Bufo canorus Camp, 1916(a)

YOSEMITE TOAD

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This species account is dedicated to the memory of Cynthia Kagarise Sherman.

1. Historical versus Current Distribution. Yosemite toads (*Bufo canorus*) are endemic to the Sierra Nevada, California, from Ebbetts Pass, Alpine County to the Spanish Mountain area, Fresno County (Karlstrom, 1962, 1973; Stebbins 1966; unpublished Sierra National Forest survey data, 1995, 2002). Sites occur from 1,950–3,444 m elevation, with the majority of sites between 2,590–3,048 m (Karlstrom, 1962). Jennings and Hayes (1994a) estimate that populations have disappeared from 50% of historically reported sites, although the overall range of the species may have only contracted in the far north and in western Fresno County. Disappearances have been concentrated at lower elevation sites on the western edge of the range, with greater persistence at higher elevation sites (Davidson et al., 2002).

2. Historical versus Current Abundance. Trends in Yosemite toad population size have not been evaluated at most sites. Kagarise Sherman and Morton (1993) report sharp population declines at seven sites in the eastern Sierra Nevada from 1971–'91. At one well-studied site at Tioga Pass with a 20-yr history of counts, the number of marked males entering breeding pools had declined ninefold (Kagarise Sherman and Morton, 1993).

3. Life History Features.

A. Breeding. Reproduction is aquatic.

i. Breeding migrations. Males arrive at breeding pools several days before females (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984). Individual males stay at breeding ponds for 1–2 wk, and females for only a few days (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984). Breeding takes place from mid May to mid August (Kagarise Sherman, 1980; G.M.F., unpublished data). Both sexes are primarily active during the day (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984). There may be ten times as many males as females at a breeding site (Karlstrom, 1962; Kagarise Sherman, 1980). Males call diurnally and can be heard from a distance of over 100 m (Kagarise Sherman, 1980). Grinnell and Storer (1924) remarked on the call, "Its mellow notes are pleasing additions to the chorus of bird songs just after the snow leaves." Camp (1916a) gave the species the name *canorus,* which in Latin means "tuneful." After breeding, both sexes move into meadow areas to feed for 2–3 mo before winter snows arrive (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984). At Tioga Pass, adults traveled 150–230 m between sites where they spent the winter at breeding ponds, with females tending to move farther than males (Kagarise Sherman, 1980).

ii. Breeding habitat. Breeding sites are typically meadow edges without deep water or adjacent steep terrain (Karlstrom, 1962). Yosemite toads will occasionally breed in the shallows of lakes (G.M.F., personal observations).

B. Eggs.

i. Egg deposition sites. Typical egg deposition sites include shallow (< 7.5 cm) pools and small, slow moving, shallow streams usually in meadows, with short emergent vegetation and loose silt substrate (Karlstrom, 1962).

ii. Clutch size. Females lay an estimated 1,500–2,000 eggs (Karlstrom, 1962) in single or double strands or in a radiating network 4–5 eggs deep (Karlstrom and Livezey, 1955). In the Tioga Pass area, eggs hatched in about 10–12 d (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984). Karlstrom (1962) estimates critical thermal maximum of 36–38 ˚C for larvae and 31 ˚C as upper limiting temperature for egg development.

C. Larvae/Metamorphosis.

i. Length of larval stage. In the Tioga Pass area, tadpoles metamorphosed 52–63 d after the eggs were laid (Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984).

ii. Larval requirements.

a. Food. Unknown, but presumably tadpoles are grazing feeders that ingest algae and other material suspended when they scrape rocks, plants, and other submerged substrates.

b. Cover. Unknown.

iii. Larval polymorphisms. Unknown.

iv. Features of metamorphosis. Unknown.

v. Post-metamorphic migrations. Unknown.

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

E. Adult Habitat. High elevation, open, montane meadows, willow thickets, and adjoining forests. Although adult toads spend little time actually in water, they are seldom found more than about 100 m from permanent water (Karlstrom, 1962). Adults take cover in rodent burrows, under surface objects, and in willow thickets (Karlstrom, 1962). In the Tioga Pass area, animals primarily utilized burrows of meadow mice (*Microtus montanus*) and pocket gophers (*Thomomys monticola*; Karlstrom, 1962).

Critical thermal maximum for adults was estimated at 38–40 ˚C and a lower thermal limit at -1 ˚C (Karlstrom, 1962). Adults seem to exhibit little temperature preference in the field, where temperatures between 2–30 ˚C were reported, with no sign of temperature stress (Karlstrom, 1962).

F. Home Range Size. Unknown.

G. Territories. Similar to most toads, calling males defend space around themselves from intrusion by other males. Males are more likely to defend calling areas when male density at breeding pools is low (Kagarise Sherman and Morton, 1984).

H. Aestivation/Avoiding Dessication. Does not occur.

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

J. Torpor (Hibernation). Animals become inactive for the winter in late September or early October and become active again from April–July, as soon as the snow melts from breeding pools (Karlstrom, 1962; Kagarise Sherman, 1980). During the winter, toads utilize rodent burrows, crevices under rocks, or the root tangle at the base of willows (Kagarise Sherman, 1980). In the Tioga Pass area, toads used rodent burrows, including those of meadow voles (*Microtus montanus*), gophers (*Thomomys* sp.), Belding ground squirrels (*Spermophilus beldingi*), and yellow-bellied marmots (*Marmota flaviventris*; Kagarise Sherman, 1980). First year juveniles spend the winter in similar habitats near the pools from which they emerged (Kagarise Sherman, 1980).

