Liberman, Y.R., Ben-Ami, F. & Meiri, S. 2024. Artificial cover objects as a tool for the survey and conservation of herpetofauna. *Biodiversity and Conservation*, 33: 1575–1590.

Ne, J.F., Luo, R. & Gu, Y.H. 1987. Overwinter habit of *Bufo gargarizans* in Guiyang. *Chinese Journal of Zoology*, 22: 26–29.

Petrovan, S.O., Al-Fulaij, N., Christie, A. & Andrews, H. 2022. Why link diverse citizen science surveys? Widespread arboreal habits of a terrestrial amphibian revealed by mammalian tree surveys in Britain. *PLOS ONE*, 17(7): e0265156.

Reques, R. & Tejedo, M. 2002. *Bufo calamita* (Laurenti, 1768). Sapo corredor. *In*: J.M. Pleguezuelos, R. Márquez & M. Lizana (eds.). *Atlas y Libro Rojo de los Anfibios y Reptiles de España*. Dirección General de Conservación de la Naturaleza - Asociación Herpetológica Española. Madrid. España.

Rödel, M.O., Brede, C., Hirschfeld, M., Schmitt, T., Favreau, P., Stöcklin, R. *et al*. 2013. Chemical camouflage – a frog's strategy to co-exist with aggressive ants. *PLOS ONE*, 8: e81950.

Saare, L. & Rannap, R. 2021. Breeding behaviour of ectotherms at high latitudes: the case of the natterjack toad *Epidalea calamita* at its northern range limit. *Behaviour*, 159: 443–462.

Salvador, A. 1985. *Guía de campo de los anfibios y reptiles de la Península Ibérica, Islas Baleares y Canarias*. Santiago García (ed.). León. España.

Schwarzkopf, L. & Alford, R.A. 1996. Desiccation and shelter-site use in a tropical amphibian: comparing toads with physical models. *Functional Ecology*, 10: 193–200.

Shoemaker, V.H. 1964. The effects of dehydration on electrolyte concentrations in a toad, *Bufo marinus. Comparative Biochemistry and Physiology*, 13: 261–271.

Sih, A. 1997. To hide or not to hide? Refuge use in a fluctuating environment. *Trends in Ecology and Evolution*, 12: 375–376.

Walsh, P.T. & Downie, J.R. 2005. The effects of shelter availability and substrate quality on behaviour and post-metamorphic growth in three species of anurans: implications for captive breeding. *The Herpetological Journal*, 15: 245–255.

Weintraub, J.D. 1980. Selection of daytime retreats by recently metamorphosed *Scaphiopus multiplicatus. Journal of Herpetology*, 14: 83–84.

A case of interspecific amplexus between *Bufo spinosus* and *Epidalea calamita* (Anura: Bufonidae) in northern Portugal

Marisa Naia[1,2,3*] & Angelica Crottini[2,3,4]

[1] Faculty of Sciences of the University of Porto. Rua do Campo Alegre, s/n. 4169-007 Porto. Portugal. C.e.: marisanaia@cibio.up.pt
[2] CIBIO, Centro de Investigação em Biodiversidade e Recursos Genéticos. InBIO Laboratório Associado. Campus de Vairão. Universidade do Porto. 4485-661 Vairão. Portugal.
[3] BIOPOLIS Program in Genomics, Biodiversity and Land Planning. CIBIO. Campus de Vairão. 4485-661 Vairão. Portugal.
[4] Department of Biology. University of Florence. Sesto Fiorentino (FI) 50019. Florence. Italy.

Fecha de aceptación: 5 de diciembre de 2025.
Key words: amphibian, breeding behaviour, mate recognition, reproductive interference.

Resumen: Se informa de un caso de amplexo interespecífico entre un macho de sapo corredor (*Epidalea calamita*) y una hembra de sapo común (*Bufo spinosus*) en la Reserva Ornitológica de Mindelo, en el norte de Portugal. Esta observación representa el primer caso documentado de amplexo entre estas dos especies de bufónidos simpátricas, aportando información sobre las interacciones reproductivas y el reconocimiento erróneo de pareja en las especies de anuros.

