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Management Considerations Related to the Ovipositing Phenology of California Red-legged Frogs (*Rana draytonii*) in the Sierra Nevada of California

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***Abstract.*—Timing of ovipositing is typically a function of environmental conditions for amphibians. The timing of this natural history function is often predictable, particularly for bi-phasic species that occur in temperate environments. For declining species, aspects of the reproductive natural history are used to facilitate detection of occupied habitats. Using regular winter and spring breeding egg mass counts, we found that the California Red-legged Frog (*Rana draytonii*) breeding season is consistent between two disparate populations: coastal sites and sites in the Sierra Nevada. In the Sierra Nevada, frogs breed through the winter and early spring months with an average peak in the number of egg mass observations occurring in mid-March, which is approximately one month prior to the onset of egg mass surveys recommended by regulatory agency survey guidelines. We recommend conducting egg mass surveys in the Sierra Nevada from mid-February to mid-April to accurately detect breeding for this species.**

Key Words.—coastal; egg mass surveys; inter-annual variability; phenology; populations; opportunistic; ovipositing

Amphibian reproductive events are typically timed with climatic conditions associated with the habitats in which they live (Duellman and Trueb1994; Stebbins and Cohen 1995; Saenz et al. 2006). Many species are capable of breeding over long periods, while others breed only during seasonal rain events (Bragg 1965; Rastogi 1980; Jørgensen 1988; Stebbins and Cohen 1995; Stebbins and McGinnis 2012). Breeding timing is associated with optimal environmental conditions that can support successful reproduction (Duellman and Trueb 1994; Stebbins and Cohen 1995). The environmental conditions that amphibians experience may change throughout the range of a species, within different habitat types, or due to anthropogenic activities, particularly for those wide-ranging species that may occur in various types of habitats (Schoenherr 2007; Wheeler et al. 2015, 2018).

In California, many anuran species have a very wide geographical range, can use a wide range of habitats, and may occur over a varied elevational gradient (e.g., Western Toad, *Anaxyrus boreas*, American Bullfrog, *Lithobates catesbaeinus*, and California Red-legged Frog, *Rana draytonii*). In northern and southern California, bi-phasic amphibians (having both an aquatic larval and a terrestrial adult life stage) occur within a wide variety of habitats, including grasslands, woodlands, and riparian and chaparral habitats; and can range from sea level to > 2,000 m elevation (Stebbins and McGinnis 2012; Flaxington 2021). The resulting variation in environmental conditions may alter various aspects of the breeding phenology of a species within their ranges.

The California Red-legged Frog, which occurs from Mendocino County south to the Santo Domingo watershed in Baja California, Mexico (Shaffer et al. 2004; Peralta-Garcia 2016), experiences significant variation in the available conditions under which it may occur (Schoenherr 2007). This species breeds in the winter and spring throughout its range (Storer 1925; Stebbins 1951; Alvarez et al. 2013; Wilcox et al. 2017; North et al. 2022). Additionally, there appears to be a high level of interannual variability in the period when egg masses are observed, with coastal populations appearing to breed earlier in the year (December/January) than inland populations (February/March; Alvarez et al. 2013). Moreover, the latest calendar date when an egg mass was observed was at an inland population (eastern Contra Costa County, California) on 17 April 2012 (Alvarez et al. 2013). To date, oviposition phenology has not been considered for populations in the Sierra Nevada. Herein we examine the time period when California Red-legged Frog egg masses have been observed among surveyed populations in the Sierra Nevada and consider the management implications associated with species surveys and detecting reproduction.

Materials and Methods

We examined data from three sites in two counties (Placer and El Dorado) in the central Sierra Nevada of California. The sites are California Red-legged Frog localities with historical records (Barry and Fellers 2013) that are monitored regularly (4–12 times annually). We

sought but were not able to examine data for an extant population of California Red-legged Frogs translocated to Yosemite National Park, Mariposa County; therefore, that population was not included in our analysis. We used multi-observer data from annual surveys at three sites. Surveys were not systematic or consistent across sites or years and therefore the data are characterized as opportunistic observations. Because these egg mass surveys were documented for disparate reasons and without coordination among the authors, these observations consisted of egg mass observation dates, with little to no attempt to determine the date at which the egg mass was laid, or the developmental stage of the egg mass.

