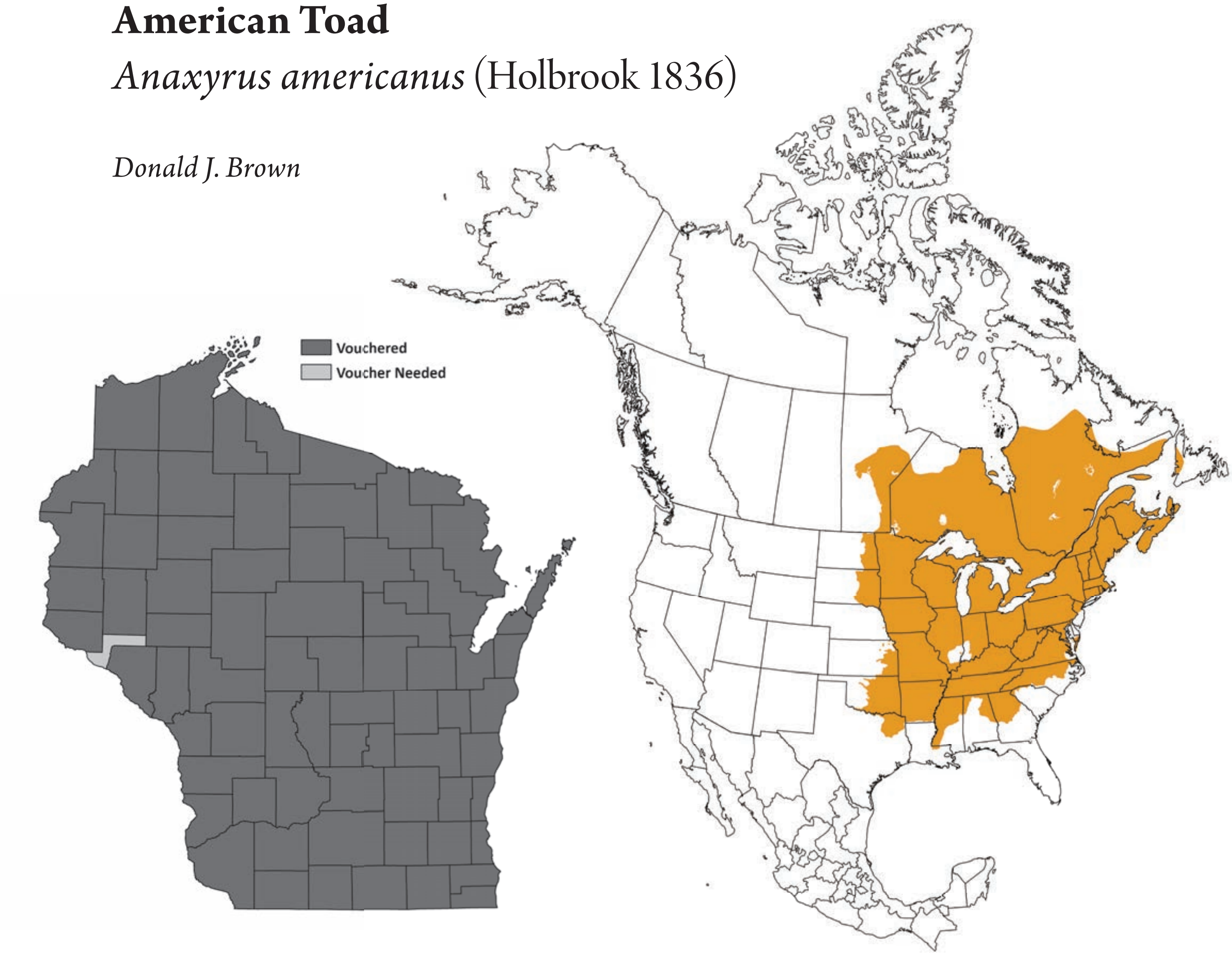
American Toad

Anaxyrus americanus (Holbrook 1836)

Donald J. Brown



Subadult American Toad (Oneida County; photo by D. Brown).

AT A GLANCE

American Toads are the only toad species found in Wisconsin, and they are distributed throughout the state. They are a fairly large anuran, with a stout body, short limbs, and 'warty' skin that is mostly mottled browns and tans but sometimes reddish. A large gland, called a parotoid gland, is found behind each eye. Larvae are aquatic and often found in natural and man-made wetlands and lakes. Juveniles and adults are terrestrial and can be found in a wide range of forested and nonforested habitats. Adults emerge from hibernation in April, and males typically begin calling to attract females by late April or early May. Mating typically occurs between late April and mid-June, and the male advertisement call, a long-duration high-pitched trill, is arguably the most attractive of Wisconsin's anurans. This species is an explosive breeder. Most reproduction occurs during large breeding congregations on only a few nights per year. Larvae develop rapidly and typically complete metamorphosis by early July. Adults primarily feed on invertebrates, and larvae scrape algae and other microorganisms from substrates. In September and October, individuals select their terrestrial overwintering locations and burrow into the soil for the winter. American Toads are currently considered a common species by the WDNR.

SYSTEMATICS

True toads (family Bufonidae) in North America were historically included in the genus *Bufo*. In an attempt to create monophyletic groups, Frost et al. (2006) proposed placing strictly North American toads in the genus *Anaxyrus*, which is currently accepted (Crother 2017). However, the systematics and classification of North American Bufonidae is an active area of research and contention (Frost et al. 2009, Pauly et al. 2009, Van Bocxlaer et al. 2010), and future classification changes are possible. In addition, hybridization events resulting in viable offspring are common within the genus *Anaxyrus* (reviewed by Dodd 2013). There are currently 19 recognized species of *Anaxyrus* (Crother 2017), with *A. americanus* (American Toad) occurring in Wisconsin. There are currently two recognized subspecies of *A. americanus* (Crother 2017), with *A. a. americanus* (Eastern American Toad) being the subspecies found in Wisconsin. The other subspecies, *A. a. charlesmithi* (Dwarf American Toad), reaches its northern distributional limit in central Illinois (Conant and Collins 1998).

