Variability in the Larval Coloration of the California Tiger Salamander

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The morphologic characteristics of many biphasic amphibians, particularly of their adult phases, have previously been described in detail. The larval phase of California tiger salamanders (*Ambystoma californiense*) has been described by Stebbins (1985. Houghton Mifflin Company, New York, NY, USA), and more recently in Stebbins and McGinnis (2012. University of California Press, Berkeley, CA, USA), as having a yellowish-gray dorsal pattern. Storer (1925. University of California Press, Berkeley, CA, USA) provided more detail: "...dark green and light yellow without obvious pattern, dorsal and caudal fins with many large diffuse melanophores." Historically, these descriptions were ample to differentiate the California tiger salamander from other, native amphibian species with which it was sympatric.

In the 1950s, however, the eastern tiger salamander (*Ambystoma tigrinum*) was introduced into California through the use of its larvae as fishing bait. In reporting on this non-native species, Riley et al. (2003. Ecological Applications 13:1263–1275) noted that its larval form is particularly difficult to differentiate from that of the native western species. Petranka (1998. Smithsonian Institution Press, Washington D.C., USA) described *A. tigrinum* larvae as yellow, brown, olive or greenish, mottled with dark brown or black—similar to Storer's (1925) characterization of *A. californiense* larvae. Petranka, too, emphasized that the tiger salamander taxa can be difficult to distinguish morphologically.

Above: The author dip netting for California tiger salamander larvae in a breeding pond in Contra Costa County, California.

Left: Example of California Tiger Salamander larvae with greenish coloration and mottled with black typical of clear pools.

Below: Example of California Tiger Salamander larvae with solid olive coloration typical of moderately turbid to clear pools.

Above: This is a typical example of an adult California tiger salamander. **Right:** Example of California Tiger Salamander larvae with translucent to white coloration and pink iridescence typical of turbid pools.

To augment the current literature, we report here the color variations we have observed in larval California tiger salamanders. We note that there is a greater variability in the color of the dorsum of the western species' larvae than suggested by Stebbins (1985), Stebbins and McGinnis (2012), and Storer (1925). In particular, we suggest that color variations in California tiger salamander larvae may be even more similar to those of the eastern tiger salamander than previously reported, particularly under certain water-clarity conditions.

In eastern Contra Costa County in April 2013 we collected California tiger salamander larvae during routine monitoring surveys in three ponds within a single hydrologic watershed. This population of *A. californiense* is known to be free of any genetic component of the eastern tiger salamander (Alvarez. 2004. Herpetological Review 35:344). Pondwater clarity ranged from clear (Nephelometric Turbidity Unit [NTU] <10) to very turbid (NTU > 2000). Using dip nets, we captured from 0 to 41 larvae at each of 45 ponds in our study area.

In the majority of sampled ponds, collected larvae fell into two size cohorts (Figure 1a–c). This suggested a bimodal temporal breeding pattern for the California tiger salamander within this area in 2013. Among collected individuals, irrespective of size, larvae were of similar color within each pond. Larvae ranged from translucent to white with a pink iridescence, to nearly solid olive or greenish mottled with black. Significantly, color patterns appeared to be associated with water turbidity: white or translucent larvae occurred in very turbid bodies, while green, darkly mottled individuals were associated with clear pools. The association between color and water turbidity needs further study. Vegetative cover, predation pressure, and other factors may also play a role.

The variation in color for this species has critical implications for field identification and species conservation. Current literature does not completely reflect the breadth of color variations we have observed and reported here, or the resemblance of the western species' larvae to those of eastern tiger salamanders. *A. californiense's* true range of larval coloration may conflate its identification with its invasive congener, *A. tigrinum*, whose larvae it can strongly resemble in clear water bodies. We urge against relying on color to distinguish individuals through phenotypic characterization. California tiger salamander larvae clearly have highly variable coloration, which may be closely associated with turbidity levels. Species identification should include a genetic component in areas where the invasive congener is suspected.

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