SUPPLEMENTAL INFORMATION

REPRODUCTIVE PHENOLOGY OF THE CALIFORNIA RED-LEGGED FROG (*RANA DRAYTONII*) IN THE SIERRA NEVADA OF CALIFORNIA, USA

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TABLE S1. Summary of survey dates, antecedent precipitation, water temperature, total number of egg masses observed, and Gosner stage for the California Red-legged Frog *Rana draytonii* in the Sierra Nevada, California, USA. Site codes H = Hughes, ENF = Eldorado National Forest, LC = Lake of the Cross, S = Spivey, YV = Yosemite Valley

Site	Year	Date	Temp.(°C)	Egg Mass #	Gosner
LC	2016	9 January	n/a	none	n/a
LC	2016	9 February	n/a	none	n/a
LC	2016	22 February	n/a	8	n/a
LC	2016	16 March	9.0	22	1–20
LC	2016	21 March	n/a	6	1–20
LC	2016	11 April	n/a	none	n/a
LC	2017	13 March	9.2	18	n/a
LC	2018	27 March	n/a	10	n/a
LC	2018	2 April	n/a	18	15–20
LC	2021	17 March	5.5	28	1–20
LC	2022	15 March	9.0	18	1–20
ENF	2016	24 February	9.4	2	1–14
ENF	2016	10 March	10	1	n/a
ENF	2016	7 April	16	0	n/a
ENF	2017	24 February	6.0	1	n/a
ENF	2017	12 March	n/a	0	n/a
ENF	2017	5 April	16.1	0	n/a

Site	Year	Date	Temp.(°C)	Egg Mass #	Gosner
ENF	2018	15 February	3.9	2	
ENF	2018	15 March		0	
ENF	2019	7 March	7.5	1	
ENF	2019	18 April	21	2	
ENF	2020	13 February	9.0	0	
ENF	2020	20 February	8.0	1	1–14
ENF	2020	27 February	10	2	1–14
ENF	2020	13 March	8.5	0	
ENF	2021	19 Jan		0	
ENF	2021	4 Feb	5.0	0	
ENF	2021	10 Feb	5.0	0	
ENF	2021	16 Feb		0	
ENF	2021	18 Feb		0	
ENF	2021	21 Feb	5.0	2	1–14
ENF	2021	1 March	5.0	0	
ENF	2021	11 March	1.0	0	
ENF	2021	17 March	5.0	0	
ENF	2021	24 March	12	0	
ENF	2021	29 March	9.0	1	1–22
ENF	2021	8 April	12	0	
ENF	2021	12 April	12	0	
ENF	2022	13 March		1	1–14

Site	Year	Date	Temp.(°C)	Egg Mass #	Gosner
ENF	2022	18 March		0	
H	2008	5 March		5	18-20
H	2008	8 March	10	2	18-20
S	1998	29 April		3	
S	2000	27 April		1	
S	2017	27 March	7.9	1	
S	2017	20 April		1	
S	2018	1 April		1	
S	2018	26 April		1*	
YV2,3,4	2019	25 March	(S2) 7.3, (S3), 8.9	19	1–14
YV2, 3, 4	2019	3 April	(S2) 9.3, (S4)12.5	6	1–14
YV1, 5, 9	2020	11 March		9	1–20
YV3	2020	16 March		1	
YV3	2020	24 April		1	
YV3, 4	2021	14 April		3	
YV3		19 April		1	
YV4	2022	22 February		1	1–14

Site	Year	Date	Temp.(°C)	Egg Mass #	Gosner
YV4, 5	2022	8 March	(S4) 15, (S5) 12.7	3	
YV6	2022	22 March	24.2	1	
YV5, 8	2022	25 March	(S5) 19, (S8) 9.0	7	
YV4, 5, 8	2022	1 April	(S4) 18, (S5) 15, (S8) 9.0	5	1–14
YV8	2022	6 April	10.1	2	
YV8	2022	13 April	11	2	
YV4	2022	14 April	10.9	2	
YV6	2022	15 April	11.5	1	
YV8	2022	20 April		1	