Interspecific amplexus is a relatively common behaviour that has been described in many amphibian species (Gül *et al.*, 2018; Ayres & Dominguez-Costas, 2020; Koynova & Natchev, 2021; Serrano *et al.*, 2022; Smirnov, 2022). Although mating in anurans is usually driven by auditory, chemical, and behavioural cues (Wells, 2007), misdirected amplexus may occur due to confusion of chemical signals, male-biased sex ratios, and failures in mate recognition, especially when there is an overlap in the breeding phenology of two sympatric species (Mollov *et al.*, 2010). This behaviour often results in unsuccessful fertilization, thus reducing reproductive success with potential

Figure 1: Axillary amplexus between a female of *Bufo spinosus* and a male of *Epidalea calamita* observed on 18th March 2024, at 21:19h, at Mindelo Ornithological Reserve, Portugal.
Figura 1: Amplexo axilar entre una hembra de *Bufo spinosus* y un macho de *Epidalea calamita* observado el 18 de marzo de 2024, a las 21:19h, en la Reserva Ornitológica de Mindelo, Portugal.

costs on individual fitness (Wells, 1977; Mollov *et al.*, 2010). In Portugal, the natterjack toad, *Epidalea calamita* (Laurenti, 1768), and the spiny toad, *Bufo spinosus* (Daudin, 1803), are two sympatric bufonid species. Both display an explosive breeding behaviour, in which reproductive effort is concentrated within a short timeframe and male-male competition for female access is expected (Wells, 1977). However, they rely on different environmental cues: breeding phenology of *B. spinosus* is related with increasing temperatures after winter, usually between February and March, whereas *E. calamita* has a more variable reproductive window depending on the onset of rainfall, from autumn to early spring (Richter-Boix *et al.*, 2006). In some years, rising temperatures, early precipitation, and the formation of temporary ponds can overlap in time, increasing the probability of synchronised reproductive activity of these two species, and potentially facilitating interspecific interactions (Dalpasso *et al.*, 2023). Although misdirected amplexus is frequent among the Bufonidae family, and cases involving one of these species have been reported (Ayres & Dominguez-Costas, 2020; Bringsøe, 2020; Soni *et al.*, 2025), no record of amplexus between *E. calamita* and *B. spinosus* has been previously documented.

Here, we report a case of interspecific axillary amplexus between a male of *E. calamita* and a female of *B. spinosus* in northern Portugal (Figure 1). The observation occurred on 18th March 2024, at 21:19h, during a nocturnal amphibian survey at Mindelo Ornithological Reserve (41º19'32.37''N / 8º44'01.91''W). The reserve is a protected coastal area characterised by a high diversity of micro-habitats, such as sand dunes, agricultural fields, oak, pine and eucalyptus forests, and numerous temporary wetlands, which favours a high diversity and abundance of amphibians in the area (Velo-Antón, 2020). Species were identified based on their morphological characteristics and the amplexus was observed on land, along the main path of the reserve. The observation site was very close (~ 2 m) from an ephemeral pond where the population of *E. calamita* is known to successfully breed. We did not detect escaping attempts by the female of *B. spinosus* during the observation. When disturbed by the camera, the pair moved into the vegetation while remaining in amplexus.

Males of *E. calamita* usually adopt a chorus lekking strategy, calling conspicuously from the ponds to attract females (Arak, 1988). In contrast, males of *B. spinosus* lack vocal sac, and their call is composed by short sounds only audible at close distance (Ortiz Santaliestra, 2014). Females of *B. spinosus* usually arrive later at breeding sites, where males are already present and competing for limited opportunities to mate (Lizana, 1990). Similarly, females of the congeneric common toad, *Bufo bufo* (Linnaeus, 1758), were reported to form amplexus on land, before reaching the water (Kovář & Brabec, 2007). *Bufo spinosus* normally prefer habitats with running or permanent water, avoiding temporary ponds where *E. calamita* are known to breed (Ortiz Santaliestra, 2014). However, local overlap commonly takes place. *Epidalea calamita* is considered a common species with high density at Mindelo Ornithological Reserve (Velo-Antón, 2020), and despite *Bufo spinosus* was considered a rare species by Velo-Antón (2020), surveys in recent years revealed that also this species in quite abundant in the area (Naia *et al.*, 2024). Unfortunately, no detailed information on the sex ratio of these two sympatric bufonid populations are known from the area, but it is expected that intraspecific competition may reduce selective pressure for mate identification (Marco & Lizana, 2002). This observation may reflect such misrecognition, likely driven by overlapping breeding periods, explosive breeding behaviour in these two syntopic species and the scarcity of conspecific (female) mates.

