Herpetological Conservation and Biology 18(3):427–435.
Submitted: 10 March 2023; Accepted: 25 September 2023; Published: 16 December 2023.

Reproductive Phenology of the California Red-Legged Frog (*Rana draytonii*) in the Sierra Nevada of California, USA

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Abstract.—**We report on the phenology of oviposition and metamorphosis by the threatened California Red-legged Frog (*Rana draytonii*) in the Sierra Nevada, California, USA, where few populations remain and efforts to establish new populations are underway. To understand the seasonality of oviposition and metamorph emergence of *R. draytonii* in the Sierra Nevada, we summarized dates of egg mass detection and metamorph emergence at four Sierran populations between 1998 and 2022. In addition, we documented egg mass detection and metamorph emergence from 2019–2022 after successful translocations of embryos or frogs to Yosemite Valley. We detected new *R. draytonii* egg masses in Sierra Nevada populations from 15 February to 27 April, followed by metamorph emergence from 14 June to 26 September. We found *ex-situ* start time (Gosner stage 42) of metamorphosis (14–18 weeks) served as a guideline to time *in-situ* surveys for metamorphs. Time between initial egg mass detection and observations of metamorphs (Gosner stage 46) in the field ranged from 16–27 weeks. Based on this result, we suggest metamorph surveys be initiated 14 weeks after the first egg mass detections. When assessing populations of *R. draytonii* for egg masses and metamorphs, the length of the survey season may be dictated by the environmental conditions (e.g., drought). The phenology of oviposition in Sierra Nevada *R. draytonii* populations will inform future conservation actions when captive rearing for translocation may be needed. Accurate detections of metamorph presence can serve as a useful metric for conservation translocations.**

Key Words.—amphibian breeding; egg mass; emergence; endangered species; metamorph; metamorphosis; oviposition

Introduction

The California Red-legged Frog (*Rana draytonii*) has been extirpated from > 70% of its former range (U.S. Fish and Wildlife Service [USFWS] 2002). Initial declines were due to commercial exploitation as a food source (Jennings and Hayes 1985). Subsequently, the introduction of invasive species (e.g., American Bullfrog, *Lithobates catesbeianus*) and the cumulative effects of habitat alteration (e.g., urbanization) and degradation (e.g., livestock and agricultural practices) caused further decline throughout its range (Jennings and Hayes 1994). The extent to which disease may have contributed to *R. draytonii* decline is unknown, but mortality from the Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*), the pathogen that causes chytridiomycosis, has been documented in Sierra Nevada, California, USA, populations of this species (Adams et al. 2020). The species was listed as Threatened under the U.S. Endangered Species Act in 1996 (Jennings and Hayes 1994; USFWS 1996). *Rana draytonii* was last observed in Yosemite National Park around 1975 at Swamp and Gravel Pit lakes at the same time when *L. catesbeianus* was first observed at these two lakes (Dave Graber, pers. comm.). The timing of breeding, oviposition, and metamorph emergence is well documented for the species along the Coast Range for *R. draytonii* (Jennings and Hayes 1994; Alvarez et al. 2013; Fellers et al. 2017), and for the closely related Northern Red-legged Frog (*R. aurora*; Storm 1960; Licht 1971, 1974; Brown 1975; Jennings and Hayes 1994). Lacking, however, is information about breeding phenology in the Sierra Nevada where *R. draytonii* formerly occupied habitats up to 1,625 m elevation.

Our study focused on egg mass detections and metamorph emergence in five populations of *R. draytonii* (four established breeding sites and one introduced site) in the Sierra Nevada. For our purposes, we gathered data on the timing of egg mass occurrence and collection of embryos for captive rearing. We also collected data from captively held frogs such as the start date of metamorphosis (i.e., front limb emergence at Gosner, 1960; stage 42). These data were used to help track the emergence of metamorphs at field sites as well as the success of introductions to Yosemite Valley. We documented the reproductive phenology for *R. draytonii* in the Sierra Nevada with the intent of demonstrating the utility of basic life-history information for planning the timeframes of surveys to detect oviposition and facilitate egg mass collection for captive rearing and translocations and to evaluate the success of such efforts (e.g., metamorphosis). These objectives are concordant with the priorities of the Recovery Plan for the California Red-legged Frog (USFWS 2002).

