SPIXIANA	47	2	301–302	München, August 2025	ISSN 0341-8391

Scientific note

The tail-vibrating behaviour is exhibited by all three *Zamenis* species found in Italy

(Serpentes, Colubridae)

Matteo Riccardo Di Nicola, Salvatore Russotto & Francesco Paolo Faraone

Many snake species can utilise their tails to enact different behaviours, such as caudal luring of prey (e. g. Fathinia et al. 2015), caudal distraction for predatory purposes (Mullin 1999), caudal movement for signalling conspecifics (e. g. Senter et al. 2014), and caudal movement or the display of brightly coloured tail parts for antipredatory purposes (e. g. Greene 1973, Allf et al. 2016). Antipredatory behaviours are hypothesised to present danger signals to the predator or to divert the predator's attention away from more vulnerable parts of the body (e. g. Greene 1973, Bjelica et al. 2023).

Among defensive caudal displays, tail vibration is one of the most commonly observed, both in venomous and non-venomous snake species (Rowe et al. 2002).

Allf and colleagues (2016) examined the evolution of the rattlesnake rattle and rattling behaviour, showing that defensive tail vibration is nearly ubiquitous in Viperidae and widespread in Colubridae, suggesting a common origin of the behaviour across the two families, and thus that the ability to vibrate the tail for defensive purposes preceded the acquisition of the rattle in rattlesnakes.

In Europe, there are 57 species of snakes (Di Nicola et al. 2022a), and tail vibration sensu stricto – understood as a relatively small-amplitude oscillation of the tail with a relatively high frequency – for defensive purposes, has been specifically described by the scientific literature only for three of them, namely *Coronella austriaca*, *Zamenis lineatus*, and *Z. longissimus* (Dyugmedzhiev 2020, Di Nicola et al. 2021b, 2022b, Lombardo et al. 2022). Furthermore, defensive tail waving – understood as broader undulation, without vibration – has been described for *Natrix tessellata* and *Dolichophis caspius* (Bjelica et al. 2023, 2024).

The defensive tail vibration is also reported, without specific cases described, for *Elaphe dione* (Ramezani et al. 2011). Moving to thematic books, we found references to defensive tail vibration as a possible behaviour for *E. dione*, *Hemorrhois ravergieri* and *Z. situla* (see: Steward 1971, Bruno & Maugeri 1990, Baier et al. 2013, Speybroeck et al. 2016). Furthermore, Polyakova et al. (2019) report tail vibration in a captive female *Z. situla* during reproduction.

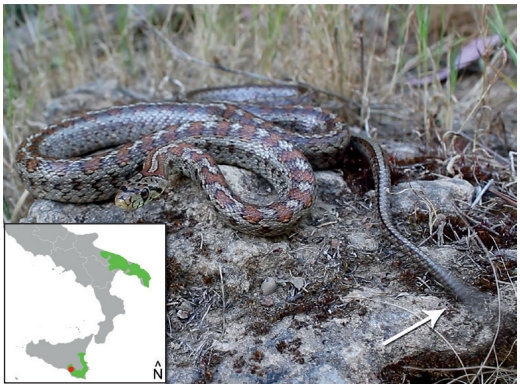

Fig. 1. Tail-vibration in the adult *Zamenis situla*. Inset: *Z. situla* distribution in southern Italy (green) with the observation site (red dot).

In this note, we report an observation in the wild of tail-vibrating behaviour sensu stricto, supported by video documentation, in the Leopard snake, *Z. situla* (Linnaeus 1758).

Zamenis situla is one of three *Zamenis* species in Italy, alongside *Z. lineatus* and *Z. longissimus* (Di Nicola 2019). The origins of Italy's *Zamenis situla* populations are still unclear due to limited genetic research. Some authors suggest that land connections from the Pliocene to the Pleistocene facilitated active colonisation (see Scillitani & Turrisi 2011), but ancient human-assisted dispersal may be another hypothesis, similar to what occurred with other snake species in Italy (e. g. Faraone et al. 2020).

The Leopard snake is mainly found in dry and stony environments and is a diurnal snake, sometimes active even during and after rainfall, with crepuscular and nocturnal habits during the warmer months (Speybroeck et al. 2016). It is aglyphous and if handled, most individuals prove to be only moderately prone to biting (Di Nicola et al. 2021a).

Matteo Riccardo Di Nicola (corresponding author), Istituto Zooprofilattico Sperimentale del Piemonte, Liguria e Valle d'Aosta, Via Bologna 148, 10154 Turin, Italy; e-mail: matteoriccardo.dinicola@izsplv.it

Salvatore Russotto, Contrada Grassura Mollaka Faia, 92027 Licata, Italy

Francesco Paolo Faraone, Department of Biological, Chemical and Pharmaceutical Sciences and Technologies, University of Palermo, Via Archirafi, 18, 90123 Palermo, Italy

On 21st April 2024, at 5 p.m. (partly cloudy weather; T: 19°C, min. 13, max. 21), near Caltagirone (Sicily, 37°06'N, 14°30'E), an adult Leopard snake (estimated length >70 cm) was spotted while standing in the shade along a path in a mixed reforestation area of eucalyptus and pine trees, with bushy undergrowth. The snake was momentarily handled and placed on a nearby rock to take documentary photographs. At the time of capture, the snake was not particularly reactive and did not attempt to bite. Once induced into a basking position on the rock, it began to repeatedly vibrate its tail, before eventually moving away, just initially continuing the tail vibrating. The moment was captured on film (https://youtu.be/pfcvU18Ong4), from which a frame was extracted (Fig. 1). To avoid further disturbance, the snake was left to retreat and continued its slow escape into the vegetation.

Among European snake species, defensive tail-vibrating behaviour does not appear to be consistently observed in all encountered individuals, but rather sporadically (Dyugmedzhiev 2020, Lombardo et al. 2022, Bjelica et al. 2023, authors pers. obs.).

Our cases described for *Zamenis* spp., as well as the one for *C. austriaca*, involved individuals observed in shaded and cool conditions, who did not exhibit a prompt escape reaction to the presence of the observers (see Di Nicola et al. 2021b, 2022b). Thus, the circumstances at the time of observation could have influenced this defensive behaviour. Potentially, a range of factors, including climatic and environmental conditions, as well as predator type, may contribute to triggering the display. Given the limited knowledge on this topic, further reports of these behaviours in the wild are valuable for advancing toward a better understanding of the mechanisms influencing this defensive display in European snake species.

Acknowledgements. Handling was conducted with permissions from Italian Ministry of Ecological Transition (MiTE prot. N. 0024526.28/02/2022 and ISPRA prot. N. 0009384/2022).

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