

AMPHIBIAN DECLINES

The Conservation Status of United States Species

EDITED BY MICHAEL LANNOO



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(Hammerson, 1986). Emergence occurs during the monsoon season in the southwest and may be cued by low frequency sound, as is the case for Couch's spadefoot toads (*Scaphiopus couchii*; Dimmitt and Ruibal, 1980a). In more temperate regions such as Iowa, emergence can occur with spring rains as early as mid-April when temperatures rise above 10 °C (unpublished data). Animals continue feeding throughout the summer on warm humid nights or after rainfall until mid-September (Mabry and Christiansen, 1991).

I. Seasonal Migrations. Unknown.

J. Torpor (Hibernation). See also "Aestivation/Avoiding Desiccation" above. Juveniles are thought to be intolerant of freezing and avoid freezing through burrowing and by having low supercooling temperatures (Swanson and Graves, 1995). These authors estimate that to avoid freezing during mild South Dakota winters, juveniles must burrow to depths of 20–50 cm.

K. Interspecific Associations/Exclusions. Three spadefoot toad species often use the same breeding pond in New Mexico (Cornejo, 1982; Woodward, 1984). Zones of interbreeding between Mexican and plains spadefoot toads have been described in Texas, New Mexico, and Arizona (Sattler, 1985; Simovich et al., 1991; Simovich, 1994). Hybridization has been induced in the laboratory between Mexican spadefoot toads and plains spadefoot toads (Forester, 1975) and may occur in nature (Hughes, 1965). Mating calls serve as reproductive isolating mechanisms (Forester, 1973). Two mating call types have been described for plains spadefoot toads (Pierce, 1976).

Throughout the Great Plains, plains spadefoot toads and Great Plains toads (*Bufo cognatus*) commonly use the same ephemeral breeding sites. Here, plains spadefoot toad tadpoles feed on the smaller Great Plains toad tadpoles (Bragg, 1940a). Plains spadefoot toads also have been reported to share breeding ponds with Woodhouse's toads (*B. woodhousii*; Collins and Collins, 1993).

L. Age/Size at Reproductive Maturity. Reproductive maturity is reached during the second year (Trowbridge and Trowbridge, 1937; Mabry and Christiansen, 1991). Iowa males range from 31–38 mm SVL, females 32–40 mm (Mabry and Christiansen, 1991). Females are also heavier than males (Collins and Collins, 1993). Mature males have keratinized nuptial pads on their thumbs.

M. Longevity. As long as 13 yr based on skeletochronology (Tinsley, 1997).

N. Feeding Behavior. Nocturnal, feeding on beetles, crickets, grasshoppers, ants, spiders, termites, moths, caterpillars, and other small arthropods (Bragg, 1944; Whitaker et al., 1977; Collins and Collins, 1993; Anderson et al., 1999b).

O. Predators. *Hydrophilus triangularis* (hydrophilid beetle larva), *Apus* sp. (a crustacean), western terrestrial garter snakes (*Thamnophis elegans*), and cannibalistic congeners feed on plains spadefoot toad tadpoles (Black, 1968). Predators of adults include prairie rattlesnakes (*Crotalus v. viridis*), Swainson's hawks (*Buteo swainsoni*), and burrowing rodents (Hammerson, 1986).

P. Anti-Predator Mechanisms. Skin gland secretions may cause sneezing, mucous discharge, and watering eyes in humans (Conant, 1975) and presumably could affect predators. Tadpole feeding aggregations only occur in the presence of predators and may deter them (Black, 1968).

Q. Diseases. Unknown.

R. Parasites. Tadpoles have been observed with *Saprolegnia* sp. fungus (Bragg and Bragg, 1957) and adults with intradermal mites (Duszynski and Jones, 1973). They may also serve as hosts for the monogean parasite, *Pseudodiplorchis americanus*, which is known to infect Couch's spadefoot toads.