Figure 1. California Red-legged Frog (*Rana draytonii*) from Lake of the Cross, El Dorado County, California, USA. (Photographed by Robert Grasso).

Materials and Methods

***Study sites*.—**As part of the planning effort to introduce *R. draytonii* (Fig. 1) to Yosemite Valley, which would be a new population (Adams et al. 2023), we focused on four currently occupied Sierra Nevada locations (Table 1; Fig. 2) considered genetically suitable as source populations (Richmond et al. 2014). We surveyed for evidence of reproduction at these four sites with extant populations and included Yosemite Valley after reproduction was observed at five locations. We refer to Yosemite Valley as one site, but it was composed of nine sub-sites (Table 1; Fig. 2). These five sites collectively were representative of the entire known range of *R. draytonii* in the Sierra Nevada, which extends from Plumas National Forest, Butte County, in the north to Yosemite National Park, Mariposa County, in the south (Fig. 2). The study sites were within the Lower

Table 1. Study site characteristics and years with monitoring of California Red-legged Frog (*Rana draytonii*) breeding in the Sierra Nevada, California, USA. The water body type is characterized as ephemeral (E) or perennial (P) as well as lotic (LO) or lentic (LN). The area variable is the approximate surface area of the pond determined from a geographic information system. We determined maximum depth manually with a meter stick, by sounding (using string and weight), or estimating visually (*). Management entity (Mgmt.) abbreviations are BLM = U.S. Bureau of Land Management, USFS = United States Forest Service, YNP = Yosemite National Park.

Watershed, Pond name	Water body type	Mgmt.	County	Elev. (m)	Max. Depth (m)	Area (ha)	Survey years
North Fork Feather River							
Hughes Pond (H)	E, LN. Impoundment of springs	USFS	Butte	768	1.4	0.1	2005–2009
American River							
Spivey Pond-1	P, LN. Impoundment of creek	BLM	El Dorado	1,004	3	0.6	2017–2018
Spivey Pond-2	P, LN. Off channel impoundment				1	0.09	
Eldorado National Forest Pond (ENF Pond)	E, LN. Excavated	USFS	El Dorado	900	1	0.008	2016–2022
Lake of the Cross (LC)	P, LN. Impoundment of a creek	Private	El Dorado	820	5.0	0.5	2016–2022
Yosemite Valley							
Sub-sites 1, 4, 7 and 9	P, LO. Backwaters of river	YNP	Mariposa	1,216	2*	0.1–1	2018–2022
Sub-sites 2, 3, 6	E, LN. Meadow pond	YNP	Mariposa	1,209	2*	0.25–1.5	
Sub-site 8	P, LO. River side channel	YNP	Mariposa	1,213	2*	0.17	
Sub-site 5	P, LN. Artificial concrete pond	YNP	Mariposa	1,215	1*	0.04	

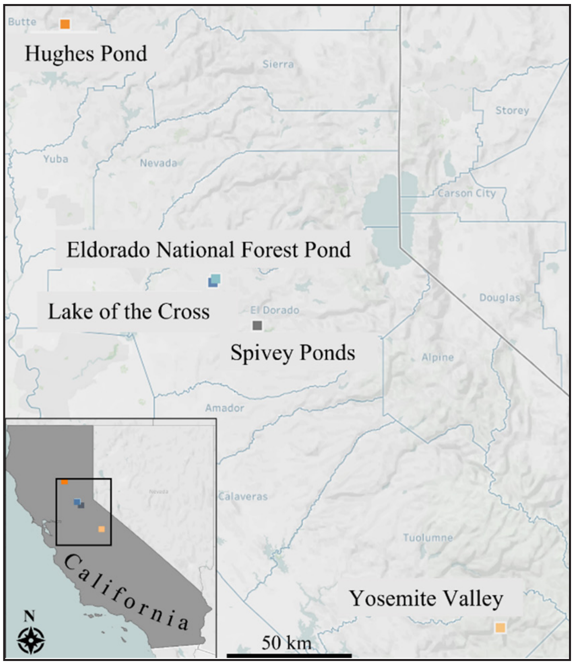

Figure 2. Location of study sites of California Red-legged Frogs (*Rana draytonii*) in the Sierra Nevada, California, USA.

