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Spontaneous exudation of skin toxin in the Spiny Toad, *Bufo spinosus* Daudin, 1803, and the Natterjack Toad, *Epidalea calamita* (Laurenti, 1768)

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Amphibians exhibit a wide diversity of antipredator defensive behaviours which vary, depending on the ecology, physiology, and morphology of the individual: jumping away, freezing still and flattening or inflating themselves, flipping on their backs, including the display of noxious skin glands or aposematic colouration, vocalising, etc. (Toledo et al., 2007). Chemical antipredator defences have been associated mostly with active foragers, which are more susceptible to detection by predators than sit-and-wait species, and with slow-moving amphibians that cannot escape predators by jumping or moving quickly (Feder and Burggreen, 1992). Unlike reptiles, which often have highly specialised toxin-delivery systems, anurans and urodeles, as passive venomous animals (Goyffon, 2022), rely mainly on chemical defence mechanisms, including static defences via dermal and parotoid gland secretions (Phisalix, 1922; Duellman and Trueb, 1994). In bufonids, the skin contains secretions rich in biogenic amines and steroid compounds (bufogenins and bufotoxins), which can cause marked irritation and, occasionally, ocular or cutaneous lesions (López-López et al., 2008; Labadie et al., 2016).

Here we report four cases of spontaneous toxin exudation in the Spiny Toad, *Bufo spinosus* Daudin, 1803, and the Natterjack Toad, *Epidalea calamita* (Laurenti, 1768), in France. Such events are rarely documented in the scientific literature (e.g., Stawikowski and Lüddecke, 2019) and seem to correspond to a defensive behaviour similar to that recently described in other toads (Szkudlarek et al., 2025; Jablonski and Ahmed, 2025).

JM and MB made our first observation on 20 September 2008 during a herpetological survey in the Ariège Region (southern France) (42.6784°N, 1.4520°E; elevation 1500 m). They observed an adult *B. spinosus* that immediately after being uncovered exuded a whitish liquid over most of its dorsal surface, from the parotoid glands to the hind limbs (Fig. 1A, B).

For *E. calamita*, two observations of toxin exudation were recorded by CE. The first one on 5 May 2009, 17:15 h in the Le Havre region, France (near 49.4569° N, 0.1936° E; elevation 5 m). This observation involved a juvenile (probably two years old), which the observer discovered under a piece of wood, that spontaneously secreted toxins only from the parotid glands. The second observation involved an adult male (63.4 mm snout-vent length, weight 26.7 g) observed on 26 May 2010, 12:30 h, in the same population (near 49.4633° N, 0.24019° E; elevation 5 m). The secretion of toxins was so intense that rapid, small squirts of liquid were observed, as well as a whitish liquid spreading all over the dorsal side, with bigger volumes around parotoids and hind limbs (Fig. 2). This toad reacted immediately when discovered under a rubber shelter plate used for toad population survey, without any other kind of action from the observer. The toad stayed in a head-butting posture which exposed the parotoid glands to predators.

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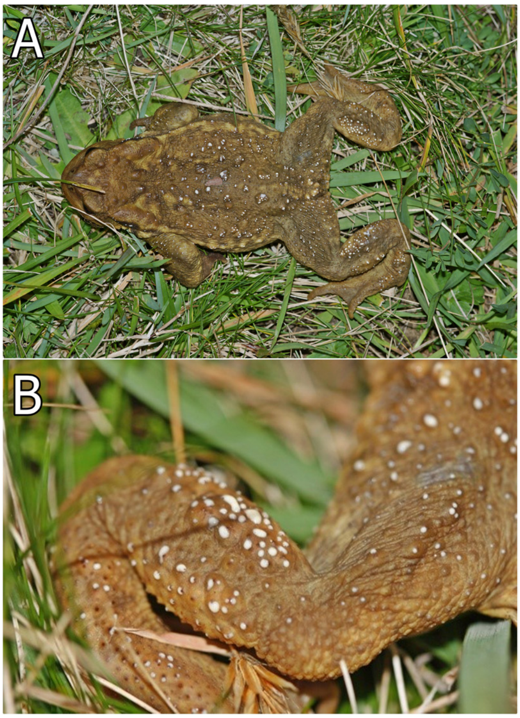

Figure 1. (A). Overview of the dorsal side of *Bufo spinosus*, which secretes toxin. (B) Close-up of the toxin-bearing hind leg. Photos by Matthieu Berroneau (A) and Jean Muratet (B).

