HERPETOCULTURE

HERPETOCULTURE NOTES

CAUDATA — SALAMANDERS

***AMBYSTOMA ANNULATUM* (Ringed Salamander). DEVELOPMENT.** *Ambystoma annulatum* is a pond-breeding salamander that occurs in the Ozark and Ouachita Mountains of Missouri, Oklahoma, and Arkansas, USA. Adults breed in the fall in ponds with permanent hydroperiods, with larvae overwintering prior to undergoing metamorphosis the following spring to early summer (Semlitsch et al. 2014. Herpetologica 70:14–22). Typical larval period length is therefore 6–8.5 mo (180–255 d; Hutcherson et al. 1989. J. Herpetol. 23:181–183). Here I describe extreme cases of larval period length in *A. annulatum*, along with what is a previously unreported phenotypic anomaly for this species.

Two cattle tank mesocosm studies were conducted at the University of Missouri in 2011–2012 (Anderson and Semlitsch 2014. Pop. Ecol. 56:265–273) and 2012–2013 (Anderson and Semlitsch 2016. J. Anim. Ecol. 85:548–558). These experiments were conducted in identical 1000-L outdoor cattle tank mesocosms (hereafter, tanks) set up in September 2011 and 2012 following standard protocols (e.g., fill with water, and add leaf litter and planktonic organisms; Semlitsch and Boone 2009. *In* Dodd [ed.], Amphibian Ecology and Conservation: A Handbook of Techniques, pp. 87–14. Oxford University Press, Oxford, UK). *Ambystoma annulatum* were reared from eggs collected from two different natural populations for each study. In 2011, eggs were collected at Daniel Boone Conservation Area, Warren County, Missouri, USA. In 2012, eggs were collected from Fort Leonard Wood, Pulaski County, Missouri, USA. These two sites are 140 km apart. Eggs hatched in the laboratory, and were then added to cattle tanks in varying densities, depending on the experiment conducted that year.

In the spring of 2012, a larva was observed that appeared substantially lighter in color than others in its tank (Fig. 1). After all other larvae had undergone metamorphosis in the spring/summer of 2012, the light-colored individual remained in a larval state (hereafter, it was nicknamed "Melo"). The tank containing this individual was filled with water through fall 2012 to observe how long it would remain in a larval state. In spring of 2013, another similarly light-colored individual was seen in a different tank in the second experiment. Upon the completion of the second experiment in July 2013, this new individual (hereafter, "Pirate") also had not metamorphosed (i.e., still retained larval morphology of external gills and a flattened tail). This second individual was also missing an eye.

Both individuals were consolidated into one tank and growth monitored every 6 mo, as long as they remained in an aquatic form. Each individual was captured with an aquarium net and dorsally photographed over a ruler. Snout–vent length was measured using ImageJ. The cloaca was visually inspected during the fall months, their typical breeding season, to observe signs of maturation, assuming it would appear similar to paedomorphic adults of *A. talpoideum* (Mole Salamander) if present (Patterson 1978. Copeia 1978:649–655). *Hyla versicolor* (Gray Treefrog) tadpoles from nearby pools were added haphazardly each

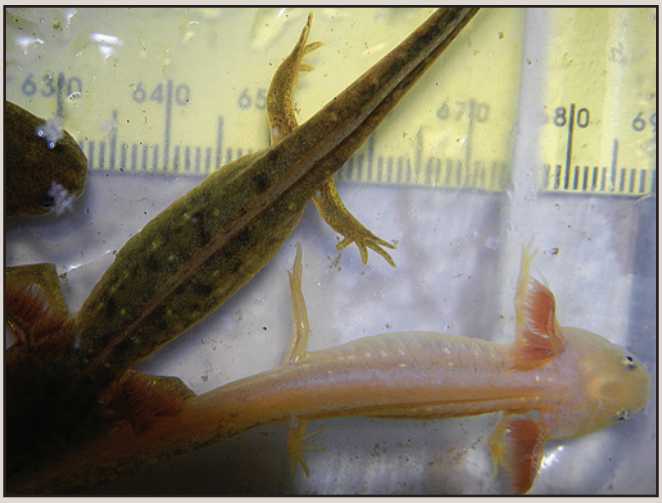

FIG. 1. Development anomaly in *Ambystoma annulatum*. The top larva shows the typical color pattern, while the bottom individual ("Melo") shows the white patterning.

FIG. 2. Development anomaly in *Ambystoma annulatum*, resulting in a yellow-orange coloration and extreme larval period length.

spring along with partially decomposed leaves for additional habitat complexity and nutrients. The tank remained open for the majority of the year, except in the summer months when approximately 70% was covered with a shade cloth cover to limit extreme temperatures. Monitoring ended in July 2016, when both specimens died within days of each other due to unknown causes, potentially from unsuitable water chemistry, temperature, or oxygen levels.

Both individuals started out pale yellow-orange in coloration (Fig. 2) before transitioning into more white with darker pigmentation on the dorsum and tail (Fig. 3). Both individuals exhibited high growth rates for the first 24 mos, before reaching a rough asymptote of 60 mm SVL (Fig. 3). At the time they died, the larval period lengths for "Melo" and "Pirate" were 1741 and 1357 d, respectively. Cloacal morphology never changed throughout the experiment to indicate either had become sexually mature.

