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First Description of Bilateral Anophthalmia (Eyelessness) in a Western Bluebird Nestling

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ABSTRACT

We report on the first documented case of bilateral anophthalmia, the congenital absence of both eyes, in a Western Bluebird (*Sialia mexicana*). The nestling was found in May 2022 in a nest box hung in an English walnut (*Juglans regia*) orchard that was part of the Putah Creek Nestbox Highway in Yolo County, California. The anophthalmic chick was part of a brood of four, of which the other three appeared normal. Anophthalmia is rarely encountered in wild birds; a literature search produced only two other records for passerines, one of bilateral anophthalmia in an American Robin and one of unilateral anophthalmia (congenital absence of one eye) in a Western Bluebird. In non-passerine birds, anophthalmia has been linked to selenium exposure and other environmental contaminants. Given the rarity of anophthalmia, documenting occurrences of birds with this and other congenital malformations may provide valuable information to clarify the costs and benefits of conserving wildlife in agricultural landscapes.

Most remaining semi-natural habitats in California's Central Valley occur as riparian ribbons along waterways surrounded by agricultural lands. Putah Creek, one such riparian area within Yolo and Solano counties, flows west-to-east through orchards, row crops, and urban areas. The creek has been a focus for long-term avian studies, resulting in many published papers on diversity, response to habitat restoration, and effects of climate on avian fitness (Dybala et al. 2015, 2018; Trochet et al. 2017; Riggio et al. 2023). The Putah Creek Nestbox Highway (PCNH), established in 2000 by the Museum of

Wildlife and Fish Biology at UC Davis, is 30-km long with over 200 boxes set out in 12 nodes across the landscape.

While conducting nestling surveys to understand the effects of temperature spikes on cavity-nesting songbirds in agriculture, we found a Western Bluebird (*Sialia mexicana*) nestling with no eyes. Anophthalmia, the congenital absence of one (unilateral) or both (bilateral) eyes, and microphthalmia (the reduction in development of one or both eyes) regularly occur in domestic fowl but have rarely been documented in wild passerine birds (Berger and Howard 1968, Pourlis 2011). Here, we document a Western Bluebird nestling hatched with bilateral anophthalmia—to our knowledge the first documented in the literature. The nest box with the anophthalmic chick was one of 10 in a PCNH node at a private walnut orchard along Putah Creek, in Winters, Yolo County, California). This individual was in box BRO6 at the latitude and longitude of 38.52^{o} N, 121.98^{o} W at 41m above mean sea level.

The anophthalmic chick was part of a brood of four nestlings, the other three of which developed and fledged normally. The nest box was monitored from nest initiation, through clutch development and incubation, and until the nestlings fledged. We also painted their toenails with non-toxic polish to enable individual tracking across measurements.

We first discovered the anophthalmic chick during a nest check on 6 May 2021. Following our research protocol, we measured all four nestlings, recording the wing chord, tail, skull, nares to tip, and tarsus in millimeters, weight in grams, and fat on an integer scale from 0 (absent) to 6 (highest possible; Table 1). Wing chord is closely tied to a chicks' age (days since hatching; Pinkowski 1975), so based on these nestlings' wing chords, we inferred that the anophthalmic chick ("Blue") hatched on the same day as its siblings "Yellow" and "Pink" (estimated as 30 April, so 6 days old on 6 May) but before its sibling "Purple" (hatch day estimated as 2 May).

We measured the nestlings again on 13 May and on 15 May 2021. On the 15th, the four fledglings were banded and photographed (Figure 1). Blue was morphologically similar to its siblings in weight, wing chord, and tarsus, but its fat score dropped dramatically between the first measurement and the second taken seven days later (i.e., at an estimated 13 days old), suggesting that it may have been underfed compared to its siblings. Western Bluebird chicks begin to open their eyes at 6-7 days (Pinkowski 1975), so the chicks with eyes may have outcompeted their anophthalmic sibling for food delivered by parents. On 25 May 2021, we checked the nest for the final time, and all nestlings had fledged except Blue, which appeared to have fully developed feathers but had died in the nest box. The specimen was deposited at the Museum of Wildlife and Fish Biology.