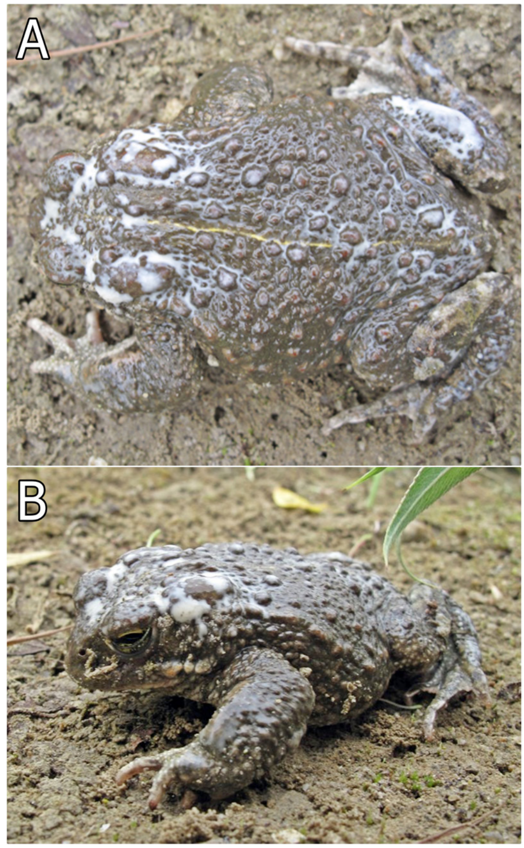

Figure 2. View of the dorsal (A) and lateral (B) sides of an adult *Epidalea calamita*. Photos by Christophe Eggert.

As with the first observation, the toad did not move nor attempt to escape.

The last observation by GD, on 9 May 2012 in Istres (PACA Region), France (43.6021°N, 4.9689°E; elevation 48 m) also involved an *E. calamita* individual. When uncovered beneath its shelter, it secreted a large quantity of whitish toxin within seconds, covering most of the dorsal body and hind legs with it (Fig. 3).

Beebee (1983) noted that toads use their chemical defences "*only under extreme duress and never under circumstances such as routine handling, even when freshly caught in the field"* and that Natterjack Toads need "*severe physical pressure or an actual bite*" to produce the white toxins. He adds that "*toads are fairly placid sorts of creatures and they don't start squirting these poisons around unless they feel very threatened indeed. Just picking up a toad will never panic it enough to secrete its poisons*". Long before Trevor Beebee, François-Marie Daudin (1803) reported about Natterjack Toads that "*lorsqu'on les touche, ils font quelques fois sortir de toutes leurs verrues une liqueur blanchâtre qui n'occasionne aucun dommage à la peau*" (English translation: "When touched, they sometimes release a whitish liquid from all their warts,

Figure 3. Overview of the dorsal side of an adult *Epidalea calamita*. Photo by Grégory Deso.

which causes no damage to the skin"), while specifying that the same phenomenon is obtained with spadefoot toads when they are mistreated. Phisalix (1922) stated that squirting needs tetanic stimulation, severe trauma, or the action of violent skin irritants. Moreover, she noticed that toxin can persist in the glands throughout an individual's life, leading to gland inflation. By studying the anti-predator behaviours of the Common Toad, *Bufo bufo* (Linnaeus, 1758), in an experimental setting, Kowalski et al. (2018) observed that toads only release toxins after predator attacks, presumably to minimise metabolically costly poison use.

Having handled hundreds of Natterjack Toads (Christophe Eggert, unpublished data), we agree with Beebee (1985) and Stawikowski and Lüddecke (2019) that individuals do not usually readily secrete their poison, but the observations we report here nevertheless show that some specimens react more or less strongly even without being handled. Being suddenly exposed to light after being sheltered can frighten some of them enough to trigger their chemical defence mechanism.

These observations likely represent an active defensive response, comparable to that described for the European Green Toad, *Bufotes viridis* (Laurenti, 1768), by Jablonski and Ahmed (2025), in which toxin secretion occurred spontaneously and was associated with a partial body-raising posture (Szkudlarek et al., 2025). Although a distinct posture was noted only in one of our cases (with a head-butting posture, a common behaviour displayed to prevent attacks in Bufonidae and other families; see Ferreira et al., 2019), the rapid and sometimes "explosive" release of skin toxins without mechanical pressure suggests a voluntary counterattack chemical defence. Similar to others like that documented in different Bufonidae, such as the Smooth-sided Toad, *Rhaebo guttatus* (Schneider, 1799), and the Cane Toad, *Rhinella marina* (Linnaeus, 1758) (Jared et al., 2011; Mailho-Fontana et al., 2014). In the latter – an invasive species – toxic defence contributes to a drastic reduction in local non-resistant species (Pettit et al., 2020, 2021; Harvey et al., 2022).

For humans, intoxication by toad skin toxins is uncommon, but has been documented. In France, Labadie et al. (2016) reported a case of painful, erythematous, and maculopapular lesions following an exposure to *B. bufo* secretions. Ocular injuries caused by toad toxin have also been reported (Van Tittleboom et al., 1988). Given the abundant secretion capacity observed in *E. calamita*, similar local effects on human skin cannot be ruled out.

Overall, these observations suggest that spontaneous skin toxin exudation in European toads is likely underreported and underestimated in both its frequency and ecological significance. This defensive mechanism represents an effective antipredator strategy that may also entail risks for humans and domestic animals, which are often overlooked (Nagy et al., 2024). Observations such as these, even as single events, can broaden the scope of information about the natural history and role of toxins in defence in two bufonid species, and facilitate future research in this subject.

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