DESCRIPTION

Adults: Dorsal base coloration can vary widely, including shades of gray, green, brown, red, and black (reviewed by Dodd 2013). The dorsum has dark spots, with typically one or two 'warts' (i.e., skin glands) per spot, and usually has a light stripe along the vertebral column (Vogt 1981, reviewed by Dodd 2013). Ventral coloration is white or cream-colored, often with heavy gray, black, or brown mottling (Figure 63). The head contains prominent L-shaped cranial crests, and a large elliptical parotoid gland is present behind each eye (Figure 64). The limbs are short, and the toes on the hind feet are incompletely webbed. A keratinized spade is present on the heel of each hind foot (see Identification Keys for Amphibians and Reptiles in Wisconsin). This is a relatively large anuran. Male SVL typically ranges from 4.5 to 8.5 cm (1.8 to 3.3 in), and female SVL typically ranges from 7.5 to 9.0 cm (3.0 to 3.5 in; Vogt 1981). The mean SVL of adult specimens from Wisconsin housed in the MPM and UWZM collections ranged from 7.5 cm (3.0 in) in females ($n = 74$) to 6.5 cm (2.5 in) in males ($n = 119$). Note that minimum adult size used as threshold for

Figure 63. Adult male American Toad showing its mottled belly and colored throat patch (Jefferson County; photo by J. Kapfer).

Figure 64. Adult American Toad displaying morphological features useful for identification, including cranial crests, parotoid glands, dark dorsal spots, and 'warty' skin (Iron County; photo by S. Viernum).

Figure 65. Metamorph American Toad. Note the relatively smooth skin and lack of cranial crests and parotoid glands but the presence of 'warts' (Dane County; photo by J. Kapfer).

inclusion in mean calculations was based on the work of Acker et al. (1986) from Illinois (see Reproduction and Development section).

Preadult stages: Eggs are bicolored, black to dark brown above and white to cream-colored below (reviewed by Dodd 2013). Eggs are deposited in two long strings that can exceed 60 m (197 ft) in length (Green 2005, reviewed by Dodd 2013). Individual egg diameter ranges from 0.1 to 0.2 cm (0.04 to 0.08 in; Green 2005). Larvae are dark brown to black, with fine silver or gold spots (particularly on the ventral side), and have transparent fins (Vogt 1981, reviewed by Dodd 2013). At hatching, larvae are 0.7–1.2 cm SVL (0.28–0.47 in; Wright and Wright 1949). Size at metamorphosis can vary widely depending on density of individuals and aquatic habitat characteristics (see Reproduction and Development section) but typically does not exceed 2.5 cm (0.98 in; Watermolen and Gilbertson 1996). Vogt (1981) stated that toadlets were 1.0–1.5 cm SVL (0.39–0.59 in) at metamorphosis, with "light yellow or bright red warts." American Toads weigh ca. 0.05 g (0.002 oz) at metamorphosis (Pough and Kamel 1984). Metamorphs and young juveniles lack prominent head characteristics and have comparatively smoother skin (Figure 65).

Variation: In addition to sexual size dimorphism (where females are larger), males differ from females during the breeding season in having dark vocal sacs and nuptial pads on the thumb and forefinger, which aid in grasping females during amplexus. Individuals can also slightly alter their dorsal coloration to more closely match the underlying substrate coloration (Heinen 1994b). A wild albino American Toad was documented in Minnesota in 1992 (Moriarty and Hall 2014), and a leucistic individual was found in North Carolina in 2004 (Brannon 2006). A giant form of the species, where female SVL may exceed 13.0 cm (5.1 in), is restricted to Wisconsin's Lake Michigan islands (Natural History Box: Gigantic Toads). Additional information on morphological variation can be found in Dodd (2013).

Diagnosis: Adult American Toads are characterized by a short and stocky body, dry skin with large warts, presence of parotoid glands, and presence of a keratinized spade on the heel of each hind foot. Larval American Toads are characterized by the presence of dorsally located eyes, a medially located vent, TL <2.5 cm (0.04 in), black coloration (with brown spots in older individuals), and a low rounded tail fin without pigmentation (Watermolen and Gilbertson 1996). American Toads represent the only toad species in Wisconsin, and adults and subadults can easily be distinguished from Wisconsin's frogs by the presence of parotoid glands, cranial crests, and a keratinized spade on the heel.

American Toad eggs can be distinguished from other amphibians in Wisconsin by their encasement

NATURAL HISTORY BOX: Gigantic Toads

The giant form of the American Toad was first documented on a few of Wisconsin's Lake Michigan islands in 1976 by Charles Alan Long (UW–Stevens Point) and his sons (Long and Long 1976). To date, studies of these gigantic morphs have been restricted to females. In 1999 Long obtained additional gigantic toad specimens and recorded more observations to compare with mainland toads from Wisconsin. Of ten females collected, mean SVL was 11.00 cm (4.3 in) and ranged from 7.48 to 12.70 cm (2.9 to 5.0 in). When compared to mainland toads in central Wisconsin, island females were 20%–30% larger and displayed little to no overlap in six morphological characteristics (Long 1982). Elsewhere in their distribution, Conant and Collins (1998) reported much smaller American Toad sizes (range = 5.1–9.0 cm SVL [2.0–3.5 in], maximum SVL = 11.1 cm [4.4 in]). Previous, though unverified, measurements from these islands suggest they could even exceed 13.0 cm SVL (5.1 in) in Wisconsin. Long also noted that the largest females walked rather than hopped. Possibly, this behavioral trait originated on these islands as an adaptive measure to minimize vulnerability to aerial predation, as land-based predation is thought to be insignificant. Long also documented delayed initiation of breeding activity on these islands compared to the mainland, which is likely due to differences in temporal climate patterns caused by the presence of Lake Michigan. Long observed tadpoles in September and noted that a few 'behemoths' were carrying larger egg masses (constituting more eggs) in early to mid-September.

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in long gelatinous strands, while most species lay eggs in globular masses or clusters. American Toad larvae can be distinguished from those of other anurans in Wisconsin by their dorsally located eyes coupled with their black body and tail fin, which possesses a rounded tip and has no pigmentation (Watermolen and Gilbertson 1996). Recently metamorphosed toadlets lack prominent parotoid glands and cranial crests but can be distinguished from Wisconsin's frogs by the presence of 'warts' (see Figure 65).