4. Conservation.

Plains spadefoot toads tend to be locally abundant and currently are not listed by any state or by the U.S. Federal Government. They are listed as Protected in Manitoba (Weller and Green, 1997); their status in Alberta is uncertain (Klassen, 1998). Plains spadefoot toads require loose, well-drained soils for burrowing and aestivating; grasslands (Anderson et al., 1999a) or grassy buffer

zones for foraging; and shallow, sparsely vegetated, fish-free, ephemeral wetlands for breeding. In parts of their range, natural breeding habitat has been severely reduced by agriculture, industrial, and other types of floodplain development.

Spea hammondi (Baird, 1859, "1857")
WESTERN SPADEFOOT

Steven R. Morey

There are two recognizable groups of North American spadefoot toads, *Scaphiopus* (Holbrook, 1836) and *Spea* (Cope, 1863). With respect to those species that are referable to *Spea*, the literature is divided, with some authors following Bragg (1944, 1945b), Stebbins (1951, 1985), Blair (W.F., 1955c), Zweifel (1956b), and Hall (1998), who treat the two groups as subgenera. We follow B.C. Brown (1950), Smith (1950), Tanner (1989b), Wiens and Titus (1991), Maglia (1998, 1999), and Crother et al. (2000), who recognize the generic distinctness of *Spea*.

1. Historical versus Current Distribution.

Western spadefoot toads (*Spea hammondi*) previously were considered to have a wide range in the arid regions of the southwestern United States and northern Mexico, possibly even central and southern Mexico, with a disjunct portion of the range in cismontane California (Tanner, 1939; Bragg, 1944; Smith and Taylor, 1948; Stebbins, 1954a, 1966; Zweifel, 1956b; Tanner, 1989b). Brown (H.A., 1976a) proposed that the populations east of California be



recognized as *Spea multiplicata* Cope, 1863 (Mexican spadefoot toads), citing marked differences in morphology, mating calls, and ecology. Patterns of allozyme variation (Sattler, 1980; Wiens and Titus, 1991) subsequently have supported the elevation of Mexican toads to species status.

In the United States, western spadefoot toads are restricted to California, where their range includes the Great Valley and associated foothills and the Coast Ranges east and south of San Francisco Bay (Stebbins, 1985; Jennings and Hayes, 1994a). Western spadefoot toads also occur in northwestern Baja California, Mexico, at lower elevations west of the Sierra San Pedro Martir Crest, south to Mesa de San Carlos (Stebbins, 1985). In California, their historical and current range are nearly identical (Jennings and Hayes, 1994a, see fig. 26). Some gaps in the distribution are probably artifacts of uneven surveys, particularly in the northern portion of their range. Western spadefoot toads have been eliminated wherever urban development and irrigated agriculture have destroyed areas where they once lived (e.g., Fisher and Shaffer, 1996). On the other hand, as with all North American spadefoot toads, western spadefoot toads readily breed in ephemeral artificial impoundments such as stock tanks and pools that form at the base of road and railroad grades, and they have colonized many areas where natural pools are rare or nonexistent. Thus, the distribution of western spadefoot toads probably differs from historical conditions.

2. Historical versus Current Abundance.

Patterns of abundance have been influenced substantially by human activities. Whenever human activities have created ephemeral impoundments where natural pools are rare or absent, western spadefoot abundance is probably higher than in the past. Examples can be found in the Coast Ranges south of San Francisco Bay, which have an abundant supply of manmade stock tanks, and in places along the eastern edge of the Great Valley and the nearby foothills, where a variety of human activities on the grazing lands have created breeding pools where suitable natural pools are rare or absent. The predominant change in historical versus current abundance, however, is that western spadefoot toads are now absent wherever urban development and irrigated agriculture have destroyed places where they were once abundant. For example, western spadefoot toads formerly were widespread but apparently are now absent on the Los Angeles coastal plain (Stebbins, 1972; Jennings and Hayes, 1994a) and much of lowland southern California. Habitat conversion has also caused losses in the Great Valley and its associated foothills (Jennings and Hayes, 1994a; Fisher and Shaffer, 1996). Historical abundance is unknown, but on

rainy nights along a road intersecting a relatively undisturbed vernal pool complex, Morey and Guinn (1992) found an average of 1.16 individuals/km of roadway during the fairly wet winter of 1982–83, and 0.68 individuals/km during the dry winter of 1984–85.