Montane Forest of the Sierra Nevada Ecoregion (http://dx.doi.org/10.3133/ofr20161021) from 800 m to 1,250 m elevation. Forests around the water bodies included a diversity of mixed hardwood and conifer species such as oaks (*Quercus* spp.), incense-cedars (*Calocedrus* spp.), alders (*Alnus* spp.), pines (*Pinus* spp.), and firs (*Abies* spp. and *Pseudotsuga* spp.; available from https://snrs.ucmerced.edu/natural-history/life-zones [Accessed 12 October 2022]). Wetland-associated plant species at the sites consisted primarily of sedges (*Carex* spp.), rushes (*Juncus* spp.), and willows (*Salix* spp.). Slight differences occurred at Hughes and Spivey ponds and Lake of the Cross where non-native plants such as Himalayan blackberry (*Rubus* sp.) were common. Cattails (*Typha* spp.) were present at Lake of the Cross (Fig. 3) and Spivey Pond.

The four extant populations of frogs bred in human-modified water bodies while the frogs in the introduced Yosemite Valley population used relatively natural habitats. Starting from the north, the Hughes Pond site had an earthen dam situated on a saddle between two tributaries to the North Fork Feather River and was mostly fed from runoff and underground springs (Patricia Tatarian, unpubl. report). Eldorado National Forest (ENF) constructed an ephemeral pond (hereafter ENF Pond; Fig. 3) in the Bear Creek watershed in 2014 to facilitate *R. draytonii* breeding while discouraging *L. catesbeianus* establishment (Neil Keung and Sam McNally, unpubl. report). Lake of the Cross also consisted of an earthen-rock impoundment on Bear

Figure 3. (A) California Red-legged Frog (*Rana draytonii*) permanent habitat (and boat-based egg mass survey), Lake of the Cross, El Dorado County, California, USA. (B) *Rana draytonii* ephemeral habitat, Eldorado National Forest Pond, El Dorado County, California, USA. (C) *Rana draytonii* ponded backwater habitat sub-site 4, Yosemite Valley, Mariposa County, California, USA. (D) *Rana draytonii* ephemeral habitat sub-site 4, Yosemite Valley, Mariposa County, California, USA. (Photographed by Robert Grasso).

Creek constructed in 1967 on private property (Diane Buchholz, pers. comm.). The Spivey Pond site consisted of two adjacent impoundments (hereafter Spivey Ponds) on the south fork of Weber Creek (Elena DeLacy, pers. comm.). The original pond was created by an earthen dam reinforced with riprap used for lumber storage in the 1940s (Barry and Fellers 2013). The American River Conservancy (ARC) and U.S. Bureau of Land Management (BLM) constructed a second off-channel pond 45 m downstream of the original pond (Elena DeLacy, pers. comm.). The ENF Pond, Lake of the Cross, and Spivey Ponds were all tributaries to the South Fork American River.

