small meeting point for three invasive lizards, whose geographic origin is uncovered by molecular analysis. *BioInvasions Records* 10: 977–990, <https://doi.org/10.3391/bir.2021.10.4.22>
- Rato C, Martins B, Rocha R, Silva-Rocha I (2021b) Uncovered genetic diversity in *Hemidactylus mabouia* (Reptilia: Gekkonidae) from Madeira Island reveals uncertain sources of introduction. *Amphibia-Reptilia* 42: 369–375, <https://doi.org/10.1163/15685381-bja10052>
- Rosado D, Rato C, Salvi D, Harris DJ (2017) Evolutionary history of the Morocco lizard-fingered geckos of the *Saurodactylus brosseleti* complex. *Evolutionary Biology* 44: 386–400, <https://doi.org/10.1007/s11692-017-9417-8>
- Rubio FJ (2001) *La Pesca en la Isla de Alborán*. Textos y Ensayos, 17. Instituto de Estudios Almerienses (Diputación de Almería), Almería, 97 pp
- Salvator L (1898) *Alboran*. Druck und Verlag von Heinr, Mercy Sohn, Prag, 89 pp
- Schleich HH, Kästle W, Kabisch K (1996) *Amphibians and Reptiles from North Africa*. Koeltz Scientific Publications, Königstein, Germany, 630 pp
- Silva-Rocha I, Salvi D, Sillero N, Mateo JA, Carretero MA (2015) Snakes on the Balearic Islands: an invasion tale with implications for native biodiversity conservation. *PLoS ONE* 10: e0121026, <https://doi.org/10.1371/journal.pone.0121026>
- Silva-Rocha I, Salvi D, Carretero MA, Ficetola GF (2019) Alien reptiles on Mediterranean Islands: A model for invasion biogeography. *Diversity and Distributions* 25: 995–1005, <https://doi.org/10.1111/ddi.12911>
- Sola AJ, Abad R, Aguirre A, Moreno D, Paracuellos M, Mota JF (2006) Capítulo I. En busca de los secretos de Al-Borani: Las expediciones científicas. In: Paracuellos M, Nevado JC, Mota JF (eds), *Entre Africa y Europa*. Historia Natural de la Isla de Alborán. RENPA, Consejería de Medio Ambiente, Junta de Andalucía, Sevilla, pp 25–36
- Suchard MA, Lemey P, Baele G, Ayres DL, Drummond AJ, Rambaut A (2018) Bayesian phylogenetic and phylodynamic data integration using BEAST 1.10. *Virus evolution* 4: vey016, <https://doi.org/10.1093/ve/vey016>
- Vargas JM, Antúnez A (1982) Inventario faunístico de Chafarinas. *Jábega* 32: 60–64
- Whittaker RJ, Fernández-Palacios JM (2007) *Island Biogeography: Ecology, evolution, and conservation*. Oxford University Press, pp 416–416
- Yus R, Paracuellos M, González JA, García H, Torres MA, Bueno I, Gámez S, Jerez D, Cabo JM (2013) IV. La Isla de Alborán. In: Yus R, Cabo JM (eds), *Historia Natural de la Región de Melilla (Guelaya, Alborán y Chafarinas)*. Fundación Gaselec, Melilla, 151 pp