

UC Merced

Biogeographia - The Journal of Integrative Biogeography

Title

Hidden in the bark: the unexpected presence of the leaf-toed gecko, *Euleptes europaea* (Gené, 1839) (Squamata, Sphaerodactylidae), in Sicily

Permalink

<https://escholarship.org/uc/item/5h63m4qt>

Journal

Biogeographia – The Journal of Integrative Biogeography, 39(2)

ISSN

1594-7629

Authors

Giocalone, Gabriele

Faraone, Francesco Paolo

Pecoraro, Marco

et al.

Publication Date

2024

DOI

10.21426/B639263791

Copyright Information

Copyright 2024 by the author(s). This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed

Hidden in the bark: the unexpected presence of the leaf-toed gecko, *Euleptes europaea* (Gené, 1839) (Squamata, Sphaerodactylidae), in Sicily

Gabriele GIACALONE^{1,§,*}, Francesco Paolo FARAONE^{1,§}, Marco PECORARO²,
Maurizio SARÀ¹

¹*Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF),
University of Palermo, Via Archirafi 18, 90123 Palermo, Italy*

²*Via Imera 59, 90138 Palermo, Italy*

** email corresponding author: gabgiaca@yahoo.it*

§ these authors contributed equally as co-first authors

Keywords: Elusive species, Gekkota, Palermo city, reforestation, reptiles.

SUMMARY

We report the first observations regarding the presence of the leaf-toed gecko, *Euleptes europaea*, in Sicily. During field activities for environmental impact assessment several leaf-toed gecko individuals were found in a restricted coastal area in the north-west of the island, near the city of Palermo. Further surveys were then carried out to better assess the presence of the species. A total of 21 *E. europaea* individuals were observed in a small area of approximately 4.4 hectares, consisting of mixed eucalyptus and pine reforestation. Out of the 21 individuals, there were 14 males, 5 females, and 2 whose sex could not be determined. Additionally, at least two pregnant females were observed. Leaf-toed geckos were found exclusively under eucalyptus bark, syntopic with two other Gekkota species (*Tarentola mauritanica* and *Hemidactylus turcicus*). The presence of such a breeding population of *E. europaea* is probably limited to a small area. However, our results do not allow us to clearly assess either its origin or its actual distribution and demography, therefore new field investigations are necessary.

INTRODUCTION

Mediterranean islands are known for a biogeographically composite herpetofauna (Bonardi et al., 2022), modulated by both natural (Poulakakis et al., 2013; Faraone et al., 2020a) and human-driven dispersal (Salvi et al., 2014; Faraone et al., 2020b). Natural colonization in amphibians and reptiles is usually linked to passive spreading, such as over-sea rafting (Stöck et al., 2016; Sherpa et al., 2023), and active movements via land bridges (Stöck et al., 2008; Faraone et al., 2022). Man-mediated dispersal is instead linked to intentional introductions (Vamberger et al., 2011; Lillo et al., 2013) or unintentionally related to the transport of goods (Silva-Rocha et al., 2015; Faraone et al., 2019).

Some European species of Gekkota have reached an almost cosmopolitan distribution, following various dispersal patterns, even overseas, making them a paradigmatic example of colonizers (Rödder and Lötters, 2009; Rato et al., 2023). This is also true for the leaf-toed gecko, *Euleptes europaea* (Gené, 1839), the only species belonging to the Sphaerodactylidae family in Europe. *Euleptes europaea* is the smallest European gecko, reaching a maximum SVL (snout to vent length) of 47.9 mm (Salvidio et al., 2011 and references therein). It is a nocturnal and secretive species that is usually found in habitats rich in rocky outcrops and sparse vegetation, where it seeks shelter inside rocky crevices or under tree bark (Salvidio et al., 2011 and references therein). Although it is less synanthropic than other European geckos, it also colonizes microhabitats linked to human activities, such as dry stone walls and building ruins, and can also be found in extreme environments such as some rocks and islets with almost no vegetation (Delaugerre and Cheylan, 1992; Salvidio et al., 2011). Its geographic range includes: Corsica, Sardinia and their satellite islets; Tuscan archipelago; small mainland spots and several coastal islets of Provence (France), Liguria, Tuscany and Campania (Italy) (see Salvidio et al., 2011 and reference therein; Delaugerre et al., 2011; Delaugerre and Corti,

2020; Di Nicola et al., 2022 for a more exhaustive list) (Fig. 1). In addition, there are some isolated observations from northern Italy that need confirmation (Iversen in Di Nicola et al., 2022).