3. Life History Features.

A. Breeding. Reproduction is aquatic.

i. Breeding migrations. Adults are terrestrial and must move from summer refuges to reach breeding sites. Breeding appears to be triggered by rainfall and is generally synchronous, usually occurring 1 or 2 d after late winter or spring rains. Additional bouts of breeding, usually by smaller numbers of individuals, can occur and pools can contain larval cohorts of different ages. Little is known about what portion of the population moves to breeding sites each year, how far individuals move to reach the breeding sites, or how long they spend at breeding sites. Throughout their range, breeding is most likely during February and March (Storer, 1925; Burgess, 1950; Stebbins, 1954a; Feaver, 1971; H.A. Brown, 1976a; Morey, 1998). Males can be heard chorusing intermittently at breeding pools for up to several weeks following the rains that precede the main bout of breeding (Stebbins, 1954a; H.A. Brown, 1976a).

ii. Breeding habitat. Western spadefoot toads breed most frequently in temporary pools such as vernal playas, vernal pools, stock tanks, and pools that form at the base of road and railroad grades, but they occasionally breed in intermittent streams where larvae develop in more or less isolated pools as the streams dry. In order to support metamorphosis, breeding pools must remain filled long enough to accommodate at least the minimum larval period—in nature, about 30 d. There is almost always substantial mortality due to desiccation among larvae born in pools lasting fewer than 35 d after the eggs are laid (Feaver, 1971; Morey, 1998). Nevertheless, it is not uncommon for western spadefoot toads to breed in pools that remain filled for only 3–4 wk, usually with unfortunate consequences for larvae. Feaver (1971), for example, observed the desiccation of entire cohorts of larvae in 17 of 23 vernal pools in the Central Valley (Fresno County).

B. Eggs.

i. Egg deposition sites. Eggs are attached to plant stems or other objects (Stebbins, 1985).

ii. Clutch size. Females lay 300–500 eggs (Stebbins, 1951) in small clusters (10–42 eggs/cluster; Stebbins, 1985).

C. Larvae/Metamorphosis.

i. Length of larval stage. Larvae and eggs are described in Stebbins (1985). In nature, eggs usually hatch in 3–4 d. Larval development is completed in about 58 d (range 30–79) and is positively correlated

with pool duration (Morey, 1998). As with other *Spea*, age at metamorphosis is flexible. Denver et al. (1998) demonstrated that larvae in drying environments transformed earlier than control larvae in constant volume environments. The cessation of feeding in drying environments was suggested as a partial explanation for the apparent acceleration of development. Morey and Reznick (2000) observed a similar effect and demonstrated that slow-growing larvae transform at near the minimum possible size, while fast-growing larvae delay metamorphosis, presumably to capitalize on growth in the larval environment.

ii. Larval requirements.

a. Food. The food of larvae has not been reported, but larvae of other spadefoot toad species eat animals, plants, and organic detritus (Pomeroy, 1981; Pfennig, 1990).

b. Cover. Larvae most often occur in turbid pools with little or no other cover.

iii. Larval polymorphisms. A characteristic carnivorous morph with a broad head, large jaw muscles, a short gut, and rapid development (Pomeroy, 1981) is uncommon but has been observed in San Luis Obispo and Riverside counties, California.

iv. Features of metamorphosis. Once the first front forelimb has emerged (Gosner stage 42; see Gosner, 1960), transforming larvae begin to make short, nocturnal terrestrial excursions—even though at this stage they still possess a long tail—returning by day to the pool if it retains water. Transforming larvae in drying pools often take refuge in moist cracks around the drying edge. The time between emergence of the front forelimbs and the complete resorption of the tail is 2–6 d. During this time, transforming individuals do not eat and can lose 30% or more of their body mass and a comparable amount of stored body fat. Juveniles are unable to capture prey until tail resorption is complete. In nature, body mass at metamorphosis (Gosner stage 42) averages 3.7 g (range 1.5–10.4 g; Morey, 1998).

v. Post-metamorphic migrations. Juveniles migrate from their natal pool a few days after metamorphosis, but little is known about how far they travel or how they survive the dry conditions that are typical in April–June when these movements usually take place. Migrations by juveniles away from the natal pool sometimes coincide with rainfall, but rainfall during this season is rare. Most of these movements take place on calm, humid nights.