SITE CHRONOLOGIES AND ADDITIONAL INFORMATION

Lake of the Cross.—Our first attempt to locate eggs at this site occurred on 9 January 2016 when we conducted a boat-based VES, and we did not observe any egg masses or adult frogs. It was not until we conducted a resurvey on 22 February that we observed the first egg masses (n = 8). Upon returning on 16 March to collect embryos, we observed a total of 30 (22 additional) egg masses and six additional egg masses (n = 36 total) in 2016. We observed no amplectant pairs or adults in 2016. On 11 April we found no new clutches and 14 hatched (i.e., jelly coat without embryos) egg masses. On 13 June 2016 we found five larvae with well-developed rear legs (Gosner 40), and a single larva near metamorphosis (Gosner 42). We did not encounter post-metamorphic individuals, YOY, or juveniles despite the high number of egg masses (total n = 128). We did a second post-metamorphic survey on 4 October 2016 where we found 11 adults, but no other life stages. In 2017, on 13 March we observed a total of 18 egg masses. In one southwest facing location in the pond, we found several *R. draytonii* egg masses unattached resting on the bottom of the pond approximately 1.5 m deep below existing egg masses still attached to submerged branches. We found a Western Pond Turtle (*Actinemys marmorata*) lodged inside a *R. draytonii* egg mass in an apparently resting state approximately 25 m east of the unattached egg masses; no consumption or dislodging of eggs was observed. In 2018, bathymetry surveyors noted 10 egg masses (Eggleton, FRST Corp 2018), on 27 March and a second survey on 2 April revealed a total of 28 egg masses (18 additional) with three egg masses that appeared to be recently (< 1 w) oviposited. The remaining (n = 25) egg masses appeared to be > 14–21 d old and were actively hatching. No additional larvae or post-metamorphosis surveys occurred in 2018. In 2021, a single survey on 17 March revealed a total of 28 egg

masses and one adult on the shoreline. No additional larvae or post-metamorphosis surveys occurred in 2021. In 2022, a single survey on 15 March, when there had been no significant precipitation since 1 January, revealed a total of 18 egg masses. No additional surveys occurred in 2022 at Lake of the Cross.

ENF Pond.—We first visited this site on 24 February 2016 and we observed two *R. draytonii* egg masses. We revisited on 10 March and observed one newly (< 48 h) oviposited egg mass as well as three adult *R. draytonii* including two in amplexus. On 14 June, we observed one metamorph and 10 larvae. A follow-up survey on 7 July recorded the presence of > 50 larvae and nine "juveniles" suspected to be YOY. In 2017, we observed a single egg mass on 24 February with no more detections on follow up surveys performed on 8, 12, and 23 March. We resurveyed on 5 April 2017 and observed recently emerged tadpoles still present on the one egg mass with no new egg masses present. During 2017 we observed a single metamorph and five "juvenile" frogs presumed to be YOY on 24 July, and four YOY on 11 October. In 2018, we observed a single egg mass on 15 February, and no new egg masses on 15 March. We did not conduct post-metamorphic surveys in 2018. In 2019, we observed one clutch on 7 March, and two additional egg masses on 18 April, when all were hatching with emerging tadpoles. We did not conduct post-metamorphic surveys in 2019. In 2020, we conducted weekly VES starting on 13 February and found one egg mass on 20 February, and two additional egg masses observed on 27 February. On 13 March we observed no new egg masses. We did not conduct surveys after 13 March 2020. In 2021, we observed a total of three egg masses at ENF Pond. We conducted daytime as well as nighttime VES on 19 January; 4, 10, 16, and 18 February with amplexus observed on 18 February, and observed two egg masses during a night survey on 21 February. We revisited the site during the day and night on 1, 11, 17, and 24 March with no new egg

