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Chapter 3

Spotted Turtle

Clemmys guttata (Schneider 1792)

Gregory J. Lipps, Jr.

Spotted Turtle. Portage County, Ohio. Greg Lipps, Jr. photo.

With its shiny black shell and bright yellow and orange markings, the Spotted Turtle is one of Ohio's most handsome reptiles. Specialized for life in shallow water wetlands, the presence of Spotted Turtles indicates the highest quality bog, fen, or wet prairie ecosystem. While frogs often get noticed for singing at the first signs of spring, Spotted Turtles can be active even before the ice has melted from their wetlands, making them truly one of Ohio's first harbingers of spring.

Etymology— Latin *klemmys*–turtle, tortoise; Greek *guttata*–spotted, speckled.

Synonyms—The following synonyms are from Ernst (1972):

Testudo guttata Shneider 1792
Testudo punctata Schoepff 1792
Testudo anonyma Schoepff 1792
Emys guttata Schwiegger 1812
Emys punctata Merrem 1820
Cyclemys punctata Wagler 1830
Terrapene punctata Bonaparte 1831
Clemmys punctata Fitzinger 1835
Geoclemys guttata Gray 1855
Nanemys guttata Agassiz 1857
Clemmys guttata Strauch 1862
Geoclemmys sebae Gray 1869
Chelopus guttatus Gray 1869
Melanemys guttatus Shufeldt 1919

Type—The type locality is considered unknown and a type specimen is not known to exist, but Mittleman (1945) indicates that Schoepf's 1792 review of specimens he collected near Philadelphia, Pennsylvania in May, 1778 should qualify, as these were apparently the first to be made known from a specific geographic locality.

Taxonomic Status—The genus *Clemmys* historically contained three species: *C. guttata*, *C. insculpta* (Wood Turtle), and *C. muhlenbergii* (Bog Turtle), but numerous researchers have called this into question and currently *C. guttata* is the only recognized member of the genus (Iverson et al. 2017). Including the other two species caused *Clemmys* to be paraphyletic to *Emys*, *Emydoidea*,

and possibly *Terrapene*. There remains competing generic arrangements, especially for related taxa (Fritz et al. 2011), but the available evidence suggests the assignment of *C. guttata* is unlikely to change. No subspecies are recognized.

Common Names—In addition to Spotted Turtle, other common names include: Yellow Spotted Turtle, Speckled Tortoise, Speckled Turtle, Speckled Terrapin, Spotted Tortoise, Pond Turtle, Spotted Terrapin, Yellow-spotted Terrapin, and Speckled Back (Surface 1908).

Description—The Spotted Turtle is a small (8–12.5 cm) turtle with a smooth, unserrated carapace and plastron. The ground **color** of the carapace is black, and is adorned with small, round, yellow spots that give the turtle its common name. Conant (1938) counted 14–114 spots in Ohio individuals, and the greatest number of spots are usually concentrated along the lower portions of the costal scutes, especially on the anterior and posterior. Mean spot counts range from 32–55 (Ernst and Barbour 1972; Gray 2008). Ventral surfaces of the marginals are orange-yellow with some dark pigment along the edges. The plastron is unhinged with a ground color usually a shade of light yellow, but ranging from ivory to reddish-orange. Much of the plastron is covered by a large black blotch, leaving the ground color concealed in all except an irregularly-shaped area down the midline and on the margins of the scutes. Increasing melanism with age may leave the entire plastron black (Ernst et al. 1994). Even within a single population, coloration of individuals can be quite variable (Figure 3-1).

Skin color is most often black, but may be closer to gray. On the head are bright orange and yellow spots and blotches, including a broken yellow band near the tympanum (Ernst 1972). The limbs may or may not have yellow spots. Each digit ends in a well-developed curved nail.