The phylogeography of *E. europaea* populations is still unresolved, due to the lack of specific studies, but it is known that its Corsican population may have originated from the northward expansion from Sardinia during the last glacial events (Salvi et al., 2019). However, the overall distribution of the species is considered relict (Delaugerre et al., 2011; Delaugerre and Corti, 2020), although for populations outside the Sardinian-Corsican system and the Tuscan Archipelago, a man-mediated origin is not excluded (Salvidio and Delaugerre, 2003).

Here we describe the presence of a population of European leaf-toed gecko in Sicily, and report preliminary data on its distribution and habitat.

MATERIALS AND METHODS

The area where the population was reported for the first time is a mixed eucalyptus and pine reforestation (Fig. 2a), rich in undergrowth and rocky outcrops, upstream of the coastal village 'Addaura' (38.186 N, 13.347 E), north of the city of Palermo (Sicily) (Fig. 3). This area is delimited by the north-facing rock walls of Monte Pellegrino, a limestone promontory (606 m asl) surrounded by the urban fabric of Palermo. The reforested area is intermingled with patches of Mediterranean scrub with a prevalence of holm oak (*Quercus ilex* Linnaeus, 1753), which dominates the surrounding rocky slopes.

A population of *Euleptes europaea* was found during field activities (involving transects of 300 m to survey the reptiles) for the environmental impact assessment preceding the installation of landslide protection system. After the discovery of the first nucleus, six active daytime research sessions were carried out, from

13 to 21 May 2024, both along random paths and within scattered spots of approximately 20 m radius in which geckos were searched under rocks or by inspecting trees. Care was taken to only partially remove the detached bark from the ground up to about 150 cm in height. Each spot was georeferenced with a GPS device and was checked only once.

The sampling sessions took place within the main reforestation and also in neighbouring areas, including the plateau just above rocky walls, characterized by garrigue with scattered reforested patches. Records were taken of every Gekkota found inside the random spots.



Figure 1. Geographic range of the leaf-toed gecko, *Euleptes europaea* (green) with the new Sicilian population (red).