masses present. During a night survey on 11 March, we noted a thin layer of ice on the pond with the two previously oviposited egg masses (21 February) experiencing near freezing temperatures with a water temp of 1° C. We observed moribund embryos at the top of one egg mass near the ice while the second egg mass was located under a small patch of snow. We conducted a daytime egg mass survey on 29 March and located one additional egg mass. On this date, we also observed a yellow water mold growing on the egg mass first observed on 29 March which was presumed to be unfertilized since no viable embryos appeared present. On 8 April we observed emerging tadpoles at the two remaining viable egg masses with embryos from 21 February. The third egg mass we observed and suspected to be originally unfertilized and first observed on 29 March was shrouded in yellow-green mold and/or algae, but tadpoles were present on the egg mass on 12 and 19 April. We observed all embryos from the two viable egg masses fully emerged by 12 April. On 8 July 2021, we observed four post-metamorphic frogs. In 2022, we first visited ENF Pond on 13 March where we observed a single recently oviposited egg mass. We resurveyed the site on 18 March and found no new egg masses. There was not a single precipitation event between 1 January and the appearance of the egg mass. On 17 July we observed > 50 late-stage *R. draytonii* tadpoles (Gosner 40–45) as well as > 10 post-metamorphic frogs.

Hughes Pond.—We heard males calling at this site in February 2008, but the first egg masses (n = 5) at this site were not detected until 5 March 2008. On 8 March we observed two additional egg masses attached to sedges on an east facing portion of the pond with a pond depth of 75 cm. We did not conduct additional egg mass surveys beyond this date. We collected larval and post-metamorphic data from 28 June 2005 until 28 July 2009. Post-metamorphic data represents the first observations of metamorphs and does not likely reflect the total number of metamorphs

present. On 28 June 2005, we observed 25 larvae (Gosner 39). We conducted a resurvey on 18 July and observed 11 post-metamorphic frogs. In 2006 and 2007 we did not conduct spring surveys, but the earliest we observed a single post-metamorphic frog in each year was on 12 July and 15 August for respective years. In 2008, the earliest we observed a single post-metamorphic frog was on 7 August and noted that Hughes Pond had desiccated by this date. In 2009 we observed the first post-metamorphic frogs on 28 July.

Spivey Pond.—The USGS confirmed the only egg masses seen at Spivey Pond were in late-April and early-May which were presumed to have been oviposited weeks earlier since there were late-stage embryos present. USGS also affirmed that egg mass surveys at Spivey in mid-March did not result in egg masses detected though gravid females were encountered as were males heard calling in early April (Pat Kleeman unpubl. data). On 27 March 2017, we visited Spivey Pond and observed a single egg mass in the older pond (Table SI 1). This was the first egg mass observed at this site since 2000 by Barry and Fellers (2013) when a single egg mass was observed on 27 April. ARC staff did encounter two "juvenile" frogs on 30 July 2015 that we presume to be post-metamorphic or YOY individuals. On 4 October 2016, we observed four metamorphs as well six late-stage larvae (Gosner 40) in the new pond. In 2017, we observed four metamorphs in the new pond and one metamorph in the old pond on 26 September.

Yosemite Valley.—At this site, we often detected (visually or with a Passive Integrated Transponder [PIT] tag reader) adult frogs along the shoreline in weeks prior to finding egg masses. We observed breeding behavior (e.g., amplexus) only once on 18 February in 2022 at Site 4.

In 2018, surveys began 1 February (Sites 1, 2, 4); adult frogs and calling males were observed at several sites but not egg masses. We conducted egg mass surveys until 29 March

and did not observe any egg masses but did find a single *R. draytonii* juvenile (YOY) in a small pool in Indian Creek on 24 September approximately 50 m from Site 4, indicating breeding had occurred in 2018.