Spotted turtles are **sexually dimorphic** in several ways (Figure 3-2). Males usually have brown eyes and a tan to brown chin, while females have orange eyes and a yellow chin (Blake 1922; Ernst 1972; Ernst et al. 1994). Blake (1922) stated that females have a conspicuous yellow or orange stripe reaching about half the length of the neck, while males have a few spots or almost none. In contrast, Rowe et al. (2012) found coloration other than the chin does not differ between the sexes. Male plastrons are concave, while those of females are flat. Plastron length (PL) and shell height relative to carapace length (CL) is greater in females (Gray 2004; Litzgus and Mousseau 2004a; Rowe et al. 2012). The tail of males is longer than that of females, and the cloacal opening usually extends past the marginal scutes. Females are on average, larger (Gibbons and Lovich 1990) and heavier (Litzgus and Mousseau 2004a) than males, although this relationship was only visible for the largest individuals and not statistically significant in a southwest Michigan population (Rowe et al. 2012). Gray and Curtis (2003) reported on two individuals (80.7 mm and 96.3 mm CL) that were sexed as females based on chin coloration, lack of concave plastron, and location of the cloacal opening, but were later found to have male characteristics when captured 3 and 2 years later, respectively (92.5 mm and 102.4 mm CL).

Juvenile Spotted Turtles have just one yellow spot per carapacial scute, except for the cervical which has none. Yellow spots are not visible on some hatchlings. Ernst (1994) noted a greater amount of black pigment around the edges of the ventral surfaces of the marginals of juveniles. The carapace of hatchlings has a more oval shape than that of adults, which is more elongated. Only in the youngest of turtles is a vertebral keel found, and even then, it is slight.

Mean **size** of adult male Spotted Turtles is 86.1–116.3 mm CL and 86.3–96.4 mm PL; for females 92.4–115.0 mm CL and 80.7–101.5 mm PL [reviewed by Litzgus and Brooks (1998a)]. Spotted Turtles in the northernmost populations (Ontario, Canada) are larger than those from southern populations (Litzgus et al. 1999), but taken as a whole the species does not appear to follow Bergmann's Rule (larger body size in cooler environs), and cell size does not correlate with latitude (Litzgus et al. 2004). Conant and Collins (1991) list the record size as 5 inches (127 mm), the same as the largest specimen reported in Ohio (Conant 1938a).

Distribution—The range of the Spotted Turtle is broken into two large swaths separated by the Appalachian Mountain range. To the east of the mountains, they are found along the Atlantic Coastal Plain and Piedmont from Maine to northern Florida. To the west of the mountains, the range of the Spotted Turtle is generally centered on the Great Lakes region, including southern Ontario, northeastern Illinois, northern Indiana, Michigan, and Ohio. Spotted Turtles are also known from southern Quebec and in extreme northwest South Carolina and adjacent North Carolina (Ernst et al. 1994).

In Ohio, the Spotted Turtle has been reported from throughout the glaciated portion of the state, with

Figure 3-1. Variation in the markings and coloration of the **A.** carapace and **B.** plastron of Spotted Turtles from a single population in Lucas County. Greg Lipps, Jr. photos.