At the most southerly site, Yosemite Valley, frogs oviposited at nine discrete breeding areas (i.e., sub-sites 1–9) with a mix of ephemeral (Fig. 3), intermittent, and perennial wetland features (e.g., ponds in meadows) that were seasonally inundated by rising Merced River floodwaters, as well as one constructed pond. Most ponds had a maximum depth of 2 m with a few exceeding this depth (Table 1). Although hydrological modifications (e.g., draining, ditching, and large wood removal) had occurred in the past, these practices had ceased, and many legacy effects from these practices had been remediated through ongoing restoration (https://parkplanning.nps.gov/document.cfm?documentID=5752). We identify the Yosemite Valley sub-sites by number, rather than name or geographic location to protect these highly sensitive areas. Sub-sites 1, 4, 7, and 9 were ponded backwaters (Fig. 3) along the Merced River that were directly connected to the river by surface flow and were permanent most years. Sub-sites 2, 3, and 6 were ephemeral (i.e., depressions within floodplain meadows) that were seasonally and intermittently inundated during river flood stage mostly through groundwater infiltration (i.e., no surface flow). Sub-site 8 was the only lotic breeding habitat characterized as a braided side channel with slow backwater areas containing permanent pools. Sub-site 5 was the only artificial pond in Yosemite Valley. This concrete pond was constructed to improve aesthetics for visitors in front of a lodging area and was also believed to be the original point of *L. catesbeianus* introduction to Yosemite Valley in the 1950s (Karlstrom 1962).

Survey methods.—To determine the phenology of oviposition and metamorphosis of *R. draytonii*, we conducted Visual Encounter Surveys (VES) for egg masses and metamorph emergence primarily during daylight hours (0900–1800). At ENF Pond in 2021 and Yosemite Valley sub-site 8 in 2022, we conducted a limited number of surveys during nighttime hours (2000–0100). We did not conduct targeted larval surveys, but we noted observations of larvae when encountered. Surveys occurred from 9 January 2016 until 1 October 2022, except at Hughes Pond, where surveys occurred from 2005–2009, and included weekly egg mass surveys from November 2007 until March 2008 (except when snow prevented access in February). For each site, we counted the total number of egg masses detected on that date and recorded the highest number of egg masses (prior to embryo emergence) for the year. We present data as the mean annual number of egg masses, a reliable index of breeding female abundance (Fellers et al. 2017).

We did not sum all egg masses observed from all dates during a year to avoid double counting. In limited instances where the breeding period was long (e.g., Yosemite Valley in 2022), we observed new egg masses after older egg mass embryos had emerged as larvae. In these cases, we summed new egg masses with previously observed egg mass totals. We calculated time to metamorphosis in weeks from the first egg mass observed to the first metamorph observed at each site. We conducted shoreline surveys for egg masses at Hughes Pond, ENF Pond, and Yosemite Valley while we used boats to survey Spivey Ponds and Lake of the Cross due to steep banks and heavily vegetated shorelines. One or two observers walked or boated along the shoreline following the protocol of Fellers and Freel (1995). At Lake of the Cross in 2016, ENF Pond in 2021, and Yosemite Valley in 2019, we conducted VES prior to the observation of new egg masses when we did not expect *R. draytonii* to have initiated breeding based on local environmental conditions (e.g., cold temperatures). Once new egg masses were detected, we treated that date as the start of oviposition. Although we did not directly observe oviposition during VES, our repeated observations of the same egg masses indicated that newly (< 48 h) oviposited egg masses and older (> 48 h) oviposited egg masses (Fig. 4) can be estimated by the diameter of and definition of the jelly coat of egg masses. For example, small diameter, undefined jelly coats represented newly oviposited egg masses whereas larger diameter, well-defined jelly coats represented older oviposited egg masses. We continued egg mass VES at Lake of the Cross and ENF Pond in these years until we did not detect any new recently laid egg masses and all older egg mass embryos hatched as larvae. We did not collect environmental data such as egg mass attachment substrate and weather conditions (e.g., cloud cover, wind, etc.); however, we opportunistically recorded water temperature at all field sites adjacent to egg masses with a handheld thermometer during egg mass surveys. We conducted metamorph surveys by observers walking along the shoreline where accessible. We used *ex-situ* development data from the San Francisco Zoo and Gardens (SF Zoo), San Francisco County, California, USA, as a reference to time field VES for metamorphs. For Lake of the Cross embryo

