# The secret life of *Epidalea calamita*: Seeking shelter in insect burrows after leaving the pond

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**Fecha de aceptación:** 03 de octubre de 2025.

**Key words:** amphibians, interspecific interactions, natterjack toad, post-metamorphic juveniles, refuge, semi-arid environments.

**Resumen:** El sapo corredor (*Epidalea calamita*) es un anfibio ampliamente distribuido en Europa y adaptado a climas semiáridos. Aunque su biología reproductiva es bien conocida, aún se sabe poco sobre su fase terrestre temprana tras la metamorfosis. Durante los meses de primavera de 2025, se realizaron muestreos diurnos semanales en una charca de Colmenar de Oreja (Comunidad de Madrid). Allí se observaron numerosos sapos recién metamorfoseados (9,0±0,9 mm de longitud) a principios de mayo refugiándose en pequeños agujeros hechos por insectos, especialmente durante las horas más calurosas del día. Este comportamiento fue frecuente en un radio de 0,8-3 metros de la charca donde, en ocasiones, hasta dos individuos compartían el mismo agujero. Este uso de refugios podría ser clave para su supervivencia, ofreciendo protección frente a depredadores y condiciones meteorológicas desfavorables. Se trata, hasta donde conocemos, del primer caso documentado de uso habitual de nidos de insectos por sapos corredores recién metamorfoseados.

The natterjack toad *Epidalea calamita* (Laurenti, 1768) is a widespread amphibian inhabiting large areas of western and central Europe. Its distribution spans from southern Scandinavia and the British Isles in the north, down to the Iberian Peninsula and parts of northern Italy in the south, and extends eastward into Poland and the Baltic states (IUCN, 2024). This species exhibits a marked preference for open habitats characterized by low vegetation and loose, sandy or stony soils, which facilitate burrowing and effective thermoregulation (Gómez-Mestre, 2014; Dursow *et al.*, 2021). Natterjacks primarily breed in shallow, sun-exposed, temporary ponds, environments that reduce predation risks associated with more permanent water bodies (Caballero-Díaz *et al.*, 2024; Cano-Barbacil & Cano, 2024). Their behavioural and physiological traits make them particularly well adapted to semi-arid and fluctuating climates, where water availability is unpredictable and temperatures can vary drastically (Reques & Tejedo, 2002). Although the reproductive biology of natterjacks has been extensively studied (see e.g., Saare & Rannap, 2021; Cano-Barbacil & Cano, 2024), the early terrestrial phase following metamorphosis remains insufficiently documented. After leaving the pond, toadlets (i.e. post-metamorphic juvenile toads) disperse into terrestrial habitats looking for shelter (Dursow *et al.*, 2021). They grow rapidly, often tripling or quadrupling in size within a few months to reach 26-50 mm by their second year (Beebee, 1983; Salvador, 1985). However, the survival strategies and shelter use of toadlets


**Figure 1:** Ephemeral pond in Colmenar de Oreja, Community of Madrid, Spain.
**Figura 1:** Charca temporal en Colmenar de Oreja, Comunidad de Madrid, España.

during the critical early terrestrial phase in natural conditions remain poorly understood (Gómez-Mestre, 2014). This knowledge gap poses a challenge for conservation, as efforts to protect breeding sites may not be enough if critical terrestrial habitats used during these early life stages are overlooked or degraded.

As part of an ongoing study on breeding phenology, we monitored an ephemeral pond in Colmenar de Oreja, Community of Madrid, Spain (40º4'40.0"N / 3º28'57.0"W; Figure 1). This shallow artificial pond (~5 m$^2$ when full) was created to support the local population of the natterjack toad, providing favourable breeding conditions due to its seasonal hydroperiod (Figure 2). The local climate is semi-arid, characterized by hot, dry summers and mild winters (Cano-Barbacil & Cano, 2024), the mean annual accumulated precipitation for the period 1991-2020 was 383.2 mm (own data), and water temperatures can reach up to 37º C at midday in the pond. The surrounding habitat consists of open Mediterranean shrubland and croplands on gypsum-rich soils. In 2025, natterjack toad egg-laying occurred from March 13th, following spring rainfall events, with the first toadlets emerging by April 29th.