DISTRIBUTION AND HABITAT

Global distribution: American Toads are present throughout the eastern half of the US and Canada. They range from southern Labrador west to central Manitoba, south to northeastern Texas, and east to the East Coast, loosely following the southern boundary of the Piedmont plateau region (Dodd 2013). Their southernmost extent is located in central Louisiana (Green 2005). In the Appalachian region, the altitudinal distribution limit appears to be <1,800 m (5,905 ft) (Green and Pauley 1987, Dodd 2004).

Distribution in Wisconsin: Published records exist for every county in Wisconsin, although a voucher was not found for Pepin (see the Appendix). American Toads have also been documented on Lake Superior islands off of Ashland and Bayfield Counties (i.e., the Apostle Islands; Hecnar et al. 2002) and Lake Michigan islands off of Door County (see Natural History Box: Gigantic Toads).

Localities of possible occurrence: American Toads have been documented in every county in Wisconsin.

Habitat: Adult American Toads are habitat generalists. Vogt (1981) stated that in Wisconsin they are "commonly found in prairies, marshes, oak savannas, semiopen coniferous and deciduous forests, gardens, and agricultural areas." Individuals have also been documented in the northwestern pine barrens of Wisconsin (Evrard 2000, Evrard and Hoffman 2000), as well as the Weaver Dunes, a sand dune prairie region in southeastern Minnesota (Wabasha County; Cochran 1986b). The tolerance of this species to a wide variety of terrestrial habitats could be related to its effectiveness at absorbing water from the soil, meaning it is less restricted by dry habitats than many other Wisconsin amphibians (Walker and Whitford 1970). In northern Minnesota, Ewert (1969) found that adults used field, forest, and bog habitat patches for foraging after the breeding season, with 132, 97, and 88 total days spent in the habitat types, respectively (n = nine males and six females observed, with 9–45 observation days each). Of all 768 locations recorded between 1 June and 15 July 1966, 36%, 35%, and 29% were in forest, field, and bog habitat types, respectively. However, the results of several studies indicate that dense forest cover could be suboptimal habitat for adults (Guerry and Hunter 2002, Perkins and Hunter 2006, Eigenbrod et al. 2011). Despite their generalist tendencies, American Toads appear to exhibit preferences for certain terrestrial habitat conditions. A mesocosm study found that metamorphs preferred deciduous leaf litter to coniferous leaf litter and coniferous leaf litter to bare soil (Smith and Schulte 2008). Within their chosen habitats, American Toads frequently aestivate within shallow self-dug burrows and crayfish burrows and beneath logs or other ground debris (Moosman and Moosman 2005).

American Toads use seasonal, semipermanent, and permanent wetlands as breeding habitat (reviewed by Dodd 2013). For example, Babbitt (2005) surveyed 103 wetlands encompassing a wide range of sizes and hydroperiods in New Hampshire and documented American Toad larvae in 0.2–2 ha (0.5–5 ac) wetlands, with intermediate (i.e., wetlands held water >4 months and <12 months) and long (i.e., wetlands did not dry) hydroperiods. Backwaters of rivers and streams also provide suitable breeding habitat (Zadnick et al. 2009). American Toads will breed in bogs in Wisconsin and Minnesota (Andrews 1915, Bellis 1959, Ewert 1969). However, a study in northern Minnesota found that American Toad eggs (n = 58 egg masses and 3,038 eggs) and larvae (n = 60) exposed to highly acidic bog water had 0% survival (pH = 4.2, 96-hr exposure; Karns 1992). Tattersall and Wright (1996) found that acidic water disrupts the nitrogen balance in American Toad tadpoles. Adults occasionally deposit eggs in highly ephemeral pools or puddles, despite the low probability of water retention to metamorphosis (Cochran 1982a; Natural History Box: Lending a Helping Hand). In Michigan, Skelly et al. (1999) found that American Toads preferred open-canopy to closed-canopy ponds for breeding. Smith and Rettig (1998) studied habitat associations based on 20 egg strands at a breeding site in Indiana and found that egg strands were more likely to be present in open-canopy areas, but vegetation within the pond was not associated with egg strand location.

After metamorphosis occurs, juveniles remain near their natal waterbody while their aerobic capacity and endurance increase through growth (Taigen and Pough 1981, Pough and Kamel 1984, Taigen and Pough 1985). American Toads hibernate terrestrially in open woodlands and fields (Ewert 1969). In selected overwintering habitats, American Toads use their hind legs to burrow into the soil and retreat below the frost line (Miller 1909b). Ewert (1969) reported that American Toads used a wide range of soil types for hibernacula in northern Minnesota, ranging from coarse sand to a surface layer containing "several inches of nearly pure dense clay."

REPRODUCTION AND DEVELOPMENT

In the Upper Midwest, it appears that males migrate to breeding wetlands prior to females (Ewert 1969, Vogt 1981). Vogt (1981) stated that females arrived at breeding sites one to two weeks after males in Wisconsin. In northern Minnesota, males spent from 0 to 15 days ($\bar{x}$ = 5 days, n = 13) at breeding sites prior to the initiation of calling activity (Ewert 1969). Field experiments in Ontario showed that first-year breeding males were able to locate breeding sites using environmental cues and that individuals did not rely on vocal or olfactory cues for orientation (Oldham 1966). However, translocated individuals required vocal cues to orient them to breeding sites. Although adults will use multiple breeding sites within and between years (e.g., Ewert 1969), some studies have indicated that breeding site fidelity is high for this species. For example, of 264 adults monitored for

