

# Atypical Timing and Placement of Egg Masses by Foothill Yellow-legged Frogs (*Rana boylei*) Baird 1854

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The Foothill Yellow-legged Frog (*Rana boylei*) is a stream obligate (but see Alvarez and Wilcox 2021) native to the coastal mountains of California and Oregon, where its range extends north into the Willamette Valley, and also east to the Sierra Nevada foothills of California (Storer 1925). *Rana boylei* are considered lek breeders; males arrive early at lekking sites to defend territories (Wheeler and Welsh 2008), with oviposition usually occurring between late March and early June (Storer 1925). Egg masses are traditionally attached to cobble or boulders substrates peripheral to the main stream channel in areas with slightly flowing water, although silt, sand, gravel, pebbles, and wood have also been observed as oviposition substrates (Fuller and Lind 1991, Wheeler and Welsh, van Hattem et al. 2021). As biphasic amphibians, *R. boylei* are compelled to time their larval stage to take advantage of the spring flush of algal growth brought on by lengthening daylight (Wassersug 1975, Wilbur 1980), yet not so early that rain-induced high flows scour egg masses from their attachment points (Mount 1995). Thus, *R. boylei* usually return to the same lekking areas (Kupferberg 1996), annually, after winter rains have diminished but flows are sufficiently high to support developing

eggs and larvae through mid-summer (Storer 1925, Stebbins 1951, Zweifel 1955, Kupferberg 1996). Herein we report a case of oviposition conditions previously undescribed for *R. boylei*.

On the afternoon of 7 June 2021, the authors were working in the headwaters of Copeland Creek on the Mitsui Ranch Preserve in Sonoma County, California (38.331060 N, -122.577012 W, WGS 1984), when they detected three (*Rana boylei*) egg masses in an isolated pool. Drought conditions had diminished Copeland Creek to the point where few remaining pools had surface flow connecting them. West Pool was a slender, oblong depression that measured approximately 4 m long and nearly 1 m at its greatest width (Fig. 1). The pool was scoured into the south side of the channel against a precipitous bank. The south bank at West Pool is held to a near-vertical slope by the well-developed root system of a California bay-laurel (*Umbellularia californica*) tree, which is deeply undercut near the west (terminal) end of the pool. The three egg masses were attached to free-floating woody debris at the top of the water column where maximum channel depths were 9 cm, 10 cm, and 25 cm, respectively, from upstream to downstream (Fig. 2). The wood to which the egg masses were attached

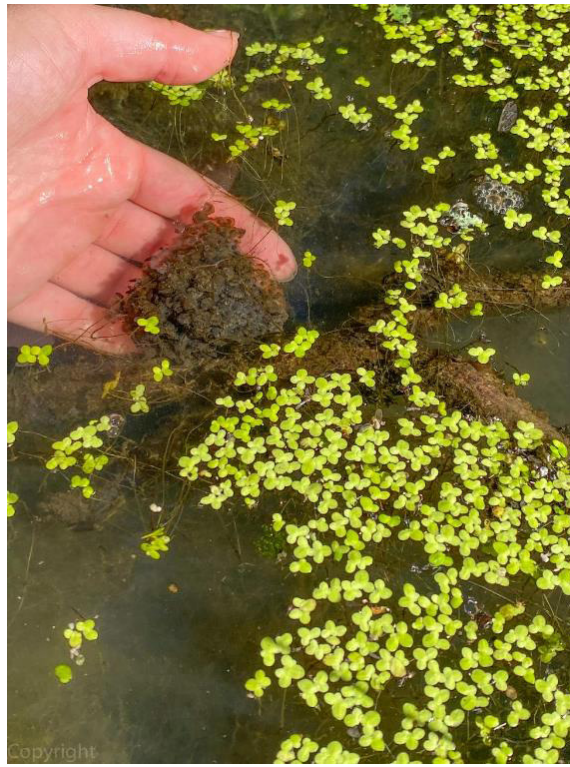
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**Fig. 1.** Conditions of west pool during the time of observation. A stump is visible, at upper right, where the local power company cut two trees, creating a western exposure for sunlight on West Pool in Copeland Creek, Sonoma County, California. Photo by J. T. Wilcox.