Here, we report observations of natterjack toadlets (9.0±0.9 mm snout-vent length; $n$ = 11) sheltering inside small insect burrows, which appeared to serve as key refuges under the hot and dry daytime conditions (Figure 3a). A mean of 10 toadlets per day were consistently observed using insect burrows during weekly daytime field surveys conducted between May 3rd and 25th, 2025. This behaviour was observed within a 0.8-3 m radius of the breeding pond (though it likely occurs at greater distances, as toadlets were also observed more than 50 m from the water's edge just a few days after completing metamorphosis). In the area adja-

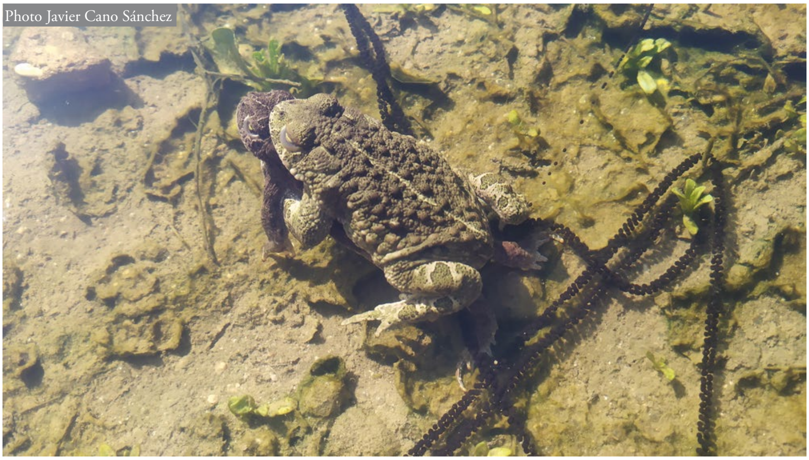


**Figure 2:** Amplexus of the natterjack toad (*Epidalea calamita*) in an ephemeral pond at Colmenar de Oreja, Community of Madrid, Spain.
**Figura 2:** Amplexo de sapo corredor (*Epidalea calamita*) en una charca temporal de Colmenar de Oreja, Comunidad de Madrid, España.

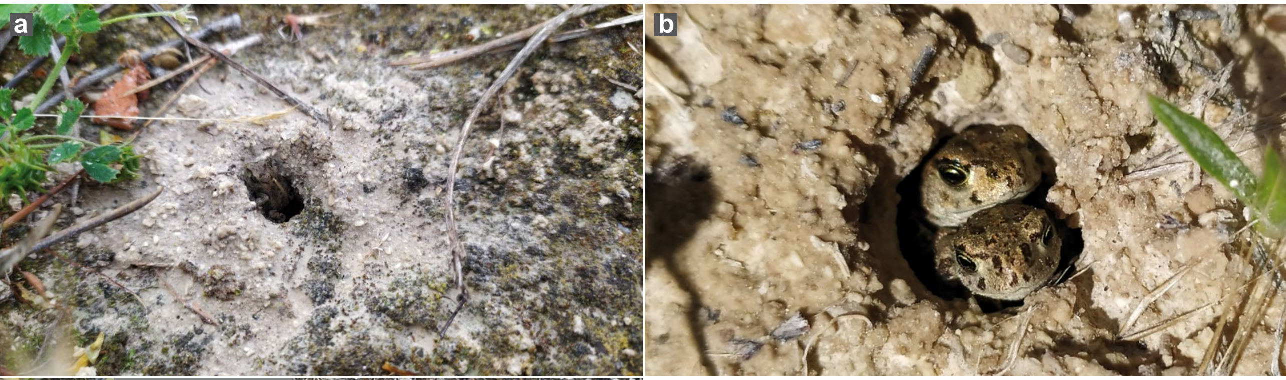



**Figure 3:** a) A natterjack toadlet (*Epidalea calamita*) using a small insect burrow as a refuge. b) Two natterjack toadlets (*Epidalea calamita*) using the same burrow. c) Insect burrow near the pond.
**Figura 3:** a) Un juvenil de sapo corredor (*Epidalea calamita*) usando un pequeño nido de insecto como refugio. b) Dos jovenes de sapo corredor (*Epidalea calamita*) usando el mismo agujero. c) Galería de insecto cerca de la charca.