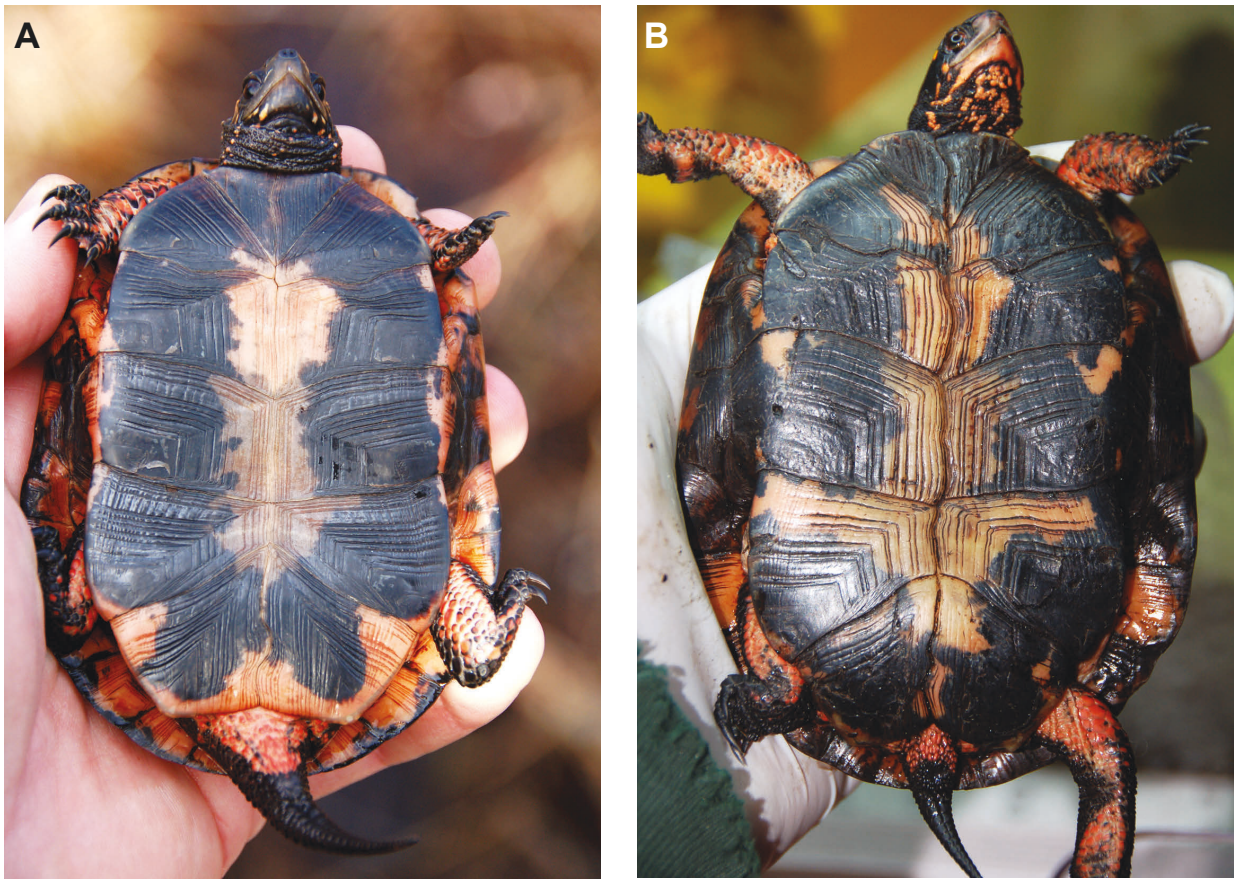

Figure 3-2. Adult Spotted Turtles are sexually dimorphic. **A.** Male with dark chin and eyes and cloacal opening that extends past the edge of the carapace. **B.** Female with light-colored chin and eyes and cloacal opening at the carapace edge. Lucas County. Greg Lipps, Jr. photos.

most extant populations centered on three general areas. The first is the northeast Ohio glacial wetlands located in the Glaciated Alleghany Plateau, where bogs, fens, and low-lying areas associated with major river systems have created habitat for the Spotted Turtle. To the west, Spotted Turtles are generally associated with the wet prairies of the Oak Openings Region in Lucas, Fulton, and Henry County. The third area occurs in Ohio's fen region in Champaign, Clark, Greene, Logan, and Miami counties, associated with numerous esker-kame complexes near end moraines and the headwaters of major river systems (Forsyth 2003). Populations do occur outside of these areas, however, including Stillfork Swamp in Carroll County which is outside of the glaciated portion of Ohio. Conant (1951) believed colonization of this site probably occurred via the drainage system of Sandy Creek. The local distribution of the Spotted Turtle can be quite perplexing, as they may be very abundant in some areas, but completely lacking in areas that appear to offer suitable habitat, a situation that has been previously noted (Conant 1938a).

Natural History—Spotted Turtles are specialists of shallow water wetland systems (Conant 1938), tending to live in areas with access to basking sites and high amounts of aquatic and emergent vegetation (Rasmussen and Litzgus 2010a). **Habitats** may include bogs, fens, wet prairies, the margins of ponds and lakes, or even roadside ditches. They will commonly use small streams, especially those associated with bogs or fens, but are not known to spend time in large lotic (flowing water) systems such as rivers. In a Maine study tracking 39 turtles over 3 years, turtles showed the strongest selection for emergent wetlands and scrub-shrub swamps, despite forested deciduous wetlands being the most available (Beaudry et al. 2008). In Illinois, Spotted Turtles used areas of shallower water and greater vegetation than sympatric freshwater turtle species (Anthonysamy et al. 2014). Individuals on a Georgian Bay (Canada) island frequented small rock pools, devoid of emergent vegetation (Reeves and Litzgus 2008). Within a pine plantation in North Carolina, 85% of the locations of 31 radiotracked turtles occurred in roadside