D. Juvenile Habitat. Once they leave the margin of the natal pool, the habitat characteristics of juveniles are probably similar to adults. Morey and Guinn (1992) found juveniles and adults together on rainy nights on roads intersecting a vernal pool complex.

E. Adult Habitat. Grasslands, oak woodlands, occasionally coastal sage scrub, or even chaparral in the vicinity of pools

suitable for breeding. Most western spadefoot toads are found at elevations below 365 m (1,000 ft). Stebbins (1985) gives an upper elevation extreme of 910 m (3,000 ft), but Ervin et al. (2001b) observed western spadefoot toads as high as 1,365 m (4,500 ft) in the mountains of San Diego County.

F. Home Range Size. Unknown.

G. Territories. Unknown. Little evidence of agonistic or territorial behavior. Males seem to maintain individual space while chorusing. Other species of *Spea* are solitary during periods of inactivity in burrows (Ruibal et al., 1969).

H. Aestivation/Avoiding Desiccation. Surface activity declines during the unbroken hot, dry periods of late spring, summer, and fall. By late summer, adults and juveniles are quiescent, usually in earth-filled burrows they construct themselves. During dry periods, western spadefoot toads are similar to other spadefoot toad species that burrow ≤ 1 m (Ruibal et al., 1969) and survive periods of osmotic stress during long periods of dormancy by accumulating urea in their body fluids. This allows them to absorb water from the surrounding soil, as long as the soil has a higher water potential than that of the body fluids (Shoemaker et al., 1969; Jones, 1980). Morey and Reznick (2001) found that even juvenile western spadefoot toads can construct burrows 10–20 cm deep in hard dry soil. Juveniles and subadults sometimes share burrows, but most are solitary. Stebbins (1951) reports an observation of western spadefoot toads emerging from kangaroo rat (*Dipodomys* sp.) burrows.

I. Seasonal Migrations. Not known for juveniles and subadults. Adults make seasonal movements to and from breeding pools. These movements are nocturnal and often coincide with rainfall (Morey and Guinn, 1992), but little is known about the distance between breeding pools and the site of the summer burrow. As with other spadefoot toads, western spadefoot toads probably do not spend the summer at the dried breeding pool. By excavating a pool in Arizona, Ruibal et al. (1969) demonstrated that spadefoot toads do not burrow into the drying mud of a breeding site.

J. Torpor (Hibernation). For several months following the first rains of autumn, periods of inactivity are spent in shallow winter burrows, where, if it is not too cold or too dry, individuals can be encountered just after sunset at their burrow entrance with only their eyes protruding from the soil.

K. Interspecific Associations/Exclusions. Western spadefoot toads tend to co-occur with other obligate ephemeral pool breeders including California tiger salamanders (*Ambystoma californiense*), Pacific treefrogs (*Pseudacris regilla*), western toads (*Bufo boreas*), and an introduced

species, American bullfrogs (*Rana catesbeiana*). Introduced fishes, typically mosquitofish (*Gambusia affinis*), green sunfish (*Lepomis cyanellus*), and various bullhead species (*Ameiurus* sp.) occasionally make their way into the ephemeral pools where western spadefoot toads breed. This happens when they swim or are washed into pools during flooding rains, or when they are intentionally released. In the past, large numbers of mosquitofish were broadcast into vernal pool complexes to control mosquitoes. Even though fishes can survive only as long as pools remain filled, I have observed that they sometimes eliminate the larvae of native amphibians, including western spadefoot toads.

