Rana boylii Baird, 1854(b)

FOOTHILL YELLOW-LEGGED FROG

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1. Historical versus Current Distribution. Historically, foothill yellow-legged frogs (*Rana boylii*) ranged throughout much of southwestern Oregon (west of the crest of the Cascade Mountains). The northernmost records are from the Santiam River system in Marion County, Oregon. In California, foothill yellow-legged frogs were found in most of the northwest and south throughout the foothill regions of the coast range (south to the San Gabriel River system, Los Angeles County) and along the western slopes of the Sierra Nevada south to Kern County, and through the Tehachapis and San Gabriel Mountains in southern California. An isolated population has been reported from the Sierra San Pedro Martir of Baja California (Loomis, 1965). A live animal from there was examined and confirmed by R.C. Stebbins, but no specimen exists today (R.C. Stebbins, personal communication). Zweifel (1955) provides a detailed map of the historical range. Foothill yellow-legged frogs range from near sea level to 1,800 m in Oregon (Leonard et al., 1993) and to 1940 m in California (Hemphill, 1952).

Since 1993, my field crews and I have conducted extensive surveys for foothill yellow-legged frogs in California, visiting 804 sites (in 40 counties) that had suitable habitat within the historical range. We found at least one foothill yellow-legged frog at 213 of these sites (26.5% of sites), representing 28 counties.

Extant populations of foothill yellow-legged frogs are not evenly distributed in California. In the Pacific northwest, 40% of the streams support populations of foothill yellow-legged frogs, while that number drops to 30% in the Cascade Mountains (north of the Sierra Nevada), 30% in the south coast range (south of San Francisco), and 12% in the Sierra Nevada foothills.

2. Historical versus Current Abundance. While the number of populations is important, population size is also critical. Only 30 of the 213 sites in California with foothill yellow-legged frogs have populations estimated to be 20 or more adult frogs.

The situation for foothill yellow-legged frogs in the Sierra Nevada is bleak; there are no populations in the southern Sierra Nevada foothills that are likely to remain viable for more than a decade. Populations in the northern Sierra are more numerous and generally larger, but they may be in decline as well. Additionally, many of the foothill streams to the northern Sierra Nevada have recreational gold mining activities, which alter the streambed and are likely having a serious, negative impact on the frog fauna.

In the south coast range, several populations of foothill yellow-legged frogs along streams draining into the Central Valley appear to be doing well, in spite of heavy livestock grazing. There are almost certainly other good foothill yellow-legged frog populations in this region, but they are on lands that are privately owned and are thus inaccessible.

The largest populations in California are in the north coast range where the estimated number of adult frogs exceeds 100 at six sites, and an additional nine populations have > 50 adult frogs. The Pacific Northwest is clearly the stronghold for foothill yellow-legged frogs in California, with healthy populations scattered throughout the region.

In Oregon, foothill yellow-legged frogs were once one of the most abundant amphibians in the Rogue River area of southwestern Oregon (Fitch, 1936). Now they are rare or absent throughout the entire western half of their range. There is only one known population in the Cascade foothills on the east side of the Willamette Valley (C. Pearl and D. Olson, personal communications). Farther south, foothill yellow-legged frogs are rare in the Klamath Basin. In the western half of the range, there are moderately good populations in the Umpqua River drainage, and frogs become more common farther south toward California.

3. Life History Features.

A. Breeding. Reproduction is aquatic. Oviposition behavior was recently described by Wheeler et al., 2003).

i. Breeding migrations. Adult migrations appear to be limited to modest movements along stream corridors (Ashton et al., 1998), but the magnitude of such movements, any seasonal component, and differences between sexes remains largely unknown.

ii. Breeding habitat. Unlike other ranid frogs in California, Oregon, and Washington, foothill yellow-legged frogs mate and lays eggs exclusively in streams and rivers. Males typically vocalize underwater (MacTeague and Northern, 1993), but frogs occasionally call above water (Ashton et al., 1998). Their calls are rarely heard.

Timing and duration of breeding activity vary geographically and across populations, but generally occurs during the spring. In California, we have found egg masses between 22 April–6 July, with an average of 3 May. In some areas such as the Trinity River (Trinity County, California), foothill yellow-legged frogs lay eggs throughout the 3 mo period of April–June (Ashton et al., 1998). Other authors cite shorter periods of breeding, i.e., within a 2-wk window that occurs between late March and May (Storer, 1925; Grinnell et al., 1930; Wright and Wright, 1949; Zweifel, 1955). Kupferberg (1996a,b) reports an approximate breeding period of 1 mo beginning late April to late May. A Marin County, California, population generally lays eggs within a much smaller window of a few weeks around late April. Rainfall during a given breeding season can delay oviposition (Kupferberg, 1996a,b). Lind et al. (1996) found that water releases from a dam on the Trinity River washed away most foothill yellow-legged frog egg masses in the main stream of the river.

