NATURAL HISTORY NOTES

CAUDATA — SALAMANDERS

***AMBYSTOMA CALIFORNIENSE* (California Tiger Salamander). TRAPPING MORTALITY.** Small vertebrates have been collected and surveyed using pitfall traps since the early 1930s (Murie and Murie 1931. J. Mammal. 12:200–209). This method is commonly used in the collection and sampling of amphibians in various habitats (Heyer et al. 1994. Measuring and Monitoring Biological Diversity, Standard Methods for Amphibians. Smithsonian Institution Press, Washington, D.C. 364 pp.). In some cases, researchers select specific locations for pitfall traps to "target" a species or life stage (Sheilds 1985. Herpetol. Rev. 16:14). Recent survey protocols adopted by the United States Fish and Wildlife Service that guide the collection of threatened and endangered species give specific methods for the collection of species that are in decline (e.g., https://www.fws.gov/sacramento/es/survey-protocols-guidelines/). In California, USA, *Ambystoma californiense* has been in decline for decades and is currently listed as either endangered or threatened at the federal level and is listed as threatened by the State. These listings obligate surveyors to use specific methods to conduct surveys that can detect the species in its habitat. The survey protocol is designed to minimize or eliminate harm to the target species while maximizing the likelihood of capture. Here, we report on the use of this protocol to collect *A. californiense* at a military base where we incurred an unanticipated mortality to a juvenile salamander.

We constructed a pitfall trap line in association with a breeding pond for *A. californiense* on Travis Air Force Base, Fairfield, California (Alvarez et al. 2021. Herpetol. Rev. 52:274–278). The trap line followed the survey protocol in that it was constructed with a plastic material that could not be climbed and was lined with 9-L buckets that included moss and a sponge for moisture and cover; a lid that could be tightly sealed if needed; and an escape stick to reduce mortality to non-target animals (following Aubry and Stringer 2000. Northwest. Nat. 81:69). The traps were checked daily, when operable, with one to two checks per day, depending upon salamander activity level.

During a rain event on 5 December 2019 (6.35 mm, following cumulative rains throughout the fall at the site), water collected in one pitfall trap causing it to become completely filled overnight and a second trap to be partially filled. Pitfall traps were checked early the following morning and *A. californiense* were collected within several traps. The first of the two flooded traps had no *A. californiense* inside and the trap was bailed of its water and sealed closed. The second trap contained a dead juvenile *A. californiense*, that was presumably drowned. The salamander was removed, measured, and collected to be deposited into the Museum of Vertebrate Zoology, Berkeley, California. Again, the trap was sealed closed. After the surface waters receded, the traps that were susceptible to inundation were located to higher areas. This modification to our trapline eliminated further flooding of the traps during this trap year.

We suspected that the juvenile *A. californiense* drowned in the partially inundated bucket, in part because the morphology and physiology of juvenile *A. californiense* is directed at a terrestrial lifestyle until these individuals become adult salamanders (Stebbins and McGinnis 2012. Amphibians and Reptiles of California, University of California Press, Berkeley, California. 538 pp.; JAA, pers. obs.). We acknowledge that there are numerous possible sources of mortality, but in four years of nearly continuous trapping, mortalities have only been attributed to desiccation of juveniles that were found on the soil surface in short grasses, and to freezing of exposed animals trapped in utility boxes (Alvarez et al. 2021, *op. cit.*). Further, we noted that the tail morphology of juvenile *A. californiense* lacks the flattened fin-like shape of adult *A. californiense* (Fig. 1; Twitty 1941. Copeia 1941:1–4). We speculated that a juvenile *A. californiense* that is trapped in a smooth-sided bucket, which is nearly filled with water, precludes this age cohort from climbing out, and continuous swimming may not have been sustainable, due in part to a tail morphology not designed for swimming (Landberg and Azizi 2010. Funct. Ecol. 24:576–587). Although we did not test the swimming ability of juveniles, we suspect their tail morphology limits their ability to swim in inundated buckets (Frolich and Biewener 1992. J. Exp. Biol. 162:107–130;

