

## Defensive display in the California Tiger Salamander, *Ambystoma californiense* (Caudata, Ambystomatidae)

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Prey-mediating survival mechanisms in salamanders are numerous and have been very broadly categorized as avoidance or anti-predator behaviours (Brodie et al., 1991; Duellman and Trueb, 1994; Stebbins and Cohen, 1995; Chivers et al., 1996). These were already differentiated by Brodie (1977), who provided 12 categories for what he believed were the general adaptations displayed by 31 different salamander genera in North America. For example, Brodie (1977) reported that different members of the genus *Ambystoma* showed distinctly different postures and behaviours when threatened. *Ambystoma talpoideum* (Holbrook, 1838) assumed a head-down and tail-up posture, while the sympatric *A. maculatum* (Shaw, 1802) used a raised-arch tail method. Of seven ambystomatid species illustrated by Brodie (1977), each had a marginally or significantly different repertoire to engage in anti-predatory behaviour. However, there has been no previous report on the anti-predator display employed by *A. californiense* Gray, 1853, which is observed and reported here.

On 24 January 2019 we investigated a buried cattle trough on the Blue Oak Ranch Reserve, Diablo Mountains, California, USA (37.3801°N, 121.7291°W), in which *A. californiense* had been reported to breed (Alvarez et al., 2021). Approximately 2 m southwest of the trough lay a 1.5 m x 2.0 m x 13 mm sheet of plywood, partially overgrown with vegetation along its edges. We overturned the plywood to find a single adult *A. californiense*. Upon its exposure, the salamander quickly assumed a pose that appeared to be a defensive display: it raised its tail and arched it over its head, while flattening the head downward against the substrate (Fig. 1A). We continued to watch the salamander for approximately

3 min, and after 2.5 min it quickly twisted its body in the opposite direction and again arched the tail over the head (Fig. 1B). The tail then began to exude a secretion, similar to what has been observed in other members of the genus (see Brodie, 1977). Congeners such as *A. gracile* (Baird, 1859) and *A. maculatum* from the United States and Canada typically put their head down, with tail arched downward, while exuding glandular secretions. *Ambystoma ordinarium* Taylor, 1940 and *A. velasci* Dugès, 1888 (reported as *A. lacustris*), which are both found in Mexico, exude secretions along the tail while thrashing it from side to side in a similar rapid action as displayed by the salamander we observed.

The individual of *A. californiense* we uncovered appeared to recognize in us a potential predator and immediately engaged in an anti-predator behaviour similar to those seen in other salamanders (Brodie, 1977; Duellman and Trueb, 1994). This included tail lashing, wagging, and undulating, body coiling, general immobility, and noxious skin secretions, all of which are also associated with aposematic coloration. These seven deterrent mechanisms are among the many that have been reported for salamanders by other researchers (Brodie, 1977; Mason et al., 1982; Duellman and Trueb, 1994; Stebbins and Cohen, 1995).

Although Duellman and Trueb (1994) suggested that amphibians could be viewed as relatively defenceless, they clearly have evolved many specialized behaviours to mitigate predation (Brodie et al., 1991). *Ambystoma californiense* appears to employ a combination of behaviours that may contribute to predation avoidance, or at least minimize injury, by signalling its unprofitability (Caro, 2005). These factors, in association with their aposematic coloration (Winebarger et al., 2018), may result in reduced predation pressure for individuals and populations, in some areas.

**Acknowledgements.** We are grateful to the University of California Blue Oak Ranch Reserve for access to the site. Amanda Murphy and an anonymous reviewer provided a helpful and constructive review of the manuscript, for which we are grateful.

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**Figure 1.** California Tiger Salamander (*Ambystoma californiense*) discovered under a piece of plywood in Blue Oak Ranch Reserve in the Diablo Mountains just east of San Jose, California, USA. (A) Immediately after discovery, the salamander quickly curled its tail over its head, protecting especially its eyes. (B) A couple of minutes later, it suddenly rotated its body into the opposite direction, again curling its tail over its head. At this point, whitish glandular secretions began to exude from the tail (red arrow).

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