Misdirected amplexus can result in significant fitness costs by delaying or preventing successful reproduction with conspecifics, shortening breeding period, prompting energy waste and even increasing predation risk (Wells, 1977). In addition, both species are known to form mating balls, where multiple males simultaneously attempt to grab a single female (Bringsøe, 2020; Reques, 2020). This reproductive behaviour may impose substantial fitness costs, for example by increasing the risk of drowning for individuals involved earlier in amplexus (Bringsøe, 2020). Documenting such observations is important to understand the ecological drivers of interspecific reproductive interactions, as well as their potential costs for individuals and populations in sympatric amphibians.

Acknowledgements: This work was supported by Fundação para a Ciência e Tecnologia (FCT) through the individual research grant 2023.02820.BD and DOI identifier: https://doi.org/10.54499/2023.02820.BD to MN. We thank A. Velasco for the help with the Spanish translation.

References

Arak, A. 1988. Female mate selection in the natterjack toad - Active choice or passive attraction. *Behavioral Ecology and Sociobiology*, 22: 317–327.

Ayres, C. & Dominguez-Costas, M. 2020. Heterospecific amplexus between *Pelobates cultripes* and *Epidalea calamita* in NorthWestern Spain. *North-Western Journal of Zoology*, 16: 106–107.

Bringsøe, H. 2020. *Bufo spinosus* (Spiny Toad) and *Sclerophrys mauritanicus* (Moroccan Toad) interspecific amplexus. *Herpetological Review*, 51: 297–298.

Dalpasso, A., Seglie, D., Eusebio Bergò, P., Ciracì, A., Compostella, M., Laddaga, L., *et al*. 2023. Effects of temperature and precipitation changes on shifts in breeding phenology of an endangered toad. *Scientific Reports*, 13: 14573.

Gül, S., Özdemir, N. & Dursun, C. 2018. First record of interspecific amplexus behaviour between *Bufotes variabilis* (Pallas, 1769) and *Pelophylax ridibundus* (Pallas 1771) with *Bufo bufo* (Linnaeus, 1758) (Anura: Bufonidae) from Turkey. *Herpetology Notes*, 11: 153–155.

Kovář, R. & Brabec, M. 2007. Reproduction strategy of *Bufo bufo* (Amphibia: Anura) in the Strnady breeding pond, Czech Republic. *Acta Societatis Zoologicae Bohemicae*, 71: 173–192.

Koynova, T.V. & Natchev, N.D. 2021. Interspecific amplexus between *Rana dalmatina* (Fitzinger in Bonaparte, 1838) and *Salamandra salamandra* (Linnaeus, 1758) in "Shumensko Plato" Nature Park, Bulgaria. *Herpetology Notes*, 14: 653–655.

Lizana, A.M. 1990. *Ecologia de* Bufo bufo *en la Sierra de Gredos*. Doctoral dissertation. Univerity of Salamanca. Salamanca. Spain.

Marco, A. & Lizana, M. 2002. The absence of species and sex recognition during mate search by male common toads, *Bufo bufo. Ethology Ecology & Evolution*, 14: 1–8.

Mollov, I., Popgeorgiev, G.S., Naumov, B.Y., Tznakov, N.D. & Stoyanov, A.Y. 2010. Cases of abnormal amplexus in anurans (Amphibia: Anura) from Bulgaria and Greece. *Biharean Biologist*, 4: 121–125.

Naia, M., Vasconcelos, C., Arenas-Castro, S. & Crottini, A. 2024. Habitat alteration, amphibian monitoring and citizen engagement: a multidisciplinary approach for freshwater conservation in Northen Portugal. Conference: *XXIII Encontro Nacional de Ecologia: Investigação ecológica ao serviço da conservação*, 43. Porto. Portugal.

Ortiz Santaliestra, M.E. 2014. Sapo común – *Bufo spinosus*. *In*: Salvador, A. & Martínez-Solano, I. (eds.), *Enciclopedia Virtual de los Vertebrados Españoles*. Museo Nacional de Ciencias Naturales, Madrid. <http://www.vertebrados ibericos.org/> [Accessed: May 9, 2025].