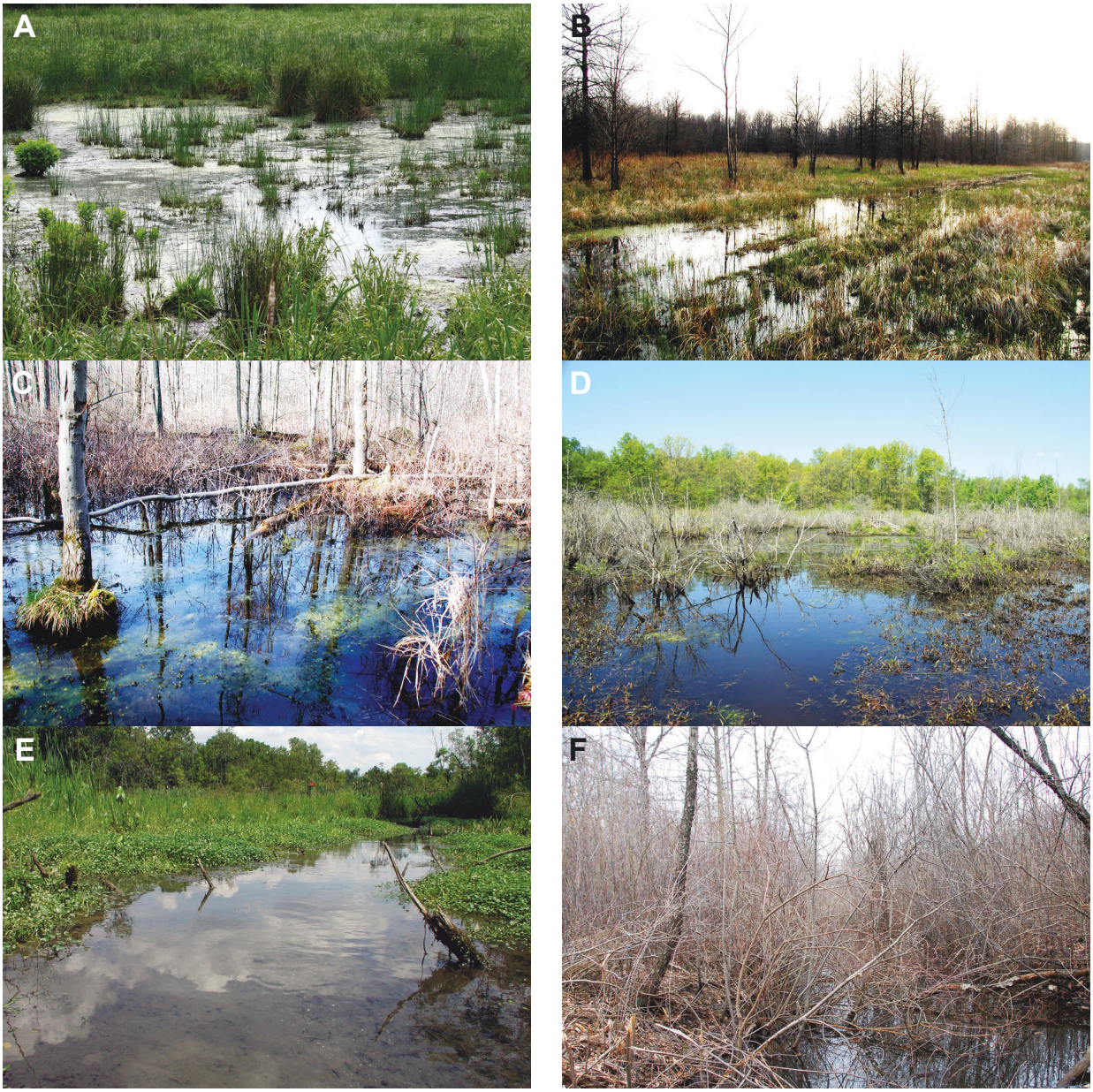

Figure 3-3. Examples of habitats used by Spotted Turtles in Ohio. **A.** Gott Fen State Nature Preserve, Portage County. Chip Gross photo. **B.** Twigrush wet prairie, Oak Openings Region, Kitty Todd Nature Preserve, Lucas County. **C.** Ephemeral wetland. Ashtabula County. **D.** Beaver-maintained wetland. Ashtabula County. **E.** Fen stream. Warren County. **F.** Ditch. Lucas County. B–F: Greg Lipps, Jr. photos.

ditches (O'Bryan et al. 2016). In Ohio, Spotted Turtles have been found in wet prairies, sedge meadows, beaver ponds, fens and fen streams, buttonbush swamps, and roadside ditches (Figure 3-3).