B. Eggs.

i. Egg deposition sites. Oviposition sites are generally shallow, slow-moving water with a cobble or pebble substrate that is used to anchor each egg mass. On occasion, egg masses may be attached to aquatic vegetation, woody debris, and gravel. Masses are usually attached to the downstream side of rocks, at the stream margin, and at depths of < 0.5 m (Stebbins, 1985; Fuller and Lind, 1992; Ashton et al., 1998).

ii. Clutch size. Egg masses vary in size and in the number of eggs/mass. The size of an egg mass after it has absorbed water (usually a few hours after oviposition) is 5–10 cm in diameter and "resembles a cluster of grapes" (Stebbins, 1985). The number of eggs/mass can range from 300–2,000 (Storer, 1925; Fitch, 1936; Zweifel, 1955), with an average of about 900 eggs (Ashton et al., 1998).

Egg masses observed in the field frequently have silt accumulation on the outer surface (Stebbins, 1985). It is not known if silt accumulation affects egg development, but the silt makes the masses less conspicuous and may reduce predation by visual predators.

Eggs generally hatch within 5–37 d (Zweifel, 1955; Ashton et al., 1998). Hatching rates are influenced by temperature, with faster developmental times in warmer waters, up to the critical thermal maximum temperature of about 26 ˚C (Zweifel, 1955; Duellman and Trueb, 1986). Tadpoles move away from their egg mass after hatching (Ashton et al., 1998).

C. Larvae/Metamorphosis.

i. Length of larval stage. Larval development is, in part, temperature dependent. Typically, tadpoles metamorphose 3–4 mo after hatching.

ii. Larval requirements.

a. Food. Tadpoles feed on algae, diatoms, and detritus by grazing the surface of rocks and vegetation. Diatom rich diets, particularly epiphytic diatoms that contain protein and fat, enhance growth, development, and survival to metamorphosis (Kupferberg, 1996a,b). Tadpoles have also been observed in the field feeding on necrotic tissue of other tadpoles and bivalves (Ashton et al., 1998).

b. Cover. Cover is essential for tadpoles. During the first week of life, tadpoles can often be found within the vicinity of the hatched egg mass. They then move to nearby areas, between and beneath cobble and gravel. When fleeing from threats, their swimming pattern is described as frantic (Ashton et al., 1998).

iii. Larval polymorphisms. None.

iv. Features of metamorphosis. As with most other frog species, major events of metamorphosis include reorganization of the digestive tract, absorption of the tail, and the emergence of front limbs (Duellman and Trueb, 1986). Foothill yellow-legged frogs metamorphose at a size of 1.4–1.7 cm SUL.

v. Post-metamorphic migrations. Young, post-metamorphic frogs tend to migrate upstream from their hatching site (Twitty et al., 1967).

D. Juvenile Habitat. Believed to be similar to adults.

E. Adult Habitat. Foothill yellow-legged frogs are primarily stream dwelling. Stebbins (1985) describes foothill yellow-legged frogs as stream or river frogs found mostly near water with rocky substrate, as found in riffles, and on open, sunny banks. Other authors have expanded this description, and/or offer variations. Critical habitat (i.e., habitat suitable for egg laying) is defined by Jennings and Hayes (1994a) as a stream with riffles containing cobble-sized (7.5 cm diameter) or larger rocks as substrate, which can be used as egg laying sites. These streams are generally small to mid sized with some shallow, flowing water (Jennings, 1988). Fuller and Lind (1992) observed subadults on partly shaded (20%) pebble/cobble river bars near riffles and pools.

Less typical streams lack a rocky, cobble substrate (Fitch, 1938). Other types of riparian habitats include isolated pools and vegetated backwaters (Hayes and Jennings, 1988). Adult frogs have been observed in deep, shady, spring-fed pools (personal communication).

F. Home Range Size. Unknown.

G. Territories. Unknown, but other ranid frogs are well known to defend breeding areas (Wells, 1977).

H. Aestivation/Avoiding Dessication. Unknown.

I. Seasonal Migrations. See "Breeding migrations" above.

J. Torpor (Hibernation). None reported.

K. Interspecific Associations/ Exclusions. Foothill yellow-legged frogs are frequently found in association with Pacific treefrogs (*Hyla regilla*), western toads (*Bufo boreas*), Sierra garter snakes (*Thamnophis couchi*), and Pacific pond turtles (*Clemmys marmorata*). Less frequent associates include coastal giant salamanders (*Dicamptodon tenebrosus*), California newts (*Taricha torosa*), American bullfrogs (*Rana catesbeiana*), northern red-legged frogs (*Rana a. aurora*), terrestrial garter snakes (*Thamnophis elegans*), and common garter snakes (*T. sirtalis*). There are records of foothill yellow-legged frogs co-occurring with California giant salamanders (*Dicamptodon ensatus*), southern torrent salamanders (*Rhyacotriton variegatus*), rough-skinned newts (*T. granulosa*), tailed frogs (*Ascaphus truei*), and northwestern salamanders (*Ambystoma gracile*; personal observations). Lind et al. (2003) recently found a male foothill yellow-legged frog amplexing a female American bullfrog.

