

Longevity in Wild California Red-legged Frogs (*Rana draytonii*) from Baja California, México

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Many amphibian species in western North America have been studied to the extent that their general natural history can be broadly defined (Storer 1925; Stebbins 1951, 2003; Grismer 2002). However, one aspect that appears to remain enigmatic in many amphibian species is longevity (i.e., life span) in the wild. Extended longevity of a species can be associated with fitness (Blanco and Sherman 2005), elevation (Liao and Lu 2010) and has also been correlated with brain size (Yu et al. 2018), yet it is a difficult aspect of a species natural history to investigate and determine (Smirina 1994; de Magalhães and Costa 2009). Skeletochronology has been used to determine age of some species of amphibians, with a relatively high level of accuracy (Hemelaar 1981). In other cases, direct observation has been used to age specimens (Conant and Hudson 1949; Engeman and Engeman 1996). Although Smirina (1994) suggested that mark recapture studies are not practical for determining age of individuals in wild populations, new technologies that include small, implanted Passive Integrated Transponders (PIT tags) have simplified this method when associated with long-term studies.

In Mexico, California red-legged frog populations are declining dramatically, mainly due to anthropogenic stresses, including ground water mining, habitat conversion, and spread of exotic species (Peralta-García 2016). We engaged in a long-term and ongoing study of the population dynamics of several California red-legged frog (*Rana draytonii*) populations at several locations of northern Baja California, Mexico. In our study we marked and recaptured individual frogs over years that provided evidence of a maximum life span that exceeds previously reported life spans for the species. Herein, we report on the longevity of wild individuals of the species and speculate on the reasons why the species is long-lived.

Beginning in 2013, while conducting an investigation of California red-legged frogs at the few remaining locations in Baja California where the species is extant, we collected and tagged individual frogs, using 12 mm implanted subdermal PIT tags (www.avidid.com) in anticipation of later recapturing the frogs to determine population patterns at these sites. At two locations, the El Potrero Ranch (30.893575° N, 115.475105° W; elev. approx. 910 m) on the Santo Domingo River, and La Grulla Meadow in the Parque Nacional Sierra San Pedro Mártir (30.914495° N, 115.643678° W; elev. approx. 2060 m), at the headwaters of the Santo Domingo River, we captured all adult and subadult frogs we encountered and marked them for long-term population analysis. Frogs were released unharmed at the site of capture. We assumed the minimum possible age for adults (based on morphology and

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Fig. 1. Adult California red-legged frog (*Rana draytonii*) from La Grulla Meadow, Baja California, Mexico, in 2013, with a minimum age range of 13 yrs upon third capture in 2022. Red arrow indicates insertion point for PIT tag. Photo by B. Hollingsworth.

reproductive status) is that of sexual maturity as stated by Stebbins (1951) and Jennings and Hayes (1994), approximately 2–4 yrs old.

In subsequent years many previously tagged frogs were recaptured during annual visits to the El Potrero site, and also during visits to the La Grulla site, which were visited from 2013 to 2017, 2021 and 2022. Among the many recaptures, three adult frogs marked as adults in 2013, were recaptured in 2020 (one male from El Potrero), 2021 (one female from La Grulla) and 2022 (a second female from La Grulla). This resulted in a known minimum age of 7, 8 and 9 yrs, respectively. If we assume the minimum age at sexual maturity is at least 2–4 yrs, these individuals would have been a minimum age range would be 9–13 yrs old.

A report by Engeman and Engeman (1996) noted that a woodhouse's toad (*Anaxyrus woodhousii*) was known to live 27 yrs in the wild, but this individual was in a semi-natural location—entrapped in a basement window well. Stebbins (1951) reported captive northern red-legged frogs (*R. aurora*) that lived 12–13 yrs, and another approximately 15 yrs, but noted most of the life span of these frogs was in captivity; his account was not attributed, but we found that it was likely that of Cowan (1941). Duellman and Trueb (1994) reported that amphibians tend to be longer lived in captivity than in the wild, which has also been supported by work from others (i.e., Conant and Hudson 1949; Zhang and Lu 2012). We reviewed the maximum age of similar-sized ranid frogs from North America reported in the literature. Similar-sized frogs were reported based on the contention by Duellmann and Trueb (1994) that larger species tend to live longer than smaller species. We found that the average maximum life span among ten similar-sized ranids was 7.7 yrs (Table 1).

Table 1. Maximum age of reported for wild ranid frogs.

| Species | Maximum age | Source |
|--------------------------------|-------------|-----------------------------|
| <i>Rana boylei</i> | 8 | Marlow et al. 2016 |
| <i>R. draytonii</i> | 13 | This study |
| <i>R. esculenta</i> | 10 | Cogalniceanu and Miaud 2003 |
| <i>R. lutriventris</i> | 7 | Reaser 2000 |
| <i>R. muscosa</i> | 10 | Matthews and Miaud 2007 |
| <i>R. pipiens</i> | 5 | LeClair and Castanet 1987 |
| <i>R. sylvatica</i> | 5 | Bastien and Leclair 1992 |
| <i>Lithobates catesbeianus</i> | 9 | Shirose and Brook 1995 |
| <i>L. clamitans</i> | 6 | Shirose and Brook 1995 |
| <i>L. septentrionalis</i> | 6 | Shirose and Brook 1995 |
| <i>L. subaquavocalis</i> | 11 | Platz et al. 1997 |

We speculate that the California red-legged frog is well adapted to a highly variable climate in California and Baja California. Since it reaches sexual maturity several years after metamorphosis, it seems likely that it would be a long-lived species. This may be supported by a need to forgo breeding in unfavorable conditions, particularly recurrent drought-prone areas (J. Alvarez, unpublished data) because a longer-lived species could then survive dry periods and still have opportunities for breeding during subsequent years. Yu et al. (2018) suggested that larger brained frogs may live longer. Several researchers have suggested that anurans living at higher elevations live longer (Lai et al. 2005; Liao and Lu 2010; Oromi et al. 2012). Indeed, this species lives at a wide range of elevations from <1 m in Marin County, California to 2060 m in La Grulla Meadow, Baja California. Our data suggest that longevity occurs at both middle (El Potrero) and high elevations (La Grulla), but we have no data for lower elevations to which to compare.

This age study provides evidence of the minimum lifespan of the California red-legged frog. Future research may provide additional data to support our contention that California red-legged frog evolved to be long-lived. Our data indicate that the three wild frogs reported here likely represent the maximum lifespan currently known for California red-legged frog. Our study is on-going and additional data in future years will likely provide further insights on the longevity of this species.

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