NATURAL HISTORY BOX: Lending a Helping Hand

American Toads often breed in semipermanent and permanent wetlands. However, it is not unusual for individuals to deposit eggs in ephemeral waterbodies that will not last long enough for tadpoles to reach metamorphosis. In May 2011 I haphazardly found a swarm of tiny black toad tadpoles packed in a small, muddy pool (ca. 1.2×2.4 m [4×8 ft] wide and 5.1 cm [2 in] deep) on top of a gravel driveway. After locating a suitable larval habitat nearby (a nearby shallow oxbow pond next to a stream), I transferred as many of them as I could (ca. 250 tadpoles) out of the puddle and into the oxbow pond, hoping a few of them would make it to adulthood. On another occasion in 2014, a friend discovered that a puddle in the grass of his lawn had filled overnight with recently hatched American Toad tadpoles. Making it his mission to save these tadpoles from imminent desiccation, he began feeding the puddle with groundwater from the hose in his yard. As the days grew hotter, his efforts became futile as the puddle continued to dwindle in size and depth. In response, he gathered up as many of the tadpoles as he could and released them into a local wetland where they might survive to metamorphosis. These stories illustrate a common situation we face in urban and suburban environments; we encounter scenarios where animals that use disturbed landscapes face a higher risk of mortality, and we have the choice to intervene or let nature take its course. Sometimes offering a bit of friendly assistance can go a long way in helping our wildlife neighbors survive in the environments modified by humans.

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two consecutive years in Ontario, 85% bred at the same site both years (mean distance to an alternate breeding site = 100 m [327 ft]; Oldham 1966).

In Wisconsin, Vogt (1981) stated that males initiated calling activity in late April or early May. Christoffel et al. (2009) listed the breeding window in Wisconsin as late April to mid-July. Anderson et al. (1981) recorded the calling period for American Toads in Portage County as May and June. Briggs and Young (1976) noted that American Toads had reproduced and ceased calling by late May in Bayfield County, which is in the most northern region of the state. Similarly, Ewert (1969) documented calling activity at a wetland complex in northern Minnesota from 1966 to 1968 and found that calling activity occurred as early as 15 May and as late as 4 June.

The male advertisement call of the American Toad is a long-duration (≤30 sec) high-pitched trill. Males usually begin calling in the evening near sunset, and calling activity may persist into the daylight hours during peak breeding periods (Dirig 1978, Sullivan 1992, Oseen and Wassersug 2002). Males typically call from land near the water's edge (while facing the waterbody), in shallow water near the water's edge, or on structures (e.g., tree branches) in the water (Figure 66; Oldham 1966). However, Ewert (1969) found that in a shallow lake (maximum depth = 6.7 m [22 ft]) in northern Minnesota, more than 50% of males observed were in open water up to 30.5 m (100 ft) from the shore. Swanson et al. (2007) found that females were attracted to artificial choruses (i.e., playback calls) at distances of up to 40 m (131 ft) in Minnesota.

Although males call to attract females over a prolonged period, American Toads are explosive breeders. As such, reproductive activity occurs within large congregations of individuals over only a few nights each year (Howard 1988). Vogt (1981) noted that for American Toads in Wisconsin, "there is usually a period of intensive breeding activity from May 3 to 16 culminating in a 2- to 3-day orgy." For explosive breeders, mating activity is highly dependent on weather and environmental conditions, such as water temperature (e.g., Oldham 1969, Christein and Taylor 1978, Oseen and Wassersug 2002), and thus annual temporal and

Figure 66. Adult male American Toads calling to attract females for mating. (a) Male calling in shallow water (Wisconsin; photo by N. Melhorn).
(b) Male calling from a branch in shallow water (Wisconsin; photo by N. Melhorn).

Figure 67. American Toads in amplexus (Jackson County; photo by A. Badje).

spatial variation in timing of the explosive events can be large. A female selects a male for mating based on the characteristics of his call and then navigates to the chosen male and nudges him (Howard 1988). The male then mounts the female's back and engages in amplexus (Figure 67). The grasp is typically axillary (i.e., behind the armpits), but lumbar grasps (i.e., just anterior to the hips) also occur, particularly if the male is substantially smaller than the female (Wright 1914, Aronson 1944, Licht 1976).

Male reproductive success is partially limited by male-male interference competition. For example, larger males can displace smaller males that are already in amplexus with females (Kruse 1982). Males can also intercept and grasp females for reproduction before they reach rival males chosen by the females based on call characteristics (Forester and Thompson 1998). Forester and Thompson (1998) found that males who intercepted females were significantly smaller than males that were found either swimming or calling. In addition, Gatz (1981a) determined that larger males arrived at breeding ponds earlier in the season, spent more nights engaged in calling activity, and had higher mating success than smaller males in Ohio. This is likely related to smaller males having greater energy constraints than larger males (Finkler et al. 2014, but see Wells and Taigen 1984). During explosive breeding events, it is not uncommon for multiple males to mount a single female, creating what are known as 'toad balls.' In Wisconsin, Vogt (1981) documented up to five males in amplexus with a single female. This behavior can result in the males accidentally drowning the female (Wright 1914, Dirig 1978). In addition, males often mount other males, either accidentally or to dislodge them from females. Males that are mounted by rival males emit a release call (a 'chirp') and vibrate to signal release (Schmidt 1990). In addition, Dodd (2013) stated that when males attempt to dislodge another male already clasped to a female, both the female and clasping male will discourage their attempt by "vigorously kicking them with their back legs." If disturbed by humans, the female will swim away (either vertically or horizontally), usually with the male maintaining amplexus (Donald Brown, West Virginia University / USFS, personal observation).

Amplexus can last from a few minutes to over a day before oviposition occurs (Aronson 1944, Wells 1977b). Wells (1977b) considered 12–24 hours to be the normal time spent in amplexus for American Toads, but to my knowledge this topic has not been well-studied. Egg strands are laid on the bottom of waterbodies (10–30 cm [3.9–11.8 in] deep; Dodd 2013) or attached to aquatic vegetation or debris (Miller 1909a). Reported clutch sizes have ranged from 2,000 to 20,000 eggs (reviewed by Green 2005). Kruse (1981) counted eggs laid by 19 females in Illinois and found that clutch size ranged from 2,792 to 13,452 ($\bar{x} = 5{,}673$). Females mate only once per year (Ewert 1969, Howard 1988). Ewert (1969) documented within-year male breeding behavior in northern Minnesota and found that six of seven observed individuals engaged in calling activity after reproducing, three of which were observed in amplexus with a second mate. Howard (1988b) also documented males mating up to two times per year in Indiana. In a laboratory study of wild males collected in Illinois, individuals were capable of successfully fertilizing egg strands up to five times in a single breeding season (Kruse and Mounce 1982). In addition, the number of fertilization events did not affect fertility, and two males fertilized one clutch per day for four and five consecutive days, respectively.