**Fig. 2.** White pin flags mark the locations of three Foothill Yellow-legged Frog (*Rana boylei*) egg masses; two smaller masses are at the left flag and the larger one is at the right flag. Copeland Creek, Sonoma County, California. Photo by J.T. Wilcox.



**Fig. 3.** Hatching egg mass of a Foothill Yellow-legged Frog (*Rana boylei*) in Copeland Creek, Sonoma County, California, on 7 June 2021. Note the embryos clinging to the mass on the lower left. Photo by J.T. Wilcox.

was comprised of small, branched tree limbs > 2.54 cm in diameter. The two smallest egg masses were half the size of the third (more typical in size) and were located at shallower depths at the top of the pool. These two smaller egg masses were more advanced in development as indicated by hatched larvae that were closely associated with the outer margins of hatched egg capsules (Fig. 3). The larger egg mass was in a much earlier stage of development (Gosner stages 14–15). Some of the embryos on the outside of this mass were opaquely white, indicating they may have been unfertilized, or parasitized by fungus (Fig. 4).

In several ways, the oviposition sites we observed at West Pool do not conform to typical sites previously described for *R. boylei*. While categorizing key microhabitat components of oviposition sites, Lind et al. (2016) found that only 1% of egg masses were oviposited in mid-channel pools, and 1% of egg masses were oviposited in water with no flow. We noted that suitable (more typical) cobble substrate was available at the bottom of West Pool but was not used for oviposition at this time. *Rana boylei* egg masses have previously been observed attached to logs, but the percentage of egg masses reported attached to logs is very small: 1% reported in Fuller and Lind (1991), and 4% reported in Lind et al. (2016). Further, logs are a more permanent, solid substrate compared to very small, free-floating branches used in this observation.

We believe that rapid changes due to extreme drought conditions greatly influenced the site and timing of oviposition by *R. boylei*. Within Copeland Creek, the only previously known lekking ground was 200 m upstream in a series of runs, glides, and pools (Alvarez and Wilcox 2019); a reach of the creek with almost no canopy cover. The creek has been intensively surveyed over the past 11 breeding seasons (Rose et al. 2023) and no egg masses had ever been observed outside of the lekking area described above. However, extreme drought eliminated the option for ovipositing in the traditional lekking ground for *R. boylei* because this section completely dried in early April, before breeding occurred. At least three times, during weekly surveys, we observed amplexed *R. boylei* pairs progressively retreating downstream as stream pools dried.

*Rana boylei* prefers an open canopy for lekking (Zweifel 1955, Lind et al. 1996, Van Hattem et al. 2021). By the time of our observation, the reach of Copeland Creek contained within the Mitsui Ranch Preserve was reduced by drought to only four remaining pools with no measurable flow between them, and West Pool had the only open canopy. By approximately 1500 hrs, on the day of our observation, the sun reached the relatively open canopy of the western side and the pool was receiving full afternoon insolation.

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**Fig. 4.** Irregularly-shaped Foothill Yellow-legged Frog (*Rana boylei*) egg mass attached to a floating stick over the deepest point in the center of the pool, at West Pool, Copeland Creek, Sonoma County, California on 7 June 2021. Photo by J.T. Wilcox.