The Placer County site (Big Gun Mitigation) is owned and operated by Westervelt Ecological Services and was managed as California Red-legged Frog habitat. The site is in the town of Michigan Bluff, California, at 930 m elevation. Most of the site was covered by a mixed density Ponderosa Pine (*Pinus ponderosa*) forest, with patches of manzanita (*Manzanita* spp.) with rural residential development nearby. Six ponds on the site ranged from 1–2 m deep, three of which have had annually reproducing populations of California Red-legged Frog. One El Dorado County site (Spivey Pond) was an Area of Critical Environmental Concern designated and managed by the U.S. Bureau of Land Management specifically as, but not exclusively for California Red-legged Frog habitat. The site was located south of the town of Sly Park, at an elevation of 980 m. The majority of the site was mixed coniferous forest and White Alder (*Alnus rhombifolia*), with rural residential development in the vicinity. Two ponds occurred on this site and range from 2–3 m deep, with one pond consistently supporting California Red-legged Frog reproduction. The third site, in El Dorado County (Bear Creek drainage), was owned and managed by the U.S. Forest Service. The site is located near the Lake of the Cross (Georgetown, California) at 710 m elevation. Most of the site was covered by a mixed density Ponderosa Pine Forest, with rural residential development in the vicinity. Four ponds occurred on the site that range from 0.3–1 m deep, one of which had a reproducing population of California Red-legged Frog on a consistent basis. Snow fell on all three sites each year, but typically occurred fewer than 5 d/y.

We collected a variety of physical data from each site, which included one or more of the following: (1) presence of California Red-legged Frogs; (2) surface water temperature adjacent to each egg mass; (3) air temperature; (4) snow presence; (5) substrate attachment; and (6) presence of potential predators. We did not consistently collect physical data, however, across sites or visits, but we collected surface water temperature and presence of snow regularly. Data used for our analysis were opportunistic and not always precise (Table 1). Therefore, we assigned a calendar week to the egg mass observation date to represent the period of egg mass

Table 1. Date of observations of egg masses of California Red-legged Frog (*Rana draytonii*) in the central Sierra Nevada of California.

Location name	Date Observed	Numerical Week	Source
Spivey	29 April 1998	17	Kathleen Freel (Berry and Fellers 2013)
Spivey	29 April 1998	17	Kathleen Freel (Berry and Fellers 2013)
Spivey	29 April 1998	17	Kathleen Freel (Berry and Fellers 2013)
Bear Creek	24 February 2016	8	Maura Santora
Bear Creek	24 February 2016	8	Maura Santora
Bear Creek	10 March 2016	10	Maura Santora
Spivey	late-April	17	Peggy Cranston - U.S. Bureau of Land Management
Spivey	late-April	17	Peggy Cranston - U.S. Bureau of Land Management
Bear Creek	24 February 2017	8	Maura Santora
Bear Creek	15 February 2018	7	Maura Santora
Bear Creek	03 March 2019	10	Maura Santora
Big Gun	22 March 2019	12	Matt Coyle
Bear Creek	18 April 2019	15	Maura Santora
Bear Creek	18 April 2019	15	Maura Santora
Spivey	30 March 2020	13	Jeff Alvarez
Big Gun	22 March 2020	11	Matt Coyle
Bear Creek	20 February 2020	7	Maura Santora
Bear Creek	27 February 2020	8	Maura Santora
Bear Creek	27 February 2020	8	Maura Santora
Spivey	03 April 2021	13	Jeffrey Jones
Spivey	03 April 2021	13	Jeffrey Jones
Spivey	08 April 2021	14	Jeffrey Jones
Spivey	08 April 2021	14	Jeffrey Jones
Bear Creek	21 February 2021	8	Maura Santora
Bear Creek	21 February 2021	8	Maura Santora
Bear Creek	29 March 2021	13	Maura Santora

presence (hereafter: observed week). For example, we assigned egg masses reported as the third week of March or 17 March to the same time period (i.e., calendar week 11).

Results

We examined 26 reported observations of egg masses from three counties in the central Sierra Nevada over a 25-y period. Twenty-four observations included specific egg mass observation dates, whereas two were reported as a portion of a month (i.e., mid-April; Table 1). We found that California Red-legged Frog egg masses were observed in the central Sierra from 15 February (7th calendar week) to 29 April (17th calendar week), an ovipositing season occurring over approximately 11 weeks. The average egg mass observation time across all sites was calendar week 11 (approximately 15 March). The observation mode was the 8th calendar week (21 February).

Lower elevations appeared to have an earlier average observed week for egg masses. For Bear Creek, the lowest elevation site, the average week egg masses were observed was week 9 (approximately the first week of March); Big Gun had an average observed week of 11 (approximately mid-March); and the highest elevation site, Spivey Pond, had the latest average observed week (approximately week 15; early April). Surface water temperatures collected from 21 egg masses at the time of first observation ranged from 3.9°–21.0° C (mean = 10.5° C). Air temperatures were not reported for most observations, and snow was reported on the ground at only two egg masses during their initial observation in March 2021. Although snow falls on each of the sites and remains on the ground for a short period (1 to 5 d), snow was reported on the ground at the time of egg mass presence only at the lowest elevation site; Big Creek drainage in El Dorado County.

Discussion

Though the observations used in this study were opportunistic, the data used to support our conclusion that California Red-legged Frog ovipositing season in the Sierra Nevada is similar to, but slightly later than, that found along the coast and inner coast ranges of California. Over 12 years, Alvarez et al. (2013) found egg masses at eight sites located throughout most of the California Red-legged Frog coastal range from 11 December through 17 April, an ovipositing season of 18 weeks. The average range among the eight sites, however, was 25 January through 12 March (a 6.5-week ovipositing season).