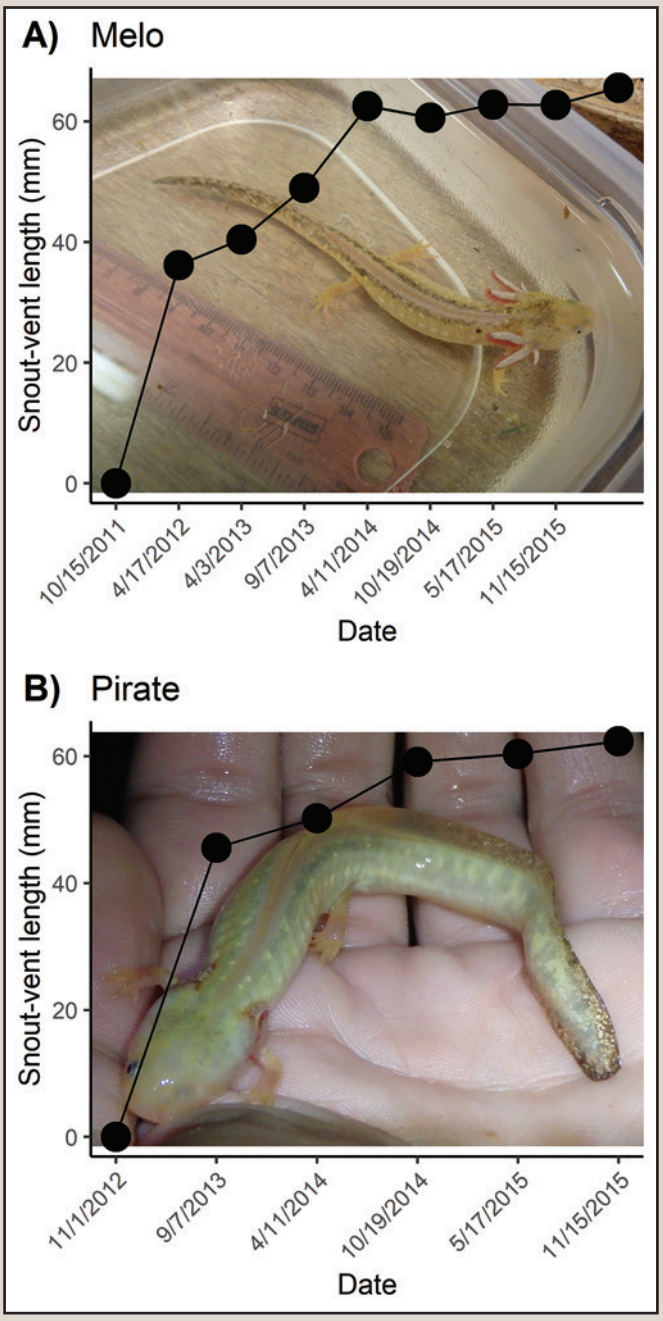

FIG. 3. Growth in snout–vent length of "Melo" (A) and "Pirate" (B), both larval *Ambystoma annulatum*. Note the missing eye in B.

I am unaware of similar reports for wild individuals of other species in the Ambystomatidae, and based on the available evidence, these individuals 1) did not become sexually mature, and 2) were not albino, based on eye coloration (Fig. 3). Thus, "Melo" and "Pirate" are examples of extreme larval period length for an ambystomatid while also lacking pigmentation. They most closely resembled *A. mexicanum* (Axolotl) in appearance, a species that also typically does not undergo metamorphosis.

The mechanism that induced this atypical development could not be determined. A physiological mechanism seems the most likely explanation that would produce this anomaly. The thyroid gland typically controls both pigmentation and metamorphosis, and thus a faulty thyroid hormone is a possible cause. Because the eggs that produced these individuals came from locations separated by over 140 km, it is not likely a genetic or physiological issue affecting only a single population. One possible mechanism is that the plastic tanks leached materials into the water that affected their development or ability to undergo metamorphosis. This seems unlikely, however, because there have been decades of studies on ambystomatids in cattle tanks, including several in the same tanks used here with *A. annulatum*, with thousands of individuals having metamorphosed and no reports of such a phenotypic variant.

Observations of *A. annulatum* in natural populations that appear similar to these individuals are not known, though albino individuals have been reported (Trauth et al. 2004. The Amphibians and Reptiles of Arkansas. The University of Arkansas Press, Fayatteville. 421 pp.). Other species of ambystomatids have been documented to exhibit albinism and other aberrant color forms (Dyrkacz 1981. SSAR Herpetol. Circ. 11:1–31; Petranka 1998. Salamanders of the United States and Canada. Smithsonian Institution Press, Washington, DC. 587 pp.). Together with colleagues I have conducted 8 years of pond surveys in over 200 wetlands for larval *A. annulatum* in Missouri and encountered numerous light-colored individuals, especially in ponds that have basins dominated by clay substrates. However, we have not observed any individuals with this coloration and similar in size to the two reported here. If this developmental anomaly does occur in natural populations, detecting it could be exceedingly difficult, as it could be misconstrued as a simple difference in coloration. Only with keeping individuals in the lab would it be possible to follow their ontogenetic trajectories to see if they remain in a suspended larval state.

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ANURA — FROGS

***LITHOBATES CAPITO* (Gopher Frog). CAPTIVE REPRODUCTION.** *Lithobates capito* is listed by the South Carolina Department of Natural Resources as a state endangered species. (South Carolina Department of Natural Resources - State Wildlife Action Plan: 2010–2015. SC Rare, Threatened & Endangered Species Inventory, SC. www.dnr.sc.gov/species/state.html). At the request of the South Carolina Department of Natural Resources, Riverbanks Zoo and Garden established an *ex situ* colony of this species by acquiring tadpoles from two separate