Eggs typically develop for two to seven days before larvae hatch (reviewed by Dodd 2013). Smith and Rettig (1998) found the mean time to hatching was 5.9 days (range = 4–8 days, $n = 17$ egg strands) at a pond in Indiana. In Wisconsin, larvae typically metamorphose and leave the water in late June to early July after a ca. seven-to-eight-week growth period (Knudsen 1957a, Vogt 1981). However, time to metamorphose, as well as larval survival, growth rate, and size at metamorphosis, can vary widely depending on habitat conditions, competition, and predation (e.g., Wilbur 1987, Skelly and Werner 1990, Pearman 1993, Sams and Boone 2010, Reynolds et al. 2011, Rittenhouse 2011). A mesocosm study found that competition with Northern Leopard Frogs (*Lithobates pipiens*) reduced survival to and size at metamorphosis (Purrenhage and Boone 2009). Werner and Glennemeier (1999) found that tadpole growth and survivorship were higher in open-canopy ponds. Another study in Michigan found that tadpoles preferred water temperatures >26°C (79°F) and occupied deeper areas of ponds at night and shallower areas of ponds during the day to maintain higher ambient temperatures (Beiswenger 1977). The tendency of American Toad larvae to form large aggregations in shallow areas during the day appears to be driven largely by individual-level responses to heat and light (Beiswenger 1977).

Recently metamorphosed individuals grow rapidly and disperse from the vicinity of natal wetlands at a weight of ca. 0.5 g (0.02 oz; Taigen and Pough 1981). See Hamilton (1934) for variation in within-year growth rates of juveniles. Males typically become sexually mature in two to three years and females in three to four years (Hamilton 1934, Kalb and Zug 1990). However, Acker et al. (1986) estimated that 3 of 37 females collected from a breeding site in Illinois were two years old. In addition, the smallest mature males and females collected were ca. 5.9 cm SVL (2.3 in) and 6.6 cm SVL (2.6 in), respectively. At a breeding site in Indiana, sexually mature males were two to six years old, ranged from 4.9 to 7.0 cm SVL (1.9 to 2.8 in), and weighed from 14 to 48 g (0.03 to 0.11 oz, $n = 400$; Howard and Young 1998). Morris and Meyer (1980) reported that a captive male originally collected from the wild in Illinois lived to be 5.5 years old, and according to Dickerson (1906), "Authentic record gives the story of one that lived to be thirty-six years of age and then was killed by accident." Acker et al. (1986) estimated that the oldest males and females collected at a breeding site in Illinois were four and five years old, respectively.

ACTIVITY

Ewert (1969) found that adults emerged from hibernation between 10 April and 8 May in northern Minnesota ($n = 6$). Allen (1868) also observed individuals on the surface in early April in Massachusetts. In northern Minnesota, individuals remained near their overwintering sites for 1–30 days ($\bar{x} = 13$ days, $n = 12$) prior to migrating to breeding sites (Ewert 1969). Breeding migrations and dispersal of juveniles after metamorphosis likely represent the greatest movements that American Toads undertake during the year. In New York, Maynard (1934) documented American Toads migrating along stream corridors up to 4 km (2.5 mi) to breeding ponds. In Maryland, straight-line post-breeding dispersal distance of females ranged from 246 to 1,015 m (807 to 3,330 ft,

$\bar{x} = 686$ m [2,251 ft], $n = 16$; Forester et al. 2006). For the 16 females tracked, maximum distance moved per day during the study period ranged from 189 to 610 m (621 to 2,001 ft). In Minnesota, Ewert (1969) documented post-breeding travel distances of 3.7–48.8 m per day (12–160 ft, $\bar{x} = 26.1$ m [85.5 ft], $n = 22$), with total dispersal distances ranging from 52 to 1,006 m (170 to 3,300 ft, $n = 22$). Ewert (1969) noted that dispersal movement was "curtailed during periods of dry days with dry nights and resumed only on rainy or warm, humid evenings." In addition, he documented juvenile American Toads ≥610 m (2,000 ft) from the nearest breeding site. Ewert (1969) also found that 13 of 18 individuals dispersed to and from breeding sites in the same general direction (angle between paths for the 13 individuals = 1°–28°, $\bar{x} = 10.3°$).

Movement and foraging activity occur before, during, and after the breeding season (Ewert 1969), although movement is minimal once individuals have migrated back to upland habitat following the breeding season. In northern Minnesota, mean movement/day for 18 active but nondispersing individuals ranged from 0.6 to 13.1 m (2 to 43 ft; Ewert 1969). In another study in northern Minnesota during the summer months, minimum distance moved per day ranged from 0.2 to 18.3 m (0.6 to 60 ft, $n = 118$ total recaptures of 61 marked individuals; Bellis 1959). However, long-distance movement events can occur during migrations to and from breeding sites. Ewert (1969) estimated linear home range sizes for 16 males by documenting locations through the full annual cycle and found that they ranged from 61 to 536 m (200 to 1,760 ft, $\bar{x} = 311$ m [1,020 ft]).

Adult activity is primarily nocturnal and crepuscular (i.e., peak activity periods occur around dusk and dawn [Higginbotham 1939, FitzGerald and Bider 1974b]). Nightly movements are apparently influenced by moon phase, with the greatest activity during new moons and lowest activity during full moons (FitzGerald and Bider 1974a). According to Dodd (2013), activity is positively correlated with temperature in the early part of the active season, but temperature becomes a less important predictor during the summer months when temperatures are higher. In northern Minnesota, movement activity in autumn was typically diurnal due to subfreezing night temperatures (Ewert 1969). Precipitation can also stimulate activity, particularly breeding activity (Fitch 1956, reviewed by Dodd 2013). In addition, post-metamorphic movement activity has been found to be positively correlated with temperature and precipitation (Gravel et al. 2012).