and the timing of oviposition. Drought appears to have forced *R. boylei* to shift to a novel downstream oviposition site in Copeland Creek, resulting in oviposition at least 3 weeks later than any time recorded in the previous 12 years (J. Wilcox, unpubl. data), which is contrary to other observations from pond-breeding amphibians under prolonged drought on the same site. Wilcox et al. (2017) observed that drought conditions resulted in earlier breeding for California Newt (*Taricha torosa*) in a northern California pond, but rains arrived early that year and it appeared that *T. torosa* had the behavioral plasticity to take advantage of early rains. In this case, multiple *R. boylei* facultatively oviposited in an atypical setting in rapidly deteriorating, drought-induced conditions. In addition, each of the three females chose to attach egg masses to small floating woody debris at the top of the water column. We speculate that females may have chosen the best opportunity for sunlight exposure for the developing embryos, and perhaps where oxygen exchange was greatest due to surface mixing from wind disturbance on the pool surface. West Pool was completely dry within a week of our observation and all larvae perished. *Rana boylei* normally oviposit in quieter places after winter rains have peaked and flooding is less of a risk (Zweifel 1955). However, in an ephemeral stream such as Copeland Creek, delayed oviposition becomes an increasing risk in the face of stream flows ceasing all together. Many female amphibians commence atresia (phagocytic digestion of oocytes) when conditions become poor, presumably shunting much needed energy toward surviving harsh conditions (Ogielska and Bartmańska 2004). Since body size is correlated to the number of eggs in a clutch, young females of small body size may explain the small size of the masses we observed (Ogielska and Bartmańska 2004). Perhaps the naïveté of young

*R. boylei* and the strong drive to reproduce overrides the message to conserve energy when confronted with extremes.

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#### NATURAL HISTORY NOTE

## Long-nosed Leopard Lizard (*Gambelia wislizenii*), Regal Horned Lizard (*Phrynosoma solare*), and other items in the diet of the Chihuahuan Raven (*Corvus cryptoleucus*) in Cochise County, Arizona

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The Chihuahuan Raven (*Corvus cryptoleucus*) is commonly encountered in desert grasslands and desertscrub in southeastern Arizona, from the New Mexico border west to the Sonoita and San Rafael valleys, and occasionally as far west as western Pima Co. It is intermediate in size between the Common Raven (*Corvus corax*) and American Crow (*Corvus brachyrhynchos*) and is best distinguished from them by snowy white base feathers on the neck (Wise-Gervais 2005, Stejskal and Rosenberg 2015). The Chihuahuan Raven is a generalist omnivore; a wide variety of plant and animal material compose the diet (Bailey 1928, Aldous 1942, Dwyer et al. 2020).

By far the most detailed study of the diet of the Chihuahuan Raven was conducted by Aldous (1942), who identified 288 different food items, including 214 animal and 74 plant taxa in 827 Chihuahuan Raven stomachs, mostly from Texas (his sample included 10 adults from Arizona). About half (49.67%) the food of the adult Chihuahuan Raven was composed of an assortment of animal matter, including earthworms, spiders and scorpions, centipedes and millepedes, insects, snails, amphibians, reptiles, birds and bird

eggs, and mammals, chiefly carrion. Of the plants in the diet, grain sorghums were the most important and made up more than a fourth of the adult birds' diet by volume. A variety of other cultivated crops were found in the stomachs of Chihuahuan Ravens. Wild fruits (particularly prickly pear [*Opuntia* sp.] hackberry [*Celtis* sp.], and buckthorn [*Condalia* sp.]) are consumed in large quantities during the summer and early fall (Imler 1939, Aldous 1942, Oberholser 1974).

In the study by Aldous (1942), reptiles, amphibians, and fishes together made up only slightly more than 1 percent of the food of the adult Chihuahuan Ravens, but they occurred in almost 10 percent of the stomachs. In this group, reptiles, including lizards, snakes, and turtles, predominated, and of the reptiles, lizards were taken most frequently. The Texas Horned Lizard (*Phrynosoma cornutum*) was the most common lizard in the diet (from 5 stomachs). Sherbrooke (2003) noted that Chihuahuan Ravens often capture Texas Horned Lizards that they feed to their young in the nest. Earless Lizard (*Holbrookia* sp.) was found in 3 stomachs. Other lizards noted, and