Wherever western spadefoot toad larvae occur in pools occupied by larval California tiger salamanders, which are carnivorous, very few toad larvae escape predation. Under these conditions, competition for food, which must be intense elsewhere, is greatly reduced; though low in number, record-sized spadefoot toad larvae are produced (over 10 g; Morey, 1998). The largest transforming western spadefoot toads consistently come from pools inhabited by California tiger salamanders. Morey and Reznick (2001) showed that the effects of size at metamorphosis on terrestrial characteristics of western spadefoot toads, such as survival, growth, and behavior, persist at least several months after metamorphosis.

L. Age/Size at Reproductive Maturity. Age at maturity is unknown. Morey and Reznick (2001) reared western spadefoot toads under a variety of conditions in the laboratory and in outdoor enclosures and found that under high-food conditions, most males developed secondary sexual characteristics by the beginning of the first breeding season following metamorphosis. Females reared under similar conditions made the transition from juvenile to adult dorsal coloration, but had small ovaries that had not reached the vitellogenic stage of the first ovarian cycle. Thus, it seems reasonable that males mature 1–2 yr after metamorphosis, while females probably are not sexually mature until at least the second breeding season following metamorphosis. Stebbins (1985) reports adult body lengths of 37–62 mm. Most individuals mature at 40–45 mm SVL, and adults <40 mm or >60 mm SVL are uncommon (Storer, 1925; Morey and Guinn, 1992). The largest individuals are usually females, but adult size differences between the sexes are not great.

M. Longevity. Unknown. Other North American spadefoot toads live several years (Snider and Bowler, 1992; Tinsley and Tocque, 1995).

N. Feeding Behavior. Adults feed mainly on insects. Morey and Guinn (1992) found that the stomach contents of 14 adult west-

ern spadefoot toads contained predominantly adult beetles (Coleoptera, mostly Carabidae) and larval and adult moths (Lepidoptera, mostly Noctuidae); crickets (Orthoptera), true bugs (Hemiptera), flies (Diptera), ants (Hymenoptera), and earthworms (Annelida) were also present.

O. Predators. Reports of predators include California tiger salamander larvae (Feaver, 1971), adult American bullfrogs (Hayes and Warner, 1985; Morey and Guinn, 1992), garter snakes (*Thamnophis*, sp.; Feaver, 1971; Ervin and Fisher, 2001), and raccoons (*Procyon lotor*; Childs, 1953). Large larvae (roughly Gosner stage 38–39) seem to be particularly attractive to vertebrate predators. At this time, for example, dabbling ducks, especially mallards (*Anas platyrhynchos*), sometimes take up short-term residence at a pool, where they consume all or almost all of the western spadefoot tadpoles. This happens most often in pools with clear water where, presumably, the larvae are easier to detect. Larvae also are vulnerable to predation by vertebrate predators as pools dry. I have found that numerous bird and mammal tracks in the drying mud at the pool's edge usually indicate that the larvae within have been eaten.

P. Anti-Predator Mechanisms. Post-metamorphic juveniles and adults produce skin secretions that may make them unpalatable to some predators. Some support for the theory that the skin is unpalatable is found in the observation that, on rainy nights, small mammals sometimes eat the carcasses of western spadefoot toads killed on roadways, leaving the skin behind. When injured or sometimes when handled, adults produce volatile skin secretions that cause sneezing and a runny nose in some humans. Stebbins (1951) describes the smell as being similar to popcorn or roasted peanuts. To the taste, the sticky skin secretions of an injured western spadefoot toad are strongly suggestive of a pharmacologically active substance; in the eyes or nose, the secretions cause a burning sensation.

Q. Diseases. Unknown.

R. Parasites. Unknown. Other spadefoot toads are host to polystomatid monogenean trematode parasites (Tinsley and Earle, 1983). In the wild, infections from these trematodes apparently do not lead to significant disease (Tinsley, 1995).

4. Conservation.

Western spadefoot toads are listed as a Species of Special Concern in California (Jennings and Hayes, 1994a) and Federally as a Species of Concern (<http://sacramento.fws.gov>). The habitats of the western spadefoot toad are coincident with some large areas of urban and agricultural development. Western spadefoot toads have been eliminated from some parts of their range by these land uses