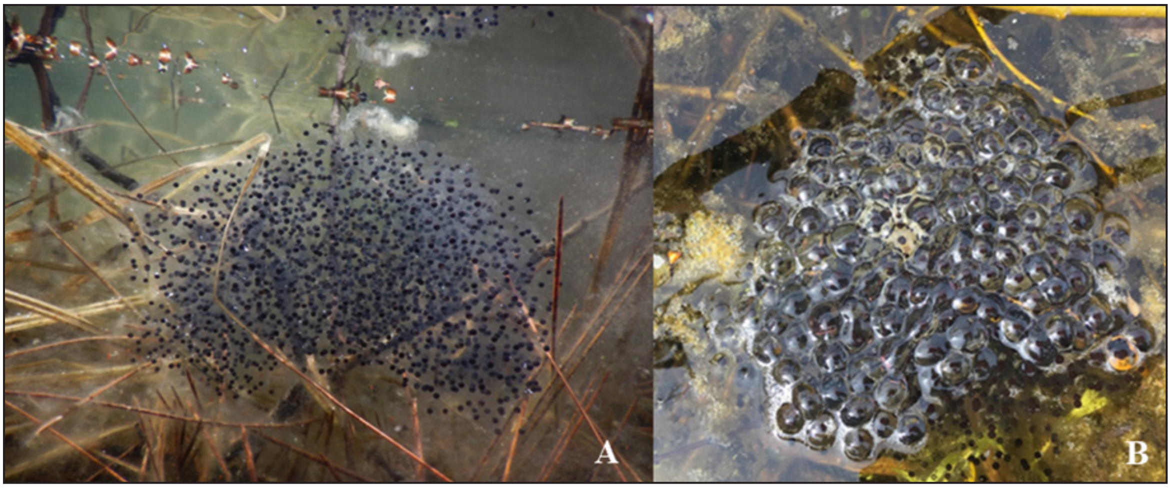

Figure 4. (A) Recently (< 48 h) oviposited California Red-legged Frog (*Rana draytonii*) egg mass from sub-site 2, Yosemite Valley, Mariposa County, California, USA. (B) Older (> 48 h) oviposited *R. draytonii* egg mass from sub-site 4, Yosemite Valley, Mariposa County, California, USA. (Photographed by Robert Grasso).

collections (2016, 2017, 2021, and 2022), we recorded the date of collection, Gosner stage (Gosner 1960), time to start of metamorphosis (i.e., Gosner stage 42), as well as water temperature of rearing aquaria at the SF Zoo. For ENF Pond, the dates of egg mass observations reported herein for 2016–2021 were also reported in Alvarez et al. (2023), in which they referred to the site as Bear Creek.

Data solicitation.—To establish a benchmark for life stage information (e.g., egg masses, metamorphs) for the Sierra Nevada, we solicited data and observations from biologists for these topics, and we conducted searches for all publicly available information. In addition, we compiled all relevant peer-reviewed literature pertaining to the aforementioned sites or *R. draytonii* accounts in the Sierra Nevada. For Spivey Ponds, we contacted and requested data from biologists from the administering agency (BLM), partner groups (ARC), and researchers (U.S. Geological Survey [USGS]), yielding one report for 2015–2018 (Elena Delacy, unpubl. report), one journal article (Barry and Fellers 2013), and field observations from USGS. For Lake of the Cross, we obtained anecdotal observations from the private landowner.

Yosemite Valley introductions.—In March 2016, we collected 3,500 *R. draytonii* embryos from Lake of the Cross. We transferred 880 to the SF Zoo for captive rearing and released the remaining 2,620 directly to Yosemite Valley. After 15 mo, we released frogs reared at the SF Zoo with snout-vent length (SVL) > 40 mm to several Yosemite Valley locations (i.e., sub-sites) starting in summer 2017. Because post-metamorphic frogs grow rapidly and reach sexual maturity in as little as 2 y for males and 3 y for females (Jennings and Hayes 1994), it seemed plausible that frogs released in 2017 could breed by 2019. Consequently, we began egg mass surveys in Yosemite Valley in March 2019 soon after ice and snow melt were completed on 11 March.