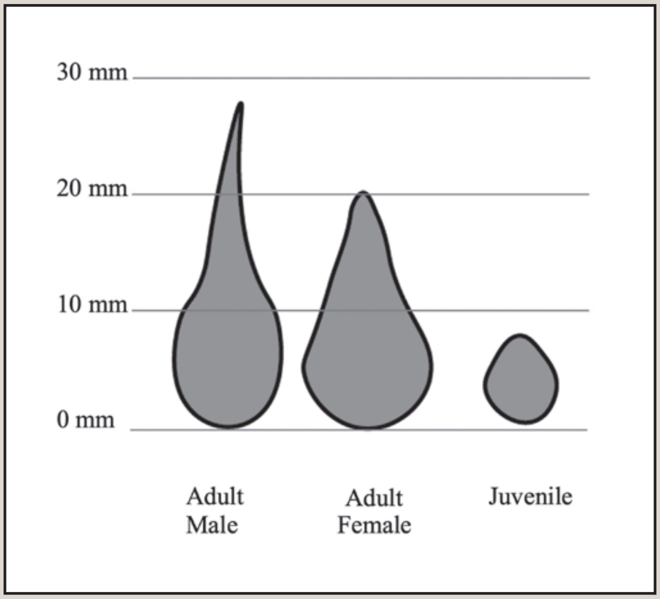

Fig. 1. Relative sizes and shapes in cross section at mid-point of tail of *Ambystoma californiense*. Drawn from road-killed salamanders or museum specimens. Cross section differences suggest a different level of ability to swim.

Fig. 2. Pitfall trap raised above flooding level using soil mound.

Azizi and Landberg 2002. J. Exp. Biol. 205:841–849). This may be confounded by lower temperatures and recent developmental metabolic demands associated with metamorphosis, that likely slow or limit the ability of salamanders to move effectively (Landberg and Azizi 2010, *op. cit.;* Stebbins and McGinnis 2012, *op. cit.*).

The type of mortality described here was not anticipated for several reasons. First, after many years of using this method to collect *A. californiense*, we rarely had traps become inundated (i.e., <5 times out of >10,000 trap days). Second, we rarely collected juvenile salamanders during the winter rainy season. Kogut and Padley (1997. Trans West. Sec. Wildl. Soc. 33:75–78) reported on mortality from drowning in pitfalls but focused on non-amphibian mortality, noting that no amphibians were trapped during the period when their pitfalls were flooded.

Since *A. californiense*, and other amphibians collected using this technique, may be in decline, rare, threatened, or endangered, every care should be taken to reduce or eliminate injury or mortality to this and other declining species. In recent years, we have continued to experience flooding of traps and have experimented with various techniques for reducing potential for mortality of juvenile *A. californiense*. First, whenever possible, we have located new trap lines in areas that are not prone to pooling water. However, we have found that very heavy rainfall events can cause sheet flow that inundates traps located even in higher areas once the soil has been saturated. Second, during rain events that are predicated to be heavy, we either close and seal the traps or periodically bail water from the traps during the rain event. Given that *A. californiense* are most active on rainy nights, we carefully monitor and manage the water levels in the traps to ensure we can still collect data while not endangering juvenile salamanders. Third, we have raised the level of individual traps by creating a slight soil mound around the trap to raise it above the flooding level while still creating easy access for salamanders (Fig. 2).

We feel that extra care should be taken in areas with impermeable soils, unpredictable or seasonally heavy rainfall, or other conditions that may allow one or more pitfalls to flood. We also feel that mechanisms that include a flotation device should be tested (Kogut and Padley 1997, *op. cit.*). This might include small pieces of wood that are left in the bottom of the pitfall but are changed if they become waterlogged from moist conditions.

Pitfall traps are a very effective technique for collecting small vertebrates and invertebrates. However, use of this technique requires careful consideration of unanticipated events of mortality or injury (e.g., flooding, predation, desiccation, etc.). Additionally, all mortality to special-status species should be presented in an easily accessible journal so that users of this technique can learn from others and limit or eliminate future unanticipated mortalities.

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AMBYSTOMA MACULATUM **(Spotted Salamander). INJURY FREQUENCY.** Small vertebrates like salamanders can obtain injuries during migrations from falls, prey handling, or predator attacks. Changes in the frequency of injuries can be indicative of changes occurring in the broader ecosystem, but knowledge of baseline injury rates can be helpful for assessing future change. Over the course of seven years, we captured 4694 *Ambystoma maculatum* surveying a drift fence surrounding a breeding wetland in south-central Tennessee on the Cumberland Plateau (35.22390°N, 85.97117°W; WGS 84). The drift fence consists of metal flashing encircling the pond with pitfall traps located every 10 m on both sides of the fence. For this analysis, we only used individuals captured while entering the wetland. We opened pitfall traps and closed regularly spaced gates for surveys between mid-January to mid-March annually from 2015–2021. Pitfall traps were checked daily, and all individuals were taken to the lab for morphological measurements (SVL and mass) before being returned to the opposite side of the fence. Over the seven-year period, 0.44% of individuals had recorded injuries including missing toes or tail tips. We assessed whether males or females were injured more frequently using a chi-square test. This revealed that the two sexes experienced equal rates of injury ($\chi^2 = 1.96$, df = 4692, P = 1.00). Overall, it appears that injury rates in this area are very low despite observations of potential predators such as *Procyon lotor* (Raccoon) or *Strix varia* (Barred Owl). Alternative explanations may be that survival from injuries is