American Toads aestivate in burrows throughout their annual active period to avoid unfavorable conditions at the ground surface or to conceal themselves from predators. Ewert (1969) observed eight aestivation events between 24 July and 16 August 1967 in northern Minnesota. Five of the individuals buried themselves 5.1–7.6 cm (2–3 in) below the soil, and three individuals buried themselves 12.7–27.9 cm (5–11 in) below the soil. Two of the individuals transitioned from aestivation to hibernation without additional emergences, and he speculated that this is common for American Toads.

Ewert (1969) documented overwintering behavior for 23 individuals in northern Minnesota (17 of which survived the winter). The majority of these entered their hibernacula in September, with 15 October being the latest date of observed surface activity. American Toads overwinter terrestrially, but laboratory studies conducted on individuals collected from Portage County concluded that they are not freeze-tolerant, nor do they have the ability to survive freezing temperatures by supercooling (Holzwart and Hall 1984). Work by Ewert (1969) supported that they survived the winter by burrowing into the soil below the frost line (but staying above the groundwater line), with maximum observed soil depths ranging from 12.7 to 58.4 cm (5 to 23 in). Miller (1909b) found that American Toads in outdoor enclosure experiments burrowed up to 62.2 cm (24.5 in) below the soil surface and also observed that individuals not buried below the frost line did not survive the winter. Ewert (1969) documented spring emergence locations for six of the individuals he monitored in northern Minnesota and found that three of them did not emerge from the spot where they burrowed into the soil for hibernation.

PREY AND PREDATORS

Adult American Toads consume various types of invertebrates, with insects often comprising the majority of the diet. Cook et al. (2002) calculated the mean stomach contents of 405 American Toads collected from throughout their distribution and found that ants (Formicidae) made up the bulk of their spring (February–June) and summer (July–September) diets (17.90% and 23.24% of prey volume, respectively), but Carabidae (order Coleoptera) were also frequently consumed in spring (14.96%) and summer (20.36%). Similarly, in Jack Pine (*Pinus banksiana*) forests in Ontario, ants were found in 88.9% of stomachs analyzed ($n = 36$) and accounted for 37.9% of documented prey items (Bellocq et al. 2000). Other Hymenoptera, Collembola, and Coleoptera species were also frequently consumed. Miller (1909b) estimated that an average-sized adult (36.6 g [1.3 oz]) consumed a mean of 1.12 g (0.04 oz) of invertebrates per day between May and August.

Larvae consume primarily algae and other microorganisms by grazing on substrates with scraping mouthparts or by filter-feeding (Test and McCann 1976, Holomuzki 1997). Larvae also reportedly scavenge on dead animals encountered in wetlands (Gibson and Mitchell 2006), including larval conspecifics (Heinen and Abdella 2005), and even sometimes cannibalize eggs (Hamel 2009). Hamilton (1930) examined the stomach contents of 400 recently metamorphosed individuals (TL 0.8–1.2 cm [0.31–0.47 in]), presumably collected in the eastern US. Primary documented food items (% by volume) included Diptera (primarily larvae, 22%), mites (15.5%), ants (12.8%), beetles (including larvae, 11.8%), thrips (10.1%), and Collembola (6.2%).

A wide variety of vertebrates prey on adult American Toads. Documented predators include many snakes species, such as hog-nosed snakes (*Heterodon* spp.), watersnakes (*Nerodia* spp.), and gartersnakes (*Thamnophis* spp.; Burt 1935, Fitch 1965, Heinen 1993, Heinen 1994a, Forester and Thompson 1998, DeVito 2003). However, American Toads may be toxic to foxsnakes (*Pantherophis* spp.; Karstad 1967). Major mammalian predators include Raccoons (*Procyon lotor*) and skunks (Miller 1909b, Oldham 1966, Schaaf and Garton 1970, Groves 1980). American Toads are also commonly consumed by predatory birds (reviewed by Ross 1989a). They were the most frequently observed prey item at a Broad-winged Hawk (*Buteo platypterus*) nest in Lincoln County (i.e., 14.9% of 107 documented prey items; Rosenfield et al. 1984). Mueller (1980) observed Mallards (*Anas platyrhynchos*) consuming adult American Toads that were diurnally active in the water. Although adults are most vulnerable to predation when they are on the ground surface, Ewert (1969) stated that 2 of 28 individuals tracked through the hibernation period in northern Minnesota died from predation. American Toad eggs are vulnerable to water mold (family Saprolegniaceae; Gomez-Mestre et al. 2006). A wide variety of invertebrates and vertebrates prey on American Toad larvae, such as dragonfly (*Anax* spp.) naiads, predaceous diving beetles (*Dytiscus* spp.), Giant Water Bugs (*Lethocerus americanus*), and Wood Frog (*Lithobates sylvaticus*) larvae (Kruse 1983, Petranka et al. 1994, reviewed by Dodd 2013). In Minnesota, Cochran and Cochran (2007) documented 13 newly metamorphosed American Toads in the stomach of a Brown Trout (*Salmo trutta*).

Predator defense mechanisms employed by various life stages include unpalatability and alterations in behavior. Adults respond to predators primarily by fleeing (if they are in or near water), crouching so that only their toxic dorsal regions are exposed, or inflating themselves to appear larger and increase predator handling time (reviewed by Dodd 2013). Some studies have found that larvae at earlier developmental stages are more palatable than newly hatched and metamorphic-stage larvae (Brodie et al. 1978, Brodie and Formanowicz 1987). The dorsal skin glands of adults contain noxious chemicals, which are particularly concentrated in the parotoid glands, although mammalian predators often avoid these chemicals by consuming adults ventrally, leaving the head and back unconsumed (Schaaf and Garton 1970). Larvae also modify their behavior in response to the presence of predators. In a laboratory experiment using larval American Toads collected from the wild in Michigan, larvae reduced their activity levels in the presence of dragonfly (*Anax junius*) naiads (Anholt et al. 1996). Holomuzki (1995) found that larvae also decreased activity levels in the presence of fish chemical cues. Petranka (1989b) determined that larvae responded to the chemical cues produced by injured conspecifics fleeing the area. Other laboratory studies found that aggregative behavior of larvae was driven by the presence of predators (Gallie et al. 2001, DeVito 2003).