Table 1. Estimated age in days since hatching and measurements (in mm except weight) during development of Western Bluebirds in nest box BRO6. Nestling "**Blue"** is the bird that expressed anophthalmia. NR = not recorded

Date	Nestling	Age (days)	Weight (g)	Fat	Wing Chord	Tail	Skull	Bill nares to tip	Tarsus
6 May	**Blue**	**6**	**14.2**	**3**	**17**	**0**	**23.1**	**4.0**	**15.4**
	Yellow	6	14.6	4	17	0	23.5	3.7	14.6
	Pink	6	13.8	4	16	0	23.0	3.1	12.3
	Purple	4	10.2	4	13	0	21.4	3.2	11.4
13 May	**Blue**	**13**	**24.2**	**1**	**43**	**14**	**29.3**	**5.5**	**22.8**
	Yellow	13	26	3	46	13	30.6	5.6	21.7
	Pink	13	27.8	3	46	12	30.0	5.5	22.2
	Purple	11	23.8	3	41	10	29.7	4.9	20.8
15 May	**Blue**	**15**	**NR**	**1**	**57**	**20**	**29.3**	**5.4**	**22.5**
	Yellow	15	NR	2	55	20	31.5	5.7	21.3
	Pink	15	NR	3	54	18	30.0	4.9	21.0
	Purple	13	NR	4	51	15	29.7	5.0	21.2

Anophthalmia is very rare in wild birds. PCNH teams have banded over 1,600 bluebirds since 2000 and have documented no other nestlings with this condition. Anophthalmia has mostly been reported in waterbirds, where it has been linked to environmental contaminants (Ohlendorf and Heinz 2011). We found only two records in the literature of anophthalmia in passerines: one of an American Robin (*Turdus migratorius*) in Massachusetts (Berger and Howard 1968) and the unilateral anophthalmia of a Western Bluebird at a nest box in Corvallis, Oregon (Eltzroth 1996). Both anophthalmic individuals also displayed abnormal beak shape; similarly, Blue appeared to have an elongated bill compared to its siblings (Figure 1).

In humans, anophthalmia and microphthalmia (A&M) can be caused by genetic or environmental factors (Harding and Moosajee 2019, Selzer et al. 2022), so we speculate that A&M in our specimen could have been caused by either or a combination of both. Mutations in over 90 human genes have been linked to A&M, most commonly new mutations in SOX2 or OTX2 (Williamson and FitzPatrick 2014, Harding and Moosajee 2019). Toxic exposures (e.g. alcohol, thalidomide, radiation), Zika virus, vitamin A and folate deficiency, and maternal hypothyroidism have also been linked to A&M (Selzer et al. 2022). Correspondingly, seven Black-necked Stilts (*Himanotopus mexicanus*) from the San Joaquin Valley of California likely acquired anophthalmia from selenium toxicosis caused by irrigation runoff from high-selenium soils (Ohlendorf and Heinz 2011).

Figure 1.
Comparison of nestling with anophthalmia (right) to its sibling Western Bluebird with eyes (left) and close-up of affected nestling.

Photos by Katia Goldberg.

Given the complexity of eye development, exposure to endocrine disruptors and neurodevelopmental toxicants (i.e. some pesticides) may increase the risk of A&M, but the rarity of the condition impedes strong inference (Kalliora et al. 2018). Because Western Bluebirds feed on insects gleaned from leaves, mother birds living or foraging on farms that spray foliar pesticides could incidentally consume toxins and pass them on to their developing eggs, thus giving rise to environmentally derived A&M in the developing chick. If contaminant exposure caused our specimen's A&M, we might expect to see clustered cases in time and/or space, but a single case could simply be a chance mutation.

Monitoring malformations and mortalities among birds remains important in understanding the effects of agriculture, pesticide use, and disturbance (e.g. Stanton et al. 2018) along Putah Creek. Furthermore, efforts to conserve birds in agricultural landscapes often include placing nest boxes in proximity to areas where agrochemicals are applied. Understanding the tradeoffs between potential mortality from pesticide exposure and expanded reproductive capacity provided by nest boxes will help managers design more efficient and effective management programs.

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