K. Interspecific Associations/ Exclusions. See "Torpor (Hibernation)" above.

L. Age/Size at Reproductive Maturity. At Tioga Pass Meadows, minimum reproductive size was 48 mm SVL for males and 60 mm SVL for females (Kagarise Sherman, 1980). Females first breed at 4–6 yr, and not every year thereafter. Males first breed at 3–5 yr of age (Kagarise Sherman, 1980).

M. Longevity. Kagarise Sherman and Morton (1984) estimate that some females may live at least 15 yr and males at least 12 yr.

N. Feeding Behavior. Adults and juveniles eat tenebrionid beetles, weevils, large ants, centipedes, spiders, ladybird beetles, dragonfly naiads, bees, wasps, millipedes, flies, mosquitoes and lepidopteran larvae (Grinnell and Storer, 1924; Mullally, 1953; Kagarise Sherman and Morton, 1984). Wood (1977) reported that hymenopterans composed almost 80% of the summer diet.

O. Predators. Predation on tadpoles has been reported for mountain yellow-legged frogs (*Rana muscosa*), dragonfly naiads (Mullally, 1953), robins (*Turdus migratorius*), and diving beetles (*Dytiscus* sp.; Kagarise Sherman, 1980; Kagarise Sherman and Morton, 1984, 1993; G.M.F., personal observations). Garter snakes, especially western terrestrial garter snakes (*Thamnophis elegans*), probably eat large numbers of larvae and juveniles (Karlstrom, 1962; Kagarise Sherman, 1980). Karlstrom (1962) reported that Brewer's black birds (*Euphagus cyanocephalus*) and California Gulls (*Larus californicus*) have been observed eating other species of tadpoles and are present in the range of Yosemite toads, but there are no records of them eating Yosemite toad tadpoles. In most years, desiccation of breeding pools, not predation, is the single major cause of larval mortality (Kagarise Sherman, 1980). Kagarise Sherman (1980) and Kagarise Sherman and Morton (1984, 1993) report on adults being killed by Clark's Nutcrackers (*Nucifraga columbiana*) and California gulls. Common

ravens (*Corvus corax*) may also eat adults (Kagarise Sherman and Morton, 1993).

P. Anti-Predator Mechanisms. Adults and juveniles can release toxic secretions from the parotoid glands. Frightened adults and juveniles may leap into the water or retreat into rodent burrows (Mullally, 1953).

Q. Diseases. Green and Kagarise Sherman (2001) examined preserved specimens from a mass die-off of Yosemite toads in the 1970s at Tioga Pass and found indications of numerous diseases. Chytridiomycosis (chytrid fungus infection) and bacillary bacterial septicemia (red-legged disease) were considered the cause of death for four specimens. In addition they found *Dermosporidium* sp. (a fungal infection), myxozoan infection (*Leptotheca ohlmacheri,* a cnidarian), and a roundworm infection (larval *Rhabdias* sp.).

R. Parasites. Helminth worms were observed by Wolton (1941). Green and Kagarise Sherman (2001) found helminths in the gut, lungs, and bladders, as well as trematodes in the lungs and bladder.

4. Conservation. The State of California lists Yosemite toads as a Species of Special Concern. Environmental groups petitioned the U.S. Fish and Wildlife Service to list the toad under the Endangered Species Act. In November 2002, the U.S. Fish and Wildlife Service decided that the listing was "warranted, but precluded," meaning that listing was warranted based on the status and threats facing the species, but that the agency had higher priorities. This leaves the toad as a Candidate species that may be reconsidered for listing in the future.

The causes of declines for Yosemite toads are unclear. Leading hypotheses for the declines are disease, airborne contaminants, and livestock grazing. In an examination of preserved specimens from a 1970 die-off, Green and Kagarise Sherman (2001) found multiple pathogens, but no single pathogen was present in more than 25% of the specimens, suggesting that the animals suffered from suppressed immune systems possibly due to a virus or chemical contaminants. Davidson et al. (2002) found that historic sites where Yosemite toads are absent had twice as much agricultural land upwind, compared to historic sites that still have toads (suggesting that windborne agrichemicals may have contributed to declines), but these differences were not statistically significant. Livestock grazing may have detrimental impacts on Yosemite toads through trampling, alteration of meadow habitat, and possible lowered water quality (D. Martin, personal communication). Other factors that may have contributed to declines are the 1980s' California drought, fish predation, and increased predation by Common Ravens (*Corvus corax*; Kagarise Sherman and Morton, 1993). According to the Breeding Bird Survey (U.S.F.W.S., unpublished data) the number of Common Ravens has increased in the Sierra Nevada by 9.5% annually over the period from 1966–'89. Because ravens may feed on Yosemite toads, an increase in the raven population could contribute to a decline of these toads. Increases in ravens may be related to human activities (Kagarise Sherman and Morton, 1993).

The U.S. Forest Service, which manages most of the land within the range of Yosemite toads, has developed plans for new management practices to help conserve Yosemite toads. Under the plans, grazing during the Yosemite toads' breeding season would be excluded from wet meadows with known populations. In addition, the Forest Service would conduct surveys for toads, monitor a sampling of known populations, study the impact of grazing, and try to avoid application of pesticides within 152 m (500 ft) of known toad sites.

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