cent to the pond, we estimated the presence of approximately 30-50 insect burrows, with an occupancy rate of about 20-33%. On several occasions, two individuals were seen sharing a single burrow (Figure 3b). The burrows used by the toadlets were narrow, cylindrical cavities approximately 6-10 mm in width, often located beneath small patches of sparse vegetation (Figure 3c). These structures are thought to have been created by ground-nesting insects such as beetles of the genus *Bolbelasmus* (Coleoptera) or certain species of Hymenoptera (e.g., *Bembix* sp.).

Similar behaviours have been previously documented in several anuran species; however, to the best of our knowledge, this observation represents the first recorded case of insect burrow use in natterjack toadlets. For example, both juveniles and adults of the West African savanna frog (*Phrynomantis microps*) have been documented inhabiting underground nests of ponerine ants (*Paltothyreus tarsatus*) (Rödel *et al.*, 2013). In Mato Grosso (Brazil), several amphibians and reptiles species have been reported in association with termite mounds (Duleba & Ferreira, 2014). Similarly, recently metamorphosed juveniles of the western spadefoot (*Spea hammondii*) remain close to breeding ponds for several days after metamorphosis, seeking refuge in drying mud cracks, under branches and logs, or even under decomposing cow dung (Weintraub, 1980). Ne *et al.* (1987) reported that juveniles of Asiatic toad (*Bufo gargarizans*) preferred stone cracks and holes as refuge. Experiments with common toad juveniles (*Bufo bufo*) revealed that toadlets showed a greater preference for shelters offering a wide field of vision and direct contact with moist substrates (Craioveanu *et al.*, 2017). In their adult stage, natterjack and common toads have been observed inhabiting mammal burrows and tree cavities, respectively (Gómez-Mestre, 2014; Petrovan *et al.*, 2022).

Shelter use offers multiple advantages to post-metamorphic amphibians, including protection from predators, enhanced prey ambush efficiency and important physiological benefits such as improved thermo and osmoregulation (Sih, 1997; Walsh & Downie, 2005; Liberman *et al.*, 2024). Owing to the microclimatic conditions provided by insect burrows, these refuges can help natterjack toadlets mitigate heat-related stress, such as desiccation and electrolyte imbalance (see e.g., Shoemaker, 1964; Hoffman & Katz, 1989; Schwarzkopf & Alford, 1996). Our observations highlight the ecological relevance of terrestrial microrefugia for recently metamorphosed toadlets in semi-arid environments. The repeated use of insect burrows, often by two individuals simultaneously, suggests their important role in early survival after metamorphosis. However, further research is needed to clarify whether natterjack toadlets show preferences for burrows created by specific insects. It remains unclear whether they use any available burrow indiscriminately, actively select those made by certain species, or avoid those associated with others.

To conclude, conservation strategies for amphibians like the natterjack toad should extend beyond the protection of breeding sites to include the preservation of surrounding terrestrial habitats that support key refuges. In practical terms, maintaining native vegetation is essential to preserve the structural and functional diversity of ecosystems, as it promotes a heterogeneous landscape and supports a rich community of invertebrates and other fauna that provide crucial ecological interactions and potential shelters. Furthermore, the deliberate provision of additional microhabitats, such as areas of loose sandy soil, rocks, coarse woody debris, or piles of dead wood, can enhance habitat complexity and increase the availability of refuges. Implementing these measures would not only improve habitat suitability for post-metamorphic stages but also strengthen the resilience of local populations in fragmented or changing landscapes.

**Acknowledgments:** M. García-París (MNCN-CSIC) and D. Gil-Tapetado (UCM), for their collaboration in identifying insect burrows. CCB benefited from a postdoctoral contract (ref. JDC2023-052358-I), funded by the Spanish Ministry of Science, Innovation, and Universities (MICIU/AEI /10.13039/501100011033) and the FSE+.

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