Spotted Turtles often use multiple wetlands, including those that are ephemeral, drying up in late summer. In the northeast, they are often residents of vernal (spring) pools (Graham 1995) and may use multiple small (mean=0.176 ha) wetlands while spending little time in permanent wetlands (Joyal et al. 2001). Over a 3-year period, 39 Spotted Turtles used 78 different wetlands, with each turtle being tracked to 1–9 (mean=3.4) different Maine wetlands (Beaudry et al. 2008). Movement between wetlands may be overland, with as much as 74% of their time spent in upland areas (Joyal et al. 2001), or through connecting ditches. Wet Prairies in northwest Ohio and buttonbush swamps in northeast Ohio with known Spotted Turtle populations routinely dry up in the

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summer, and at least in northwest Ohio, the Spotted Turtle is frequently found in the extensive roadside ditch network of the region.

Most of a Spotted Turtle's active life in Ohio occurs in areas with little to no canopy cover. Exceptions to this are some of the larger and deeper shrub-scrub wetlands of northeast Ohio, where the dominant vegetation is Buttonbush and a full canopy of trees is unable to establish due to the hydrology. Otherwise, activity within forested areas appears to be limited to the early part of the season prior to trees leafing out. Spotted Turtles will, however, commonly utilize forest edges for periods of inactivity, such as dormancy in the late summer and overwintering.

The **behavior** that perhaps is most notable for the Spotted Turtle is that of early season activity. Individuals have been observed active during every month from January to November in Ohio, with 77% of captures coming during April and May (Conant 1938). Studies in other states have found similar results, with 85%, 68%, 74%, and 92% of captures being reported between March and May in Northeastern Pennsylvania, Southeastern