In 2019, egg mass surveys began 10 March and by 15 March most suitable breeding locations in Yosemite Valley were free of ice and snow. On 25 March, we observed egg masses at Sites 2, 3, and 4. We revisited all three sites on 3 April and observed additional egg masses at Camp 6 Pond (12.5° C) and at Yellow Pine (9.3° C), but we did not observe any new egg masses at Cooks Meadow. At Site 4 on 9 August 2019, we captured two larvae (Gosner 40). We conducted a post-metamorphosis frog survey at Site 4 and at a small in-channel pool nearby (approximately 50 m) in Indian Creek on 4 October 2019. We captured eight metamorphs in the Indian Creek pool with SVLs varying between 34.4–39.5 mm. We did not observe larvae or post-metamorphic frogs at Site 2 or Site 3 on follow-up surveys between April and October 2019.

In 2020, surveys were limited due to pandemic related restrictions. On 11 March, we observed five newly oviposited egg masses at Site 1 with two egg masses being very large and estimated at > 2,500 eggs each. At Site 9, we observed three egg masses and two adult frogs. Two of the egg masses at Site 9 we observed had green algae present on them, and embryos appeared more developed (Gosner 20) and were close to emerging. At Site 5, we observed five adult frogs and one egg mass with poor visibility due to water turbidity. We conducted additional late season egg mass surveys on 24 April 2020 at Sites 1–5 and 9. Site 3 had filled to a water depth > 1.0 m by this date, and we observed one recent egg mass as well as two adult frogs. Sites 1,2, 4, 5 and 9 had all attained pond depths > 0.5 m, but no new egg masses or adults were observed. We conducted a final survey on 1 May 2020 when Sites 2, 5, 6, and 7 had

attained depths > 0.75 m, but did not locate any egg masses. We did observe six adult frogs at Site 5 on this date.

In 2021, we initiated surveys after ice and snow melt on 1 March and continued until 1 May. The spring 2021 breeding period followed a below average winter precipitation year in which many confirmed breeding areas (e.g., Sites 2, 3, and 4) had not filled. We did not observe any egg masses on 1 March or during a revisit to these sites on 8 March in which many suitable or previously documented breeding areas were still dry and not filling. We continued weekly surveys to sites where water was present from mid-March until 13 April with no egg mass or adult frogs observed during this period. During a survey on 14 April, we observed one egg mass at Site 3 and two egg masses at Site 4. We conducted a follow-up survey on 19 April and observed one additional egg mass at Site 3. We conducted additional egg mass surveys after 21 April but did not locate any additional egg masses in any Yosemite Valley locations. In 2021, we observed levels of egg mass mortality up to 60% that was not observed in previous years. Post-metamorphic surveys began on 3 June 2021, and although no egg masses were observed during egg mass surveys (March–April) at Site 5, we observed thousands of *R. draytonii* larvae on this date as well as one hatched egg mass. We conducted a follow-up survey to Site 5 on 22 July and observed > 25 post-metamorphic frogs with numerous larvae still present.

In 2022, we observed the first evidence of breeding on 18 February at Site 4 with three adult frogs (two in amplexus), but no egg masses observed. We conducted a follow-up survey on 22 February and observed one recently oviposited egg mass at this site. From this date, we conducted weekly egg mass surveys at all past and suitable breeding areas in Yosemite Valley until 15 May. On 22 March, we observed one egg mass at Site 6 and during a revisit on 25 March observed larvae emerging from the egg mass with a water temperature of 14.8° C. On 1

April we observed egg masses at Sites 4, 5, and 8. We observed a second recently oviposited egg mass at Site 6 on 15 April with a water temperature of 11.5° C. We revisited Site 6 on 25 April and observed larvae emerging from the 15 April observed egg mass with a water temp of 16.5° C. We revisited Site 6 on 2 May and did not observe any new egg masses but the hatched-out egg mass from 25 April was still clearly visible with some green algae growth. At Site 8, we observed larvae emerging from two egg masses deposited in an off-channel pond originally deposited on 11 April. Post-metamorphic surveys began on 14 July 2022, and we observed four recent *R. draytonii* metamorphs at Site 4 in a small pool of water that remained as much of the pond had dried by this date. By this date several other Yosemite Valley locations had already desiccated including Site 6 where no metamorphs were observed.