The approximate average time for all egg masses reported by Alvarez et al. (2013) was the first week of March. This is similar to but only a week earlier than found in this study for the Sierra Nevada (mid-March). Both studies show extensive inter-annual variability and inter-site variability. This is likely due to local climatic conditions, including water levels in the aquatic breeding habitat. Because sites in this study were in adjacent counties, we did not expect to see any difference in timing of egg mass deposition.

Elevation may have an effect on ovipositing timing in the Sierra Nevada; however, we did not examine this statistically due to a small sample size. We note that higher elevations had slightly later average observed dates for ovipositing, but our data are only indicating that egg masses were observed on a certain date, not the actual oviposition date. Further examination of the effects of elevation or other site-level variables on oviposition phenology would require more precise data at these and additional sites in the Sierra Nevada. We speculate that the effect of elevation is more closely related to microclimate conditions than to elevation itself.

The U.S. Fish and Wildlife Service (USFWS) provides California Red-legged Frog survey guidelines for the breeding and non-breeding period (https://nrm.dfg.ca.gov/FileHandler.ashx?DocumentID=83914&inline. [Accessed 20 July 2023]). In the section identified as Survey Periods, section IV.B., the guidelines suggest that egg mass surveys be conducted under the best survey period, which, for the California Red-legged Frog Sierra Nevada population, should not begin before April 15. If this starting time were adhered to, only 25% of the observed egg masses in our study would have been identified, and no egg masses would have been identified at the Big Gun site. With 75% of the egg masses observed between mid-February and mid-April in the Sierra Nevada, it appears that the survey guidelines should be shifted to include a broader time frame that would include the months of February, March, and April.

For comparison, over a 3-y period, egg masses oviposited at El Potrero, Santo Domingo Watershed, Baja California, Mexico, at a similar elevation (900 m) to the sites we examined, were oviposited from early March to mid-April. This suggests that despite, the location of the El Potrero site at the southernmost extent of the range of California Red-legged Frogs, the timing of ovipositing appears similar to that for the Sierra Nevada populations. It also suggests an absence of a latitudinal effect of ovipositing because the Baja population is approximately 1,000 km south of the Sierra Nevada populations, yet the approximate timing of reproduction is nearly the same.

There appears to be significant inter-annual variability in the phenology of ovipositing in the California Red-legged Frog (Alvarez et al. 2013; this study). Others studying the closely related Foothill Yellow-legged Frog (*R. boylii*) found a similar pattern that included inter-annual variability and an extended breeding season, which varied based on location, water temperature, flows, and other factors (Storer 1925; Wheeler et al. 2003, 2015, 2018; Rose et al. 2023). In the context of an extended breeding season, we observed only minor ovipositing timing differences between the populations of California Red-legged Frogs that occur on the coast and those that occurred in the Sierra Nevada. Further, although there

appears to be a minor elevational effect, it is likely that local conditions related to temperature preferences may be affecting timing of ovipositing, which appears similar to Foothill Yellow-legged Frogs (Catenazzi and Kupferberg 2013; Wheeler et al. 2015, 2018; Rose et al. 2023). The California Red-legged Frog appears to remain a winter and spring breeder, with an oviposition phenology that typically ranges from mid-December (extreme coastal populations) to late-April (inland populations), irrespective of latitude.

Although an egg mass was observed at Point Reyes National Seashore in the first week of November (Patrick Kleeman, pers comm.), November breeding is likely uncommon to rare for California Red-legged Frogs. A larger, range-wide assessment, which includes earlier (November and December), and later (April and May) surveys is needed to better understand understudied and or underreported populations (i.e., Butte County, Baja California, and central coast populations) and potential extremes in oviposition timing for this species. For example, California Red-legged Frogs at La Grulla Meadow, Baja California, Mexico (1,850 m elevation), may oviposit later in the year due to persistent snow and cold weather, potentially limiting activity of frogs perhaps into late April or May. Populations in the northernmost extent of the range (i.e., Butte County) are understudied, and no reports exist for the timing of ovipositing or the presence of egg masses.

Surveys for California Red-legged Frogs, including USFWS-approved surveys, should consider the best available information about the breeding phenology of the species to detect egg masses in aquatic breeding habitat. This should include updating current survey guidelines for the species. Egg masses may not be easy to detect in some habitat types (Wilcox et al. 2017) but may also be missed if the timing of those surveys begins at the later stages of breeding activity, which the current (i.e., 2005) USFWS survey guidelines suggest. We recommend USFWS survey guidelines be updated to reflect the current understanding of the species reproductive natural history.

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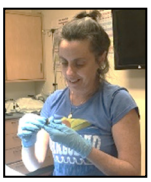

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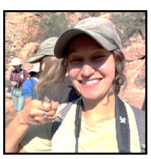

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