Spotted Turtle distribution in Ohio

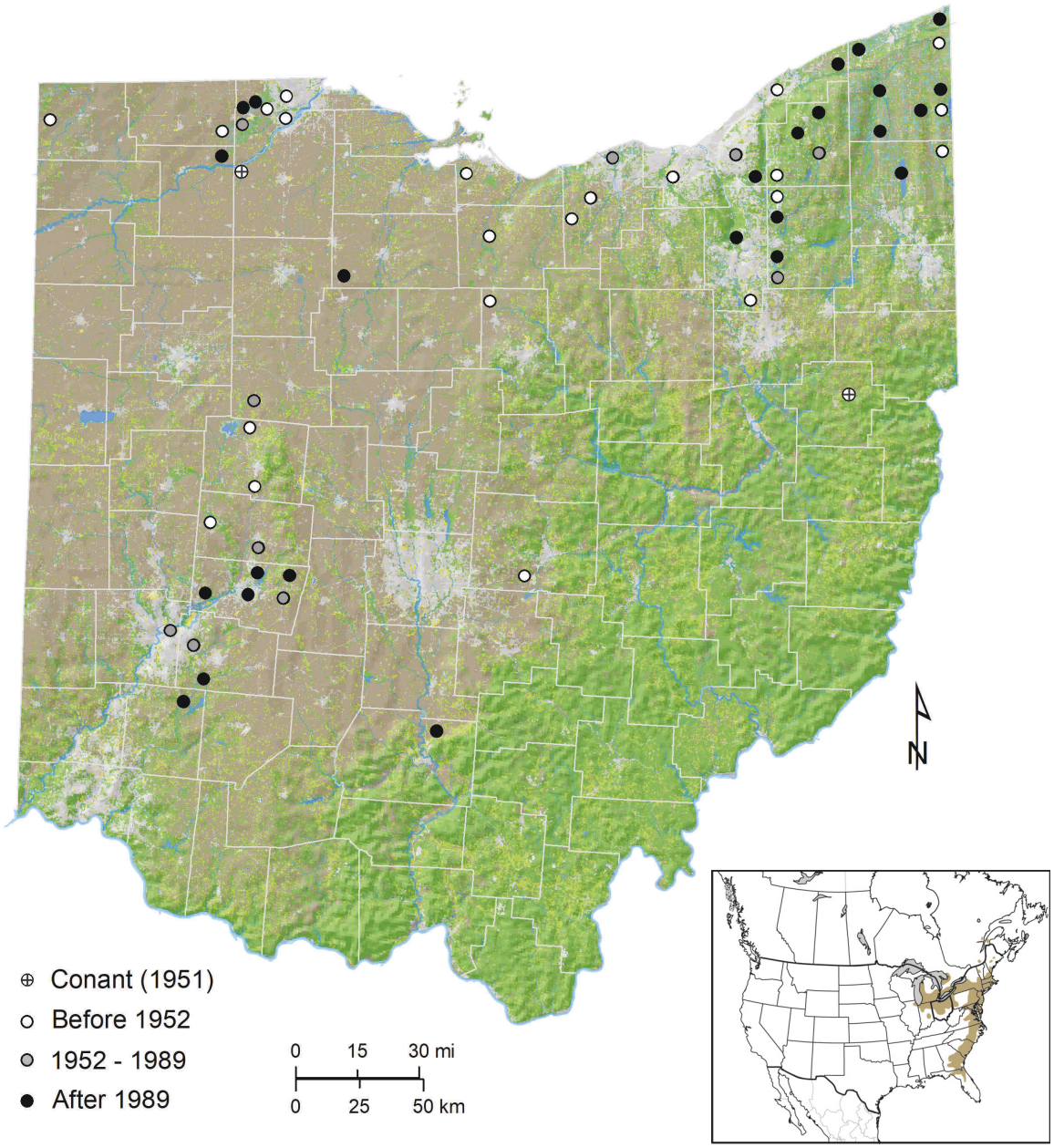

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Figure 3-4. Spotted Turtles tend to bask in a more cryptic manner than other basking species of freshwater turtles, such as the Painted Turtle. Lucas County. Greg Lipps, Jr. photo.

Pennsylvania, Maryland, and Massachusetts, respectively [reviewed by Gray (2004)].

Activity usually begins when water temperatures exceed 5–9.2°C and ambient temperatures are above 4.2–9°C (Ernst 1967; Ernst 1982; Haxton and Berrill 2001; Gray 2004), although activity has been observed when air temperatures are as low as 2°C (Litzgus and Brooks 2000). In Clark County, turtles usually left the hole in which they were overwintering within a few days after ice melted from the hole (Lewis and Ritzenthaler 1997). On two occasions (March 6 and April 7), I have witnessed courting pairs of turtles beneath thin ice in a wet prairie in western Lucas County. Minimum water temperature for feeding has been reported as 7.7°C (Ontario, Canada, 45°N; Rasmussen et al. 2009), 12.7°C for captive animals at the Toledo Zoo that were housed outside (41°N; pers. obs.), 15°C (Ontario, Canada, 44°N; Haxton and Berrill 2001), and 17°C (Ontario, Canada, 45°N; Litzgus and Brooks 2000). That turtles are often active at temperatures lower than the minimum reported for feeding supports the notion that the earliest activity is focused on courtship and mating.

Radiotelemetry technology has been used extensively to study Spotted Turtles (Graham 1995; Perillo 1997; Litzgus and Brooks 1998b; Lewis and Faulhaber 1999; Litzgus et al. 1999; Litzgus and Brooks 2000; Haxton and Berrill 2001; Joyal et al. 2001; Litzgus and Mousseau 2003; Beaudry et al. 2008; Rasmussen et al. 2009; Yagi and Litzgus 2012; Anthonysamy et al. 2014; O'Bryan et al. 2016; Buchanan et al. 2017), and from these studies much is known about the annual activity cycles of the species. From March to mid-June, Spotted Turtles remain mostly within open canopy wetlands, except in more southern populations, where activity within forested areas appears to be common (Litzgus and Mousseau 2004b). Overland migration is not uncommon, with individuals traveling from 20–570 m, to reach adjacent wetlands or nesting sites (Ernst 1976; Joyal et al. 2001; Gray 2004), although some individuals may spend the entire year within a single wetland (Rowe et al. 2013). **Home range** estimates range from 0.53–19.06 ha (minimum convex polygons, MCP) and are not correlated to latitude or habitat fragmentation [reviewed by Litzgus and Mousseau (2004b) and Slavenko et al. (2016)]. When Beaver activity resulted in an increase in aquatic habitat at a Canadian site, the resident Spotted Turtle population responded with