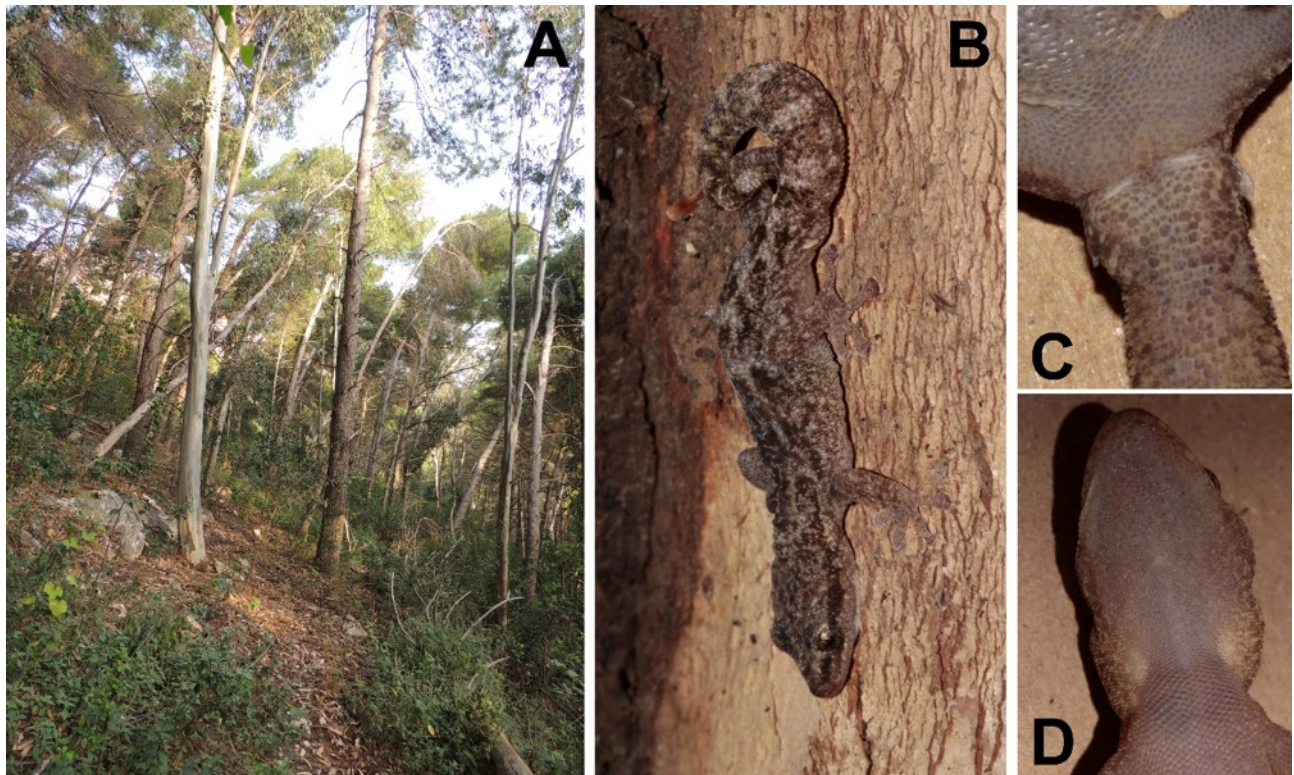


Figure 2. Habitat and habitus of *Euleptes europaea* in the study site. A) mixed reforestation, habitat of *Euleptes europaea* in Monte Pellegrino discovery site (Sicily); B) subadult male *in situ*; C) enlarged base of the tail and post-cloacal spurs (male); D) enlarged neck glands (female).

For every leaf-toed gecko found, the sex was determined by verifying the enlarged base of the tail, prominence of the post-cloacal spurs in males, and absence of spurs and presence of bumped neck glands in females (see Salvidio et al., 2011, Fig. 2c, b).

Descriptive statistics [mean \pm standard deviation and min-max range] were calculated on frequencies and altitude (m a.s.l.) of the observations. To estimate the extent of the distribution of *E. europaea* in Sicily, on the basis of our preliminary observations, we used the Minimum Convex Polygon (MCP) method, as implemented in the QGIS software.

RESULTS

The first three leaf-toed geckos were found on 13 May 2024, along the reptiles-targeted transects. After further active research, a total of

21 individuals (14 males, 5 females, and 2 whose sex could not be determined) were detected. *Euleptes europaea* was found exclusively under the bark of eucalyptus trees, in an area of approximately 4.4 hectares (MCP) with an average altitude of 79.7 ± 12.4 (52-105) meters (Fig. 3). This area extends just outside the northern margin of the Natural Reserve and the Site of Community Importance "Monte Pellegrino" (ITA020014, Directive 92/43/EEC of 21 May 1992). No leaf-toed geckos were found on the plateau overlooking the reforestation (Fig. 3). On average, 1.3 ± 0.6 (1-3) individuals were found in each inhabited tree.

Of the five females observed, at least two appeared to be pregnant, as evidenced by their noticeably swollen neck glands and the distinct bulges of two eggs visible on the sides of their bellies.

The other two species of Gekkota present in Sicily *sensu stricto* were also found during the sampling, in close syntopy with *E. europaea*. Out of 138 sampled trees we found 26 *Tarentola mauritanica* (Linnaeus, 1758) (1 gecko/5.3 trees) and 12 *Hemidactylus turcicus* (Linnaeus,

1758) (1 gecko/11.5 trees). For the leaf-toed gecko we estimated, within the area where it was found, approximately 1 gecko/6 trees. In two cases *E. europaea* was found on the same tree with other geckos, once with *T. mauritanica* and once with *H. turcicus*.