Reques, R. 2020. *Ecologia, estudio y conservacion de los anfibios*. Tundra ediciones. Almenara. Spain.

Richter-Boix, A., Llorente, G.A. & Montori, A. 2006. Breeding phenology of an amphibian community in a Mediterranean area. *Amphibia-Reptilia*, 27: 549–559.

Serrano, F.C., Días-Ricaurte, J.C. & Martins, M. 2022. Finding love in a hopeless place: A global database of misdirected amplexus in anurans. *Ecology*, 103(8): e3737.

Smirnov, N.A. 2022. The cases of abnormal amplexus in anura on the territory of the chernivtsi region, Ukraine. *Zoodiversity*, 56: 489–494.

Soni, S.P., Apte, V., Joshi, P. & Cyriac, V.P. 2025. Barking up the wrong frog: global prevalence of misdirected amplexus in anuran amphibians. *Biological Journal of the Linnean Society*, 145: blae062.

Velo-Antón, G. 2020. Amphibian micro-hotspot at the Mindelo Ornithological Reserve (Porto, Portugal). *Boletin de la Asociacion Herpetologica Española*, 31: 151–155.

Wells, K.D. 1977. The social behaviour of anuran amphibians. *Animal Behavior*, 25: 666–693.

Wells, K.D. 2007. The Ecology and Behavior of Amphibians. Chicago University Press. Chicago. USA.

Predatory interactions between lacertid lizards (Lacertidae) and scorpions (Scorpiones), including the first report of predation by an Italian Wall Lizard *Podarcis siculus* (Rafinesque-Schmaltz, 1810) on a Balearic Small Wood-Scorpion *Euscorpius balearicus* Caporiacco, 1950 in Menorca, Spain

Przemysław Zdunek[1,2*], Karol Wałach[2,3] & Anthony Herrel[4,5,6,7]

[1] Pôle Sup Nature. 205 Rue de l'Acropole. 34000 Montpellier. France. C.e.: zdunek.komodo@gmail.com
[2] NATRIX Herpetological Association. ul. Opolska 41/1. 52-010 Wrocław. Poland.
[3] Department of Invertebrate Evolution. Institute of Zoology and Biomedical Research. Faculty of Biology. Jagiellonian University. ul. Gronostajowa 9. 30-387 Kraków. Poland.
[4] Mécanismes Adaptatifs et Evolution. UMR 7179. Muséum national d'Histoire naturelle CNRS. Paris 75005. France.
[5] Department of Biology, Evolutionary Morphology of Vertebrates. Ghent University. 9000 Ghent. Belgium.
[6] Department of Biology. University of Antwerp. 2610 Wilrijk. Belgium.
[7] Naturhistorisches Museum Bern. 3005 Bern. Switzerland.

Fecha de aceptación: 13 de noviembre de 2025.
Key words: predator-prey interactions, reptiles, sauria, venomous prey, introduced species.

Resumen: Los escorpiones pueden considerarse depredadores oportunistas que cazan principalmente invertebrados, pero las presas vertebradas no son infrecuentes en la dieta de algunos escorpiones. Este fenómeno se denomina depredación cruzada y describe la situación en la que dos especies pueden convertirse en presas la una de la otra. Presentamos aquí una nueva observación de depredación por parte del lagartija italiana (*Podarcis siculus*) sobre el escorpión balear (*Euscorpius balearicus*), así como un resumen de los casos documentados de depredación por parte de Lacertidae sobre escorpiones. El caso que describimos no solo es una nueva observación de depredación, sino también un ejemplo de una especie introducida que representa una amenaza potencial para una especie endémica.

Scorpions (Arachnida: Scorpiones) can be regarded as opportunistic predators that mainly hunt invertebrates (insects, arachnids, other scorpions; e.g. Polis, 1979; Polis & McCormick, 1986; McReynolds, 2020; Rodríguez-Cabrera *et al.*, 2020), but vertebrate prey are not rare in the diet of some scorpions (e.g. Anderson, 1956; McCormick & Polis, 1982). Infrequent predation by scorpions on lizards has been observed in both laboratory and experimental studies (Hardy, 1947; Banta, 1957; Garcia-Cardenete, 2003; Castilla *et al.*, 2008), and during *in situ* observations (Rodriguez-Mu-