REPTILES & AMPHIBIANS

Observations of Amplexus in Mountain Yellow-legged Frogs (*Rana muscosa*) in the San Jacinto Mountains

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The Mountain Yellow-legged Frog (*Rana muscosa*) is an endangered species that inhabits high-elevation montane streams and lakes in California and brumates during the winter (Calatayud et al. 2021; Hammond et al. 2021). While the *R. muscosa/R. sierrae* (Sierra Nevada Yellow-legged Frog) species complex in the Sierra Nevada is thought to reproduce during the late spring or early summer (Matthews and Preisler 2010; Fellers et al. 2013), few data have been collected on reproduction in the wild for the southern distinct population segment of *R. muscosa*, which inhabits the San Bernardino, San Gabriel, and San Jacinto Mountains. The southern distinct population segment is listed as endangered at both the state and federal levels (USFWS 2002; CNDDB 2024) and is in a particularly precarious state, with an estimated population of only a few hundred adults remaining in the wild (Backlin et al. 2015; Chambert et al. 2022). Tadpoles are often documented in the southern population, but egg masses are rarely found (A. Backlin, pers. comm.; Curtis et al., unpubl. data). Information on the reproductive phenology of wild *R. muscosa* in southern California is sparse, although understanding this aspect of the species' natural history could benefit *ex-situ* conservation breeding efforts (Michaels et al. 2014).

To begin gathering information on reproductive phenology, we combined camera traps and visual surveys with environmental data collection (Table 1) at one site inhabited by wild *R. muscosa* in the San Jacinto Mountains (elev. ~1,829 m). We deployed camera traps (Reconyx Hyperfire 2, timelapse mode: 15-minute interval) and reviewed images from traps deployed in four different pools from 4 April 2021–10 June 2021. Photographs revealed two instances of *R. muscosa* engaged in amplexus out of the water at two separate locations at 1630 h on 9 April 2021 and at 1900 h on 16 April 2021. Air temperatures recorded on the camera traps at the time of amplexus were 20.5 °C (daily average = 10.7 °C) and 7.7 °C (daily average = 6.3 °C), respectively.

We also conducted visual encounter surveys and collected environmental data (Table 1) at the same site in the first half of 2022. This sampling period allowed us to monitor *R. muscosa* during seasons when severe weather conditions have historically limited in-person data collection. Between February and April 2022, we observed multiple amplectant pairs (Fig. 1). Our first observation was of an amplectant pair at 1400 h on 17 February 2022 resting at the bottom of a plunge pool with a wetted width of 3.8 m and an average

Figure 1. Amplectant pairs of Mountain Yellow-legged Frogs (*Rana muscosa*) in nature: Amplectant pair underwater on 17 February 2022 (A); amplectant pair underwater on 6 April 2022 (B); amplectant pair out of water on 17 May 2023 (C). Photographs by Michelle Curtis.

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Table 1. Dates and environmental data collected for observations of amplexus at one southern California site inhabited by the Mountain Yellow-legged Frog (*Rana muscosa*). A dash indicates that data were not available for that date.

Date	Time	Detection Method	Water Temperature (°C)	Air Temperature (°C)	Relative Humidity (%)
9 Apr 2021	1630 h	Camera trap	—	20.5	—
16 Apr 2021	1900 h	Camera trap	—	7.7	—
17 Feb 2022	1400 h	Visual survey	1.1	5.5	58.9
6 Apr 2022	1225 h	Visual survey	7.8	20.6	56.0
17 May 2023	1350 h	Visual survey	6.7–10.6	20.6	59.3

depth of 0.54 m. We used a spirit-filled thermometer to measure water temperature, which was 1.11 °C. Snow fell on 15 February 2022 but had almost entirely melted, and only a thin layer of icy snow (< 5 cm) lined the stream's banks. We used a Kestrel 3000 weather meter and documented air temperature (5.5 °C) and relative humidity (58.9%). We surveyed 410 m of the stream and found no other amplectant pairs, adults, tadpoles, or egg masses. However, we did detect two dead metamorphs, one 20 m downstream of the amplectant pair and one in the same pool. We revisited the site on 2 March 2022, detecting no adults and one dead metamorph. On 6 April 2022, we resurveyed the site and found another amplectant pair at 1225 h in 0.41 m of water in a pool with a wetted width of 4.64 m. Based on our visual survey, the second pair was smaller and likely younger than the first pair we had observed. At the time of the observation, water temperature in the pool was 7.8 °C, air temperature was 20.6 °C, and RH was 56%. We observed two additional females that appeared gravid with swollen abdomens and one female that appeared to have recently oviposited based on the slack skin on her sides. We found this female in the same pool where we observed the first amplectant pair in February. We did not detect egg masses on any surveys; however, we did find first-year tadpoles on 6 June 2022 in both pools where we observed amplexus.

In 2023, we conducted additional surveys during the fall, winter, and spring seasons on 18 February, 11 April, 17 May, 14 November, and 11 December. At 1350 h on 17 May 2023, we observed an amplectant pair out of the water on a rock in a shallow section of the stream, with a wetted width of 0.95 m and a depth of 0.33 m (Fig. 1). Air temperature was 20.6 °C and RH 59.3%. Water temperature at the site that day ranged from 6.7 to 10.6 °C. During this survey we also documented two additional adults, two juveniles, two frogs of an unknown life stage, and 16 second-year tadpoles.

Information on the breeding timeline of the southern population segment of *R. muscosa* is limited, but previous accounts suggest that it begins in April (Storer 1925; Wright and Wright 1949). Breeding at high-elevation sites in the Sierra Nevada Mountains occurs when the ice melts from the lakes and streams between June and August (Zweifel 1955; Pope and Matthews 2001; Fellers et al. 2013). Our observations suggest that *R. muscosa* in the San Jacinto Mountains start breeding earlier and over a wider range of time (February–May) and temperatures (water: 1–8 °C, air: 5.0–20.6 °C) than previously known. Whether this is related to warmer winters or greater winter temperature fluctuations that have been documented in this region is currently unknown; additional data on reproductive phenology and water temperatures are needed to test this hypothesis. More winter surveys in streams with known inhabitants also could provide valuable information that could help determine how *R. muscosa* are maintained in *ex-situ* conservation programs (Jacobs et al. 2021). A better understanding of links between environmental conditions and reproduction in this species could also be critical for mitigating impacts of climate change on *R. muscosa* and other endangered montane amphibians.

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