Results

Oviposition.—Although we did not visit all sites each year (Supplemental Information), we detected egg masses at all five study sites during all years sampled (Fig. 5). We did not directly observe oviposition at any site. We observed the highest counts of egg masses at Lake of the Cross, surveyed 2016–2018 and 2021–2022 (mean number of egg masses per year = 25.6; 95% confidence interval [CI] = 16.1–35.1; range, 18–36), followed by Yosemite Valley (mean = 16.3; 95% CI

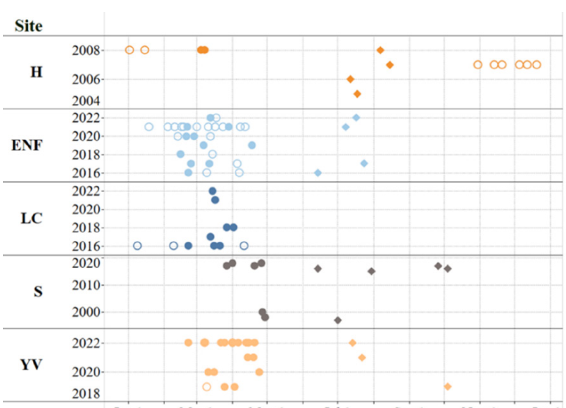

Figure 5. Dates of California Red-legged Frog (*Rana draytonii*) egg mass surveys (open circles = no detections; closed circles = detections) and first metamorphs detected (diamonds) at five sites in the Sierra Nevada, California, USA. Site codes are H = Hughes Pond, ENF = Eldorado National Forest Pond, LC = Lake of the Cross, S = Spivey Ponds, YV = Yosemite Valley.

= -0.5–33; range, 4–25), surveyed 2019–2022. By contrast, Spivey Ponds, surveyed 1998, 2000, and 2017–2018, and ENF Pond, surveyed 2016–2022, had the fewest counts of egg masses (mean = 2, 95%; CI = 0.7–3.3; range, 1–3; and mean = 2.1; 95% CI = 1.3–3.0; range, 1–3; respectively), followed by Hughes Pond (total n = 7) which was only surveyed in 2008.

For Lake of the Cross (2016) and ENF Pond (2021), we documented the start and end of oviposition at these sites (Fig. 5). At two sub-sites (sub-sites 2 and 4) in Yosemite Valley that experienced drought in 2020–2022 (data available from https://water.ca.gov/water-basics/drought [Accessed 31 May 2023]), we did not detect any egg masses. At sub-site 2, where oviposition was documented 25 March 2019, we found no evidence of oviposition in 2020, 2021, or 2022 due to lack of standing water (Supplemental Information Table S1). At sub-site 4, we observed egg masses on 25 March 2019 but not in 2020 due to lack of standing water. We observed egg masses at sub-site 4 again in 2021 and 2022 during drought conditions when water depths had reached depths > 0.5 m from February-April in these years. Across all years and sites, collectively, we detected oviposition over a 10-week period (Fig. 5), with the earliest *R. draytonii* egg mass observed on 15 February 2018 at ENF Pond and the latest in Spivey Ponds on 27 April 2000. We took spot measurements of water temperature at all five field sites adjacent to egg masses (mean water temperature = 10.3° C; 95% CI = 9.5°–11.2° C; range, 8.2°–12.5° C; Supplemental Information Table S1).

Metamorphs.—We detected metamorphs at four of the five study sites at different times (Fig. 5). We did not encounter metamorphs at Lake of the Cross, and only on one occasion at this site (13 June 2016) did we encounter larvae (n = 5) with well-developed rear legs (Gosner stage 40) and a single larva nearing the start of metamorphosis (Gosner stage 41). The earliest metamorphs (Gosner stage 46) we observed occurred on 14 June at ENF Pond, and the latest we observed were on 26 September 2016 at Spivey Ponds (Table 2). Time from egg mass detection and collection to start of metamorphosis (Gosner stage 42) at SF Zoo ranged from 14–18 weeks (Table 3). Time between initial egg mass detection and observations of metamorphs (Gosner stage 46) in the field ranged from 16–27 weeks (Table 2).