Figure 3. Detailed distribution of the inspected spots. White dots = spots where *E. europaea* was observed; red dots = spots without *E. europaea* findings; yellow line = Minimum Convex Polygon calculated on the *E. europaea* observations.

DISCUSSION

We report the first observations regarding the presence of the leaf-toed gecko in Sicily. Our data (number and distribution of observations, finding of pregnant females, etc.) suggest the presence of a breeding population of *E. europaea*, probably limited to a small area. The apparent narrowness of its distribution and the secretive habits of the species could be the reasons why this population has remained unnoticed in this area, which was the subject of several studies in the past (Lo Valvo, 1986).

Our field observations confirm the coexistence of *E. europaea* in close syntopy with the other two geckos, *Tarentola mauritanica* and *Hemidactylus turcicus* (Radi and Zuffi, 2022; Deso et al., in press), whose relationships in this study area deserve to be explored in depth. Furthermore, we have confirmed the arboreal habits of this lizard and a strong adaptation to

eucalyptus woods which, despite their non-native status, seems to constitute a structurally ideal habitat for the *E. europaea* life cycle (Deso et al., in press; Salvi et al., 2023).

The dispersal processes that have determined the fragmented distribution of *E. europaea* are still unclear, due to the lack of in-depth studies. This species is overall considered to have a relict distribution (Salvidio et al., 2011), although human influence on the origin of its peripheral populations cannot be excluded (Salvidio and Delaugerre, 2003). Part of the Sicilian and Sardinian herpetofauna is the result of man-mediated dispersal following the last glacial events (Fritz et al., 2009; Stöck et al., 2016; Faraone et al., 2020b), in this context fauna exchanges occurred between the two islands (Giacalone et al., 2009; Senczuk et al., 2017), which were also sources of further dispersions towards the Italian peninsula (Mori

et al., 2022). The human-driven origin of this *E. europaea* population is plausible, since it is located about 400 m from an ancient port, which was created for fishing and trading activities in the 16th century (Lo Cascio, 1995). Subsequently, during the first half of the 20th century, the port was also a shipyard, initially intended for the construction of wooden boats (Cancila, 1999). As documented, maritime landings and wood trade can facilitate the dispersal of non-native reptile species (D'Amico et al., 2018; Mori et al., 2022). Although the scenario of introduction appears likely, given the absence of genetic data and the strong overseas dispersal capacity of geckos (Carranza et al., 2000; Hawlitschek et al., 2016), it is currently not possible to definitively assess the origin of this population.

The conservation status of the leaf-toed gecko is characterized by two different trends. Populations of small island and islets appear very fragile, as evidenced by local extinctions in recent decades in Provence (Salvidio and Delaugerre, 2003) and Tunisia (Delaugerre et al., 2011). On the other hand, on the large islands and mainland, it could be widespread as recent studies have pointed out a less fragmented distribution than expected (Salvidio et al., 2011; De Pous et al., 2012). The overall conservation status of this lizard has been assessed as Near Threatened (NT) with unknown population trend by the IUCN global red list (Corti et al., 2009) and Least Concern (LC) with declining populations by the IUCN Italian red lists (Rondini et al., 2013, 2022). *Euleptes europaea* is protected throughout Europe, as it is currently listed on Appendix II of the Bern Convention and Annex II and IV of the EU Habitats. This latest directive prescribes the establishment of special protection areas and local conservation measures, as already undertaken in some areas (Deso and Reynier, 2024). Based on available information, the Sicilian population of *E. europaea*, due to its apparent extreme localization and unknown origin, deserves further investigation to quickly undertake management or conservation measures.

ACKNOWLEDGEMENTS

The sampling took place in the context of authorized field activities for the environmental impact assessment preceding the installation of landslide protection system on the rock walls of Monte Pellegrino, overlooking the urban areas of Vergine Maria and Addaura. We thank Matteo Riccardo Di Nicola, Federico Marrone, Edoardo Razzetti and Luca Vecchioni for their precious opinions and advices. We are also grateful to the director of the Monte Pellegrino reserve Giovanni Provinzano and Fabio Papini (Agristudio) for their permissions and availability.