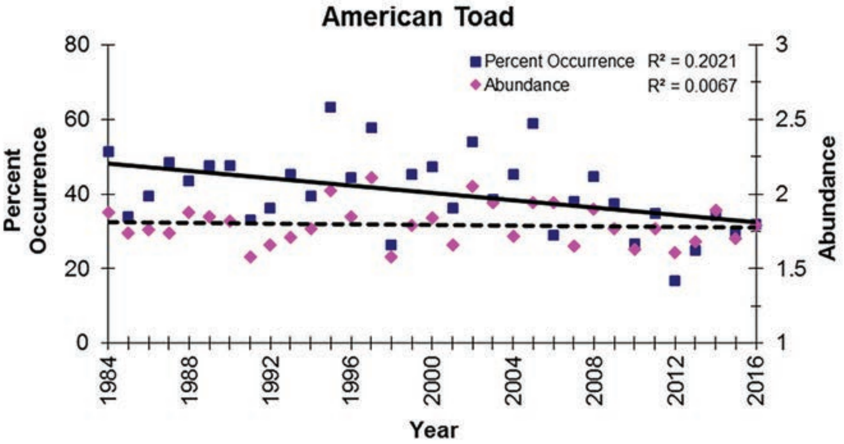

Figure 68. Long-term trend in occurrence (%) and abundance (rank) of American Toads across Wisconsin Frog and Toad Survey statewide monitoring sites. See Introduction to Species Accounts chapter for details on this monitoring program (figure courtesy of WDNR).

Watermolen (2014) compiled the literature on documented parasite infections for the American Toad in Wisconsin, which included 1 fungus (chytrid fungus [*Batrachochytrium dendrobatidis*]; Ortiz-Santaliestra et al. 2013), 1 leech (*Desserobdella picta*; Bolek and Janovy 2005), 14 nematodes, 10 trematodes, and 2 cestodes. Blais (2016) documented the American Medicinal Leech (*Macrobdella decora*) on four adult American Toads at a created wetland in Connecticut. Of the helminth parasites, nematodes are reportedly the most prevalent in American Toads from Wisconsin (Bolek and Coggins 2000, 2003, Yoder and Coggins 2007). At a breeding site in Minnesota where the trematode *Ribeiroia ondatrae* was abundant, 60% of observed metamorph American Toads ($n = 618$) displayed at least one malformation (Johnson and Hartson 2009). In mesocosm studies, survival to metamorphosis decreased when tadpoles were exposed to trematodes (Raffel et al. 2010a, Rohr et al. 2010).

CONSERVATION

Status: Globally, the American Toad is listed as a Least Concern species by the IUCN. It is considered a common species by the WDNR. Based on data collected through the Wisconsin Frog and Toad Survey (1984–95), the status of American Toads in Wisconsin appeared to be stable in 1995, with a significant regional increase observed over the survey period in the Driftless Area (Mossman et al. 1998). However, Wisconsin Frog and Toad Survey data collected over a longer period (1984–2016) indicates that breeding site occupancy may be decreasing over time (Figure 68).

Populations: Population sizes of explosive breeding anurans with short life spans, such as American Toads, can naturally fluctuate widely over time (Blaustein et al. 1994, Pechmann and Wilbur 1994). For example, the number of males detected was >200 in 1982 and <10 in 1984 at a pond in Indiana (Howard 1988b). Such high turnover (or perceived turnover due to lack of breeding activity) can result in dynamic patterns of extirpation and colonization of local breeding sites (e.g., Petranka and Holbrook 2006). Trenham et al. (2003) analyzed American Toad call survey data collected through the Wisconsin Frog and Toad Survey from 1981 to 1998 ($n = 1{,}112$ sites where the species was detected). They found that at 99% of survey sites, American Toads were not detected in at least one of the three survey years. Although false absences (i.e., species were present but not detected) likely accounted for some of the turnover, the authors concluded that "observer error alone [was] an unlikely explanation for the observed detection frequencies."

Reported sex ratios for American Toads are nearly always male-biased. For example, Oldham (1966) reported that only 15% of the 5,937 adults captured at breeding sites in Ontario over a four-year period were female. Mean number of males and females detected annually at a pond in Indiana was 41.3 and 19.3, respectively, over a three-year period (Howard 1988b). However, because reported sex ratios are typically based on captures at breeding sites, there are a number of potential sampling biases associated with the estimates (e.g., males are present at breeding sites for more nights than females, males can mate multiple times per year). However, Christein and Taylor (1978) used pitfall traps to sample American Toads migrating to breeding ponds in Ohio, and results were still highly male-biased (7.17M:1F, $n = 711$). The adult portion of American Toad populations may be inherently male-biased because males typically mature one year earlier than females (see Reproduction and Development section), and thus probability of survival to maturity is likely lower for females. Field sampling coupled with simulation modeling indicated that this was the case for a closely related species, the Houston Toad (*Anaxyrus houstonensis*; Swannack and Forstner 2007).

Threats: Due to their biphasic life cycles, amphibians in Wisconsin are vulnerable to anthropogenic impacts to both aquatic and terrestrial systems (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). However, unlike many of Wisconsin's amphibians and reptiles, American Toads have persisted through and in some cases benefited from the major anthropogenic landscape changes that have occurred in the region since European settlement. For example, Knutson et al. (2000) found that relative abundance of American Toads was positively associated with agricultural and urban edge habitat in Wisconsin and Iowa. Paloski (2006) did not find a significant relationship between lake shoreline development or surrounding land use and detection/nondetection of American Toads based on call surveys conducted at 14 lakes in Portage County. Burton et al. (2009) found that cattle use of ponds appeared to benefit American Toads in Tennessee. In contrast, Price et al. (2004) found that for populations inhabiting Great Lakes coastal wetlands (i.e., Lake Michigan and Lake Huron), landscape-scale development (and forest cover) was negatively associated with site occupancy by calling males. In Ontario, occupancy of wetlands for breeding in an agricultural landscape was positively associated with amount of forest cover and crop diversity in the surrounding landscape (Collins and Fahrig 2017).