Table 2. Dates of first detection for egg masses and metamorphs of California Red-legged Frog (*Rana draytonii*) at four Sierra Nevada, California, USA, locations (ENF = Eldorado National Forest, YV = Yosemite Valley). The abbreviation SE = standard error.

Location	Egg mass detection	Metamorph detection	Weeks elapsed
Hughes Pond	5 March 2008	7 August	22
ENF Pond	22 February 2016	14 June	16
	24 February 2017	24 July	21
	21 February 2021	8 July	20
	13 March 2022	17 July	18
Spivey Ponds	27 March 2017	26 September	26
YV Site 4	25 March 2019	4 October	27
YV Site 4	22 February 2022	14 July	20
Mean ± SE			21.3 ± 1.3

Discussion

To aid the recovery of *R. draytonii* in the Sierra Nevada and facilitate conservation translocation projects, we compiled necessary baseline information regarding seasonality of oviposition at five Sierran sites. We compiled older (1998–2009) and more recent (2016–2022) survey data and first determined that oviposition by *R. draytonii* in the Sierra Nevada can extend from late winter through mid-spring, starting as early as 15 February and ending as late as 27 April. The second notable finding is that *R. draytonii* oviposited in ephemeral waterbodies (e.g., ENF Pond, Hughes Pond, Yosemite Valley sub-sites 2, 3, 4, and 6) as well as permanent waterbodies. The third important result was that seasonality of oviposition was similar between extant populations and a new population of *R. draytonii* in Yosemite Valley founded after eradication of *L. catesbeianus* (Kamaroff et al. 2020). In Yosemite Valley, frogs oviposited in a range of habitat types (e.g.,

Table 3. Dates of embryo collection, Gosner (1960) stage on day of collection, dates when first individuals in the cohort started metamorphosis (front limb emergence, Gosner stage 42), and mean water temperature for California Red-legged Frog (*Rana draytonii*) reared at the San Francisco Zoo and Gardens, San Francisco County, California, USA. Embryos from Lake of the Cross arrived at the zoo on the same day as their collection in the field. The abbreviation SE = standard error.

Year	Embryo collection date(s)	Gosner stage	Start of metamorphosis (Gosner stage 42) dates	Weeks elapsed	Mean water Temperature (° C)
2016	16 and 21 March	< 14	17 July	17.5	17
2017	13 March	≤ 16	13 July	17	17.7
2021	17 March	< 16	3 July	15	16.9
2022	14 March	> 16	30 June	14	17.2
Mean ± SE				15.9 ± 0.8	17.2 ± 0.3

ephemeral, permanent, lentic, lotic, etc.), but egg mass detection dates were similar to the other four sites. Inter-annual variation in seasonality of oviposition, or the total lack of egg mass observations in some years at previously used locations in Yosemite Valley, was likely due to drought conditions, when water depths were insufficient for oviposition. To optimize detection of target life stages, surveys in any given year may have to be adjusted to account for annual variation in environmental conditions (i.e., snowpack and drought).

With regard to metamorph emergence, the compiled data suggest that time to metamorphosis after detection of egg masses of *R. draytonii* takes an average of 21 weeks. Therefore, the hydroperiod of ephemeral habitats would need to be similar for larvae to metamorphose successfully. In 2008 at the ephermal Hughes Pond, we first observed egg masses on 5 March and first detected post-metamorphic frogs on 7 August indicating it took *R. draytonii* approximately 22 weeks to metamorphose. In 2021 at another ephemeral pond, ENF Pond, we observed the first two egg masses on 21 February. These egg masses hatched by 29 March, and on 8 July, we detected metamorphs, indicating approximately 20 weeks to metamorphosis. The ENF Pond had dried by 2 September 2021 indicating that timing of oviposition and hydroperiod are important to allow successful metamorphosis. Further study is needed to assess time to metamorphosis and metamorph fitness in ephemeral habitats during drought conditions.