AUTHOR CONTRIBUTIONS

GG: Conceptualization, organization, manuscript preparation. FPF: Dataset curation, analysis, manuscript preparation. MP: Dataset curation, manuscript review. MS: Organization, conceptualization, manuscript preparation. All authors contributed equally to sampling.

REFERENCES

- Bonardi, A., Ficetola, G.F., Razzetti, E., Canedoli, C., Falaschi, M., Lo Parrino, E., Rota, N., Padoa-Schioppa, E. & Sindaco, R. (2022) ReptIslands: Mediterranean islands and the distribution of their reptile fauna. *Global Ecology and Biogeography*, 31, 840–847. DOI: 10.1111/geb.13490
- Cancila O. (1999) Palermo. Laterza, Bari.
- Carranza, S., Arnold, E.N., Mateo, J.A. & Lopez-Jurado, L.F. (2000) Long-distance colonization and radiation in gekkonid lizards, *Tarentola* (Reptilia: Gekkonidae), revealed by mitochondrial DNA sequences. *Proceedings of the Royal Society B: Biological Sciences*, 267, 637–649. DOI: 10.1098/rspb.2000.1050
- Corti, C., Cheylan, M., Geniez, P., Sindaco, R. & Romano A. (2009) *Euleptes europaea*. The IUCN Red List of Threatened Species 2009: e.T61446A12486542. Digital resource

available at <https://dx.doi.org/10.2305/IUCN.UK.2009.RLTS.T61446A12486542.en>

- D'Amico, M., Bastianelli, G., Faraone, F.P. & Lo Valvo, M. (2018) The spreading of the invasive Italian wall lizard on Vulcano, the last island inhabited by the critically endangered Aeolian wall lizard. *Herpetological Conservation & Biology*, 13, 146–157.
- Delaugerre, M. & Cheylan, M. (1992) Atlas de répartition des Batraciens et Reptiles de Corse. Parc Naturel Régional de Corse, Ecole Pratique des Hautes Etudes, Pampelune.
- Delaugerre, M.J. & Corti, C. (2020) Tiny but “strong”: the European Leaf-toed gecko, *Euleptes europaea*, a terrestrial vertebrate able to survive on tiny islets. *Israel Journal of Ecology and Evolution*, 66, 223–230. DOI: 10.1163/22244662-bja10017
- Delaugerre, M.J., Ouni, R. & Nouira, S. (2011) Is the European Leaf-toed gecko *Euleptes europaea* also an African? Its occurrence on the Western Mediterranean landbrige islets and its extinction rate. *Herpetology Notes*, 4, 127–137.
- Deso, G., Priol, P., Reynier, T. & Renet, J. (in press) High occupancy of European leaf-toed gecko *Euleptes europaea* in two island stands of *Eucalyptus* sp.: tree selection, co-occurrence and habitat effect. *Ethology Ecology & Evolution*. DOI: 10.1101/2023.02.08.527781 [preprint on bioRxiv]