Although they appear somewhat resilient to anthropogenic disturbance, some impacts associated with agricultural or urban/suburban landscapes are subtle and difficult to detect. Many studies have found that agricultural pesticides and herbicides, such as atrazine and carbaryl, can negatively impact larval American Toads (e.g., Boone and James 2003, Storrs and Kiesecker 2004, Distel and Boone 2009). In addition, Storrs Méndez et al. (2009) showed that American Toads are capable of terrestrial uptake of atrazine. In Ontario, agricultural activity was negatively associated with hatching success and positively associated with larval deformities (Bishop et al. 1999). However, a laboratory study using American Toad eggs collected from Dane County found that exposure to atrazine at concentrations typically encountered in the wild did not affect egg hatching success, larval mortality, or larval swimming speed (Allran and Karasov 2001). Using individuals collected from La Crosse County, Howe et al. (1998) found the median lethal concentration (LC50) for atrazine differed between early-stage (66.4 mg/L [0.008 oz/gal]) and late-stage (15.8 mg/L [0.002 oz/gal]) larvae. Ammonium nitrate fertilizer may also negatively affect larval survivorship (Hecnar 1995). However, a laboratory study using American Toad eggs collected from Washburn County found that exposure to a concentration gradient of ammonium did not influence egg hatching success (Jofré and Karasov 1999). A thorough review of documented chemical impacts on American Toad larvae can be found in Dodd (2013).

Exotic invasive plant species have also been found to negatively impact larval American Toads. In New York, replacing Cattail (*Typha latifolia*) with exotic invasive Eurasian Purple Loosestrife (*Lythrum salicaria*) resulted in slower development rates and higher mortality rates for American Toad larvae, possibly due to toxicity of higher tannin concentrations or alteration of the algal community (Brown et al. 2006). In a complementary laboratory study, it was found that the natural compounds released by degrading Eurasian Purple Loosestrife leaves negatively impacted growth and survival (Maerz et al. 2005b). American Toad survival to metamorphosis and mass at metamorphosis were also reduced in experimental mesocosms that contained nonnative compared to native wetland vegetation (Maerz et al. 2010).

Many studies have found that larval habitat quality for American Toads is influenced by the presence of predators and competitors. For example, Babbitt et al. (2003) found that relative abundance of American Toad larvae was negatively associated with the presence of fish in New Hampshire ($n = 42$ wetlands sampled). American Toads avoided breeding in ponds with predatory Wood Frog larvae in North Carolina (Petranka and Holbrook 2006). American Toads are also sensitive to acidic environments (see Habitat subsection). In Ontario, larval mortality was 85%–100% in ponds with pH <4.5, whereas mortality was <25% in ponds with pH >5 (Freda and McDonald 1993). Gibbs et al. (2005) also found that landscape-scale detection of populations in New York was positively correlated with soil pH.

Desiccation is a major source of mortality for juveniles, particularly in open habitats (Rittenhouse et al. 2008). Thus, juveniles appear to benefit from forest cover over grassland when dispersing from their natal ponds (Rothermel and Semlitsch 2002). In addition, like many amphibians, dispersing juvenile and migrating adult American Toads are highly vulnerable to road mortality (Ashley and Robinson 1996, Mazerolle 2004, Mazerolle et al. 2005). Diseases such as redleg disease (e.g., Dusi 1949), ranaviruses (e.g., Driskell et al. 2009), and chytridiomycosis (e.g., Gahl et al. 2012, Wise et al. 2014) could also be detrimental to local populations. For example, Ortiz-Santaliestra et al. (2013) showed that American Toads exposed to *Batrachochytrium dendrobatidis* (Bd) at the beginning of the larval development period exhibited reduced mass and survivorship compared to late-stage exposed and nonexposed individuals. Standish et al. (2018) detected Bd on 30.0% of adult ($n = 10$), 35.3% of juvenile ($n = 17$), and 14.3% of larval ($n = 7$) American Toads sampled in western Wisconsin. In addition, 10.0% of adults, 5.9% of juveniles, and 28.6% of larvae tested positive for a ranavirus. See the chapter Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles for additional information on threats.

Management: In general, management activities that reduce understory vegetation density, such as mechanical removal and prescribed fire, appear to benefit this species (Kirkland et al. 1996, Greenberg and Waldrop 2008, Matthews et al. 2010). However, post-management availability of cover objects, such as logs, is important (Pitt et al. 2013). Preservation or restoration of breeding wetlands to minimize presence of chemicals and exotic invasive vegetation would benefit this species (see Threats subsection). Efforts to reduce road mortality, such as roadside fencing near breeding wetlands, would also likely benefit this and many other species (Ashley and Robinson 1996, Aresco 2005). See the chapter Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles for additional information on amphibian management.

Anthropogenically modified or created aquatic environments, such as mitigation wetlands and water impoundments, are commonly used by American Toads (Lehtinen and Galatowitsch 2001, Nedland et al. 2007, reviewed by Brown et al. 2012b). Kline (1998) documented adult or larval American Toads at 14 of 21 created or restored wetlands surveyed in Ozaukee County. Kent (1983) documented American Toads calling in a sewage treatment bog in Bayfield County. Brand and Snodgrass (2010) found that American Toads exclusively used stormwater ponds or artificial wetlands for breeding, despite the availability of natural wetlands, in both suburban and forested watersheds in Maryland. Golf course ponds provided suitable larval habitat in Missouri (Boone et al. 2008). Shulse et al. (2012) determined that production of metamorphs in created wetlands was higher when they contained shallow slopes.

SPECIAL REMARKS

Across the American Toad's distribution, hybridization occurs between American Toads and a variety of other *Anaxyrus* species (reviewed by Dodd 2013). The resulting offspring typically display intermediate morphological and call characteristics (Blair 1963, Green and Pustowka 1997). American Toads are not known to climb trees. However, Cochran (2008b) reported an observation of an American Toad sitting on a rotting tree stump 1 m (3.3 ft) above the ground in a Chippewa River floodplain (Buffalo County). He speculated that the individual either climbed the tree stump or swam to the stump during the high-water period a few months prior and remained there.