L. Age/Size at Reproductive Maturity. It is generally thought that individuals reach reproductive maturity in the second year after metamorphosis (Storer, 1925; Zweifel, 1955), but Jennings (1988) reports that individuals may reproduce as early as 6 mo after metamorphosis. Also, there may be differences by sex. Additional work in this area is needed.

M. Longevity. The life span of foothill yellow-legged frogs is not known, and comparisons with the closely related mountain yellow-legged frogs may not be appropriate because these two species live under such different environmental regimes.

N. Feeding Behavior. Most of the literature regarding the diet of foothill yellow-legged frogs is rather general in description. Nussbaum et al. (1983) reports that the diet includes flies, moths, hornets, ants, beetles, grasshoppers, water striders, and snails. Terrestrial arthropods (87.5% insects, 12.6% arachnids) were the primary prey items of recently metamorphosed foothill yellow-legged frogs at a single site studied by Van Wagner (1996). Storer (1925) and Fitch (1936) note that terrestrial and aquatic insects are probable food for post-metamorphic frogs.

O. Predators. A host of vertebrates and perhaps some aquatic invertebrates feed on foothill yellow-legged frogs. Most species of garter snakes (*Thamnophis* sp.), which co-exist with foothill yellow-legged frogs, prey upon both tadpoles and juvenile frogs. This includes common garter snakes (*T. sirtalis*), terrestrial garter snakes (*T. elegans*), and Sierra garter snakes (*T. couchii*). All but Oregon aquatic garter snakes (*T. atratus hydrophilus*), which prefer tadpoles (Jennings and Hayes, 1994a), are reported to primarily eat young, post-metamorphic individuals (Fitch, 1941; Zweifel, 1955; Lind, 1990).

Several species of amphibians prey upon foothill yellow-legged frogs. Rough-skinned newts (*Taricha granulosa*) eat foothill yellow-legged frog egg masses (Evenden, 1948). Non-indigenous American bullfrogs prey on foothill yellow-legged frogs (Crayon, 1998). Bullfrog larvae apparently do not feed on foothill yellow-legged frogs, but through competitive interactions for algal resources, they can cause a substantial reduction of survivorship and a decreased mass in post-metamorphic individuals (Kupferberg, 1997).

There are no reports of native salmonids preying on foothill yellow-legged frogs, though a variety of introduced trout and warm water fishes eat both the eggs and tadpoles. Green sunfish (*Lepomis cyanellus*, Centrarchidae) are especially pernicious and will systematically eat eggs and larvae (Werschkul and Christensen, 1977). Native Sacramento squawfish (*Ptychocheilus grandis*) feed on adult frogs and eggs (Brown and Moyle, 1997; D. Ashton and R. Nakamoto, personal communication).

P. Anti-Predator Mechanisms. None reported.

Q. Diseases. None reported.

R. Parasites. None reported.

4. Conservation. Foothill yellow-legged frogs are susceptible to a wide range of environmental impacts including loss of habitat, pesticides, competition/predation from nonnative species (e.g. warm-water fish, bullfrogs, crayfish), disease, water impoundments, logging, mining, and grazing in riparian zones. In the Sierra Nevada foothills of California, air-borne pesticides (that move east on the prevailing winds blowing across the highly agriculturalized Central Valley) are likely to be the primary threat to foothill yellow-legged frogs (LeNoir et al., 1999; Sparling et al., 2001; Hayes et al., 2002b). It is unknown whether pesticides are contributing to the decline of foothill yellow-legged frogs in Oregon (especially east of the agricultural parts of the Willamette Valley), but it should be examined. The populations of foothill yellow-legged frogs in greatest decline are all downwind of highly impacted (mostly agriculturalized) areas, while the largest, most robust frog populations are along the Pacific coast.

Many nonnative species are likely to be competitors and/or predators of foothill yellow-legged frogs, but few studies have examined the impacts of these nonnatives. Chytrid fungus has been found in foothill yellow-legged frogs, but it is not known what the effect on foothill yellow-legged frogs might be, or even whether the fungus is a native pathogen. In some areas, nonnative American bullfrogs co-occur with foothill yellow-legged frogs and are known to have a negative impact (Kupferberg, 1996b, 1997a), but it is unclear whether this is sufficient to cause population-level declines. The role of other nonnatives needs to be investigated.

There is concern that dams along many river drainages negatively impact foothill yellow-legged frogs. Dams not only interfere with normal dispersal and movements, but also provide refugia for nonnative species that are likely affecting foothill yellow-legged frogs. Unfortunately, there is little research on the role of dams and how they relate to native amphibians.

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