- Deso, G. & Reynier, T. (2024) Construction of a refuge wall with crevices to protect European leaf-toed geckos *Euleptes europaea* and young Turkish geckos *Hemidactylus turcicus* on the Ile du Levant, France. *The Herpetological Bulletin*, 167, 20–24. DOI: 10.33256/hb167.2024
- Di Nicola, M.R., Colombo, M. & Russo, F. (2022) First record of European leaf-toed gecko *Euleptes europaea* (Gené, 1839) (Squamata, Sphaerodactylidae) in Campania (Italy). *Rivista del Museo Civico di Scienze Naturali “Enrico Caffi”, Bergamo*, 35, 79–82.
- Faraone, F.P., Barraco, L., Giacalone, G., Muscarella, C., Schifani, E. & Vecchioni, L. (2019) First records of the Brahminy blind snake, *Indotyphlops braminus* (Daudin, 1803) (Squamata: Typhlopidae), in Italy. *Herpetology Notes*, 12, 1225–1229.
- Faraone, F.P., Melfi, R., Di Nicola, M.R., Giacalone, G. & Lo Valvo, M. (2020a) The genetic identity of the only Italian population of the genus *Macroprotodon* Guichenot, 1850 on the island of Lampedusa, Sicily. *Vertebrate Zoology*, 70, 235–240. DOI: 10.26049/VZ70-2-2020-09
- Faraone, F.P., Melfi, R., Di Nicola, M.R., Giacalone, G. & Lo Valvo M. (2020b) Phylogenetic relationships of the Italian populations of Horseshoe Whip Snake *Hemorrhoids hippocrepis* (Serpentes, Colubridae). *Acta Herpetologica*, 15, 129–135. DOI: 10.13128/a_h-9058
- Faraone, F.P., Melfi, R., Di Nicola, M.R., Giacalone, G. & Lo Valvo, M. (2022) Phylogenetic affinities of the Italian population of Eastern Montpellier Snake, *Malpolon insignitus* (Serpentes, Lamprophiidae). *Herpetology Notes*, 15, 711–715.
- Fritz, U., Harris, D.J., Fahd, S., Rouag, R., Martínez, E.G., Casalduero, A.G., Široký, P., Kalboussi, M., Jdeidi, T.B. & Hundsdörfer, A.K. (2009) Mitochondrial phylogeography of *Testudo graeca* in the Western Mediterranean: Old complex divergence in North Africa and recent arrival in Europe. *Amphibia-Reptilia*, 30, 63–80. DOI: 10.1111/j.1439-0469.2010.00565.x
- Giacalone, G., Lo Valvo, M. & Fritz, U. (2009) Phylogeographic link between Sicilian and Corso-Sardinian *Testudo h. hermanni* confirmed. *Acta Herpetologica*, 4, 119–123. DOI: 10.13128/Acta_Herpetol-3413
- Lillo, F., Dufresnes, C., Faraone, F.P., Lo Valvo, M. & Stöck, M. (2013) Identification and potential origin of invasive clawed frogs *Xenopus* (Anura: Pipidae) in Sicily based on mitochondrial and nuclear DNA. *Italian Journal of Zoology*, 80, 566–573. DOI: 10.1080/11250003.2013.847502
- Lo Cascio P. (1995) Mondello tra torri e pirati. Flaccovio, Palermo.
- Lo Valvo, M. (Ed.) (1986) La fauna del Parco della Favorita e di Monte Pellegrino (Palermo). *Il Naturalista Siciliano*, 10, 31–163.

