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A case of idiopathic ocular heterochromia in *Ensatina eschscholtzii xanthoptica* Stebbins, 1949, in northern California, USA

Jeff A. Alvarez[1,*], Tommy Dryer[2], Ryan Anderson[3], Bayan Ahmed[4], Sage Bylin[3], Amanda Casby[5], Jacky Daley[6], Mira Falicki[3], Megan Fee[5], Alex Freeman[7], Julia Gaudio[8], Jordan Graves[8], Caroline Hamilton[5], Kevin Herrera[3], Ian Jackson[3], and Melia Zimmerman[9]

Physical anomalies or malformations have been reported for many species of amphibians worldwide (e.g., Meteyer, 2000; Henle et al., 2017; de Souza et al., 2021). A recent report by de Souza et al. (2021) documented that the various physical anomalies from 111 reviewed frog species had enigmatic causes and were likely derived from a wide range of predatory attacks and/or environmental degradation. Gonçalves et al. (2019) found a high level of mutagenicity in tadpoles in Brazil that could be attributed to agricultural activities (e.g., pollutants, habitat modification and degradation). In the United States, Johnson et al. (2001) reported on the physical abnormalities in both frogs and salamanders in California and considered infection by the trematode *Ribeiroia* to be a major cause. Blaustein and Johnson (2003) reported on 60 amphibian species with malformations, which were attributed to a complex suite of potentially interacting mechanisms. It appears clear that the causes of these malformations and anomalies remain a critical area of study. We noted that reports of physical malformations or anatomical anomalies in salamanders are uncommon and perhaps the issue is underreported in this group. Herein we report an instance of ocular heterochromia in the plethodontid salamander *Ensatina eschscholtzii* in the northern San Francisco Bay Area of California, USA.

As part of peer-level training to identify and work with amphibians in the region, we conducted surveys of woodland salamanders (family Plethodontidae) at the Fairfield Osborn Preserve in Sonoma County, California, USA (38.3423° N, 122.5938°W; elevation 520 m). We performed time-constrained visual encounter surveys in a mixed coastal oak woodland habitat type characterized by steep hillsides and perennial and ephemeral water features (e.g., creeks, springs, ponds). These surveys focused on turning dead and downed woody debris that was primarily composed of logs and large branches of oak (*Quercus* sp.) and California bay (*Umbellularia californica*). Upon discovery of salamanders, we identified individuals to species, noted their condition, age class, and specific location, and returned them to the site of capture.

Under a decomposing branch in *U. californica* woody debris, we located and temporarily collected a female *E. eschscholtzii* adult. Based on our geographic location, we determined that this specimen was a Yellow-eyed Salamander, *E. e. xanthoptica*. This taxon is known by and named for the conspicuous yellow-golden coloration of the upper third of the iris in the eye, which is not present in any of the six subspecies to the north, east, or south. Approximately 16 km north of our location, the Oregon salamander (*E. e. oregonensis*) occurs, and is a morphotype with black eyes (Stebbins, 2003). Approximately 90 km south of our survey location, the Monterey ensatina (*E. e. eschscholtzii*) is another subspecies with black eyes (McGinnis and Stebbins, 2018). Both the nominate subspecies and the Oregon morphotype intergrade with *E. e. xanthoptica*, but our

[1] The Wildlife Project, PO Box 188888, Sacramento, California 95818, USA.
[2] WRA Environmental Consultants, 2169-G East Francisco Boulevard, San Rafael, California 94901, USA.
[3] Forde Biological Consultants, 10664 Presilla Road, Santa Rosa Valley, California 93012, USA.
[4] Department of Water Resources, 715 P Street, Sacramento, California 95814, USA.
[5] Stantec, 2890 Gateway Oaks Drive, Sacramento, California 95833, USA.
[6] Environmental Science Associates, 2600 Capitol Avenue, Suite 200, Sacramento, California 95816, USA.
[7] McCormick Biological, 12-3600 Pegasus Drive, Bakersfield, California 93308, USA.
[8] Swaim Biological, 4556 Contractors Place, Livermore, California 94551, USA.
[9] Fairfield Osborn Preserve, Sonoma State University, Lichau Road, Penngrove, California 94951, USA.
[*] Corresponding author. Email: jeff@thewildlifeproject.com

experience at this site suggests that *E. e. xanthoptica* is the only ensatina occurring in Fairfield Osborn Preserve.

On the individual in question, we immediately noticed that the right eye was atypical – completely dark – while the left eye included the yellow-golden colouration in the upper third of the iris (Fig, 1). We observed no aberrant colouration in all other (n = 19) ensatinas observed in the same area, whose yellow-golden upper iris allowed their unequivocal identification as *E. e. xanthoptica*. We concluded, through discussion, that despite our collective, extensive experience with this and the other ensatina subspecies, none of us could recall any instances of heterochromia. In fact, a literature search produced no reports of complete or sectoral heterochromia in any salamander species.

The cause of this anomaly, like many physical anomalies in amphibians, is unclear (de Souza et al., 2021). Lourenço-de-Moraes et al. (2013) and Henle et al. (2017) did report heterochromia in Bahia's Broad-snout Casque-headed treefrog, *Nyctimantis arapapa* (Pimenta et al., 2009), and in the common toad, *Bufo bufo* (Linnaeus, 1758), respectively. We also found a single image from an online source that suggests that a red-eyed treefrog (*Agalychnis callidryas*) was also found with heterochromia (https://birdingspotsmn.com/product/red-eyed-leaf-frog-with-heterochromia), but this could not be verified. Although we believe, based on close examination, that our observation is best classified as sectoral heterochromia, it may be complete heterochromia that could not be differentiated in the field. We feel that this report of ocular heterochromia is significant because of the geographic location, and we recommend that observers closely examine the entire salamander before making a species identification because in this area of northern California, *E. eschscholtzii* might be confused with a similar declining sympatric species, the red-bellied newt, *Taricha rivularis* (Twitty, 1935), whose dark eyes are a diagnostic feature.

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Figure 1. Adult *Ensatina eschscholtzii xanthoptica* from the Fairfield Osborn Preserve in Sonoma County, California, USA, presenting with ocular heterochromia in the right eye. This condition manifests itself by an entirely black iris (blue arrow) instead of the diagnostic yellow-golden upper iris seen in the left eye with. Photo by R. Anderson.

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