We found *ex-situ* time to the start of metamorphosis (i.e., Gosner stage 42; 14–18 weeks) served as a conservative guideline to time *in-situ* time to metamorphosis (i.e., Gosner stage 46; 16–27 weeks). Based on this result, we still suggest that VES for metamorphs begin approximately 14 weeks after new egg mass detection and recommend starting 1–2 weeks earlier if date of oviposition for observed egg masses is unknown. The decision of then to cease metamorph surveys may be site-specific and depend on local environmental variation (e.g., hydroperiod), but based on our data, we recommend continued weekly sampling by VES for at least 27 weeks. To increase metamorph detection rates, we recommend dip netting to confirm the presence of larvae and perform night VES whenever possible.

We hope this study demonstrates the use of basic life-history information for planning the timeframes for monitoring and conservation activities for *R. draytonii* in the Sierra Nevada. Assessing oviposition timing and metamorph emergence for remaining populations (e.g., Placer County, California, USA) would provide a more complete picture in the Sierra Nevada. Given the cryptic nature of this species and difficulty in detecting post-metamorphic life stages even in known occupied areas, egg mass surveys may serve as confirmation of presence and relative abundance assuming the number of egg masses equals the number of adult females present. When assessing new or previously unsurveyed extant populations of *R. draytonii* for egg masses, we recommend that surveys begin on, or before, 1 February. The length of the egg mass survey season may be dictated by new data in any particular year at any given location, but our findings suggest that by 15 May most, if not all, oviposition has likely ceased in the Sierra Nevada. Temperature data, although limited, suggest that water temperatures nearing 10° C are favorable for oviposition (Supplemental Information Table S1). Although not evaluated in our study, it remains unknown whether precipitation events in the Sierra Nevada influence oviposition, and further study is needed.

Information provided here should serve as a baseline and be applicable to extant populations of *R. draytonii* not included in this study and can aid in recovery efforts (e.g., reintroductions, translocations, and augmentations) elsewhere in the Sierra Nevada. Knowing when to conduct VES for egg masses and metamorphs, as well as scheduling other surveys such as environmental DNA (eDNA) sample collection to coincide with larval development periods, should increase detection rates. Conducting metamorph surveys following successful documentation of oviposition is especially important for introduced or reintroduced populations. This is especially true for *R. draytonii* populations in ephemeral waterbodies that may experience shortened hydroperiods due to drought conditions. This will not only provide information on cohort fate for future recruitment into the population, but it will also provide valuable information on whether habitats remain suitable for conservation actions into the future such as artificial creation of ponded habitat such as ENF Pond. The success of translocations and pond excavation as conservation tools that can aid in recovery of *R. draytonii* (and other amphibian species) will depend on knowledge of breeding phenology, especially as climate changes (Blaustein et al. 2010).

Acknowledgments.—This study was funded by the Yosemite Conservancy, and we thank Schuyler Greenleaf and Frank Dean for their support. We thank Peggy Cranston for sharing data, and Diane Buchholz, Elena DeLacy, Colleen Kamoroff, Jessica Thompson, Molly Thompson, Rachel Friesen, Cora Grasso, and Jocelyn Wright for assistance with fieldwork. We thank Roland Knapp for conceptualization of this project and for assistance with fieldwork. We thank Chris Nagano, Josh Hull, Sarah Markegard, Rick Kuyper, Ian Vogel, Kate Bocskor, Sam Lantz, Emily Leung, Chloe Hansum, and Sam Sosa from the U.S. Fish and Wildlife Service for field assistance and support of this project. We also would like to thank Laura Patterson from the California Department of Fish and Wildlife and Rachel Mazur, Linda Mazzu, and Don Neubacher from the U.S. National Park Service for support of this project. We thank Pat Kleeman and Adam Backlin for field site information. This work was conducted under U.S. Fish and Wildlife Service Permit (TE-86906B-1, ES-92167B-1), California State Scientific Collection Permit (#5130), and Yosemite National Park Permit (YOSE-2018-SCI-0072).

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Supplemental Information: http://www.herpconbio.org/Volume_18/Issue_3/Grasso_etal_2023_Suppl

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