- Mori, E., Andreone, F., Viviano, A., et al. (2022) Aliens coming by ships: distribution and origins of the ocellated skink populations in peninsular Italy. *Animals*, 12,1709. DOI: 10.3390/ani12131709
- Poulakakis, N., Kapli, P., Kardamaki, A., Skourtanioti, E., Göcmen, B., Ilgaz, Ç., Kumlutas, Y., Avci, A. & Lymberakis P. (2013) Comparative phylogeography of six herpetofauna species in Cyprus: late Miocene to Pleistocene colonization routes. *Biological Journal of the Linnean Society*, 108, 619–635. DOI: 10.1111/j.1095-8312.2012.02039.x
- Radi, G. & Zuffi, M. (2022) One site, three species, three stories: syntopy of geckoes *Euleptes europaea* (Gené, 1839), *Hemidactylus turcicus* (Linnaeus, 1758), *Tarentola mauritanica* (Linnaeus, 1758) in a coastal area of southern Tuscany (central Italy). *Acta Herpetologica*, 17, 187–195. DOI: 10.36253/a_h-11547
- Rato, C., Deso, G., Renet, J., Delaunier, M.J., Marques, V. & Mochales-Riaño, G. (2023) Colonization routes uncovered in a widely introduced Mediterranean gecko, *Tarentola mauritanica*. *Scientific Reports*, 13, 16681. DOI: 10.1038/s41598-023-43704-8
- Rödger, D. & Lötters, S. (2009) Niche shift versus niche conservatism? Climatic characteristics of the native and invasive ranges of the Mediterranean house gecko *Hemidactylus turcicus*. *Global Ecology and Biogeography*, 18, 674–687. DOI: 10.1111/j.1466-8238.2009.00477.x
- Rondinini, C., Battistoni, A., Peronace, V. & Teofili, C. (2013) Lista Rossa IUCN dei Vertebrati Italiani. Comitato Italiano IUCN e Ministero dell’Ambiente e della Tutela del Territorio e del Mare, Roma
- Rondinini, C., Battistoni, A. & Teofili, C. (2022) Lista Rossa IUCN dei vertebrati italiani 2022. Comitato Italiano IUCN e Ministero dell’Ambiente e della Sicurezza Energetica, Roma
- Salvi, D., Schembri, P.J., Sciberras, A. & Harris, D.J. (2014) Evolutionary history of the Maltese wall lizard *Podarcis filfolensis*: insights on the ‘Expansion-Contraction’ model of Pleistocene biogeography. *Molecular Ecology*, 23, 1167–1187. DOI: 10.1111/mec.12668
- Salvi, D., Delaunier, M., Carranza, S. & Harris, D.J. (2019) Evolutionary history of the leaf-toed gecko *Euleptes europaea* reveals recent biogeographic cross-road between Sardinia and Corsica. (ABSTRACT). In: XX European Congress of Herpetology, Milan 2-6 September 2019: Program & Abstracts, pp. 111.
- Salvi, D., Berrilli, E., Bruni, G., Garzia, M., Gomes, V., Radi, G. & Delaunier, M.J. (2023) The secret life of a rock-dweller: arboreal acrobatics observed in the European leaf-toed gecko *Euleptes europaea*. *Herpetozoa*, 36, 135–141. DOI: 10.3897/herpetozoa.36.e103465
- Salvidio, S. & Delaunier M. (2003) Population dynamics of the European leaf-toed gecko (*Euleptes europaea*) in NW Italy: implications for conservation. *Herpetological journal*, 13, 81–88.
- Salvidio, S., Lanza, B. & Delaunier, M.J. (2010) *Euleptes europaea* (Gené, 1839). In: Fauna d’Italia. Vol. 45 (ed. by C. Corti, M. Capula, L. Luiselli, E. Razzetti and R. Sindaco), pp. 258–270. Edizioni Calderini de Il Sole 24 ORE, Milan.
- Senczuk, G., Colangelo, P., De Simone, E., Aloise, G. & Castiglia, R. (2017) A combination of long term fragmentation and glacial persistence drove the evolutionary history of the Italian wall lizard *Podarcis siculus*. *BMC Evolutionary Biology*, 17, 1–15. DOI: 10.1186/s12862-016-0847-1
- Sherpa, S., Salvi, D., Silva-Rocha, I., Capblancq, T., Paris, J.R., Carretero, M.A. & Ficetola, G.F. (2023) Reconstructing the complex colonization histories of lizards across Mediterranean archipelagos. *Journal of Biogeography*, 51, 157–172. DOI: 10.1111/jbi.14739
- Silva-Rocha, I.R., Salvi, D., Sillero, N., Mateo, J.A. & Carretero, M.A. (2015) Snakes on the Balearic Islands: an invasion tale with implications for native biodiversity conservation. *PLoS One*, 10, e0121026. DOI: 10.1371/journal.pone.0121026

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 Evolutionary Biology*, 8, 56–74. DOI: 10.1186/1471-2148-8-56

Stöck, M., Grifoni, G., Armor, N., Scheidt, U., Sicilia, A. & Novarini, N. (2016) On the origin of the recent herpetofauna of Sicily: comparative phylogeography using homologous mitochondrial and nuclear genes. *Zoologischer Anzeiger*, 261, 70–81. DOI: 10.1016/j.jcz.2015.10.005

Vamberger, M., Corti, C., Stuckas, H. & Fritz U. (2011) Is the imperilled spurthighed tortoise (*Testudo graeca*) native in Sardinia? Implications from population genetics and for conservation. *Amphibia-Reptilia*, 32, 9–25. DOI: 10.1163/017353710X541869

Submitted: 19 June 2024

First decision: 3 July 2024

Accepted: 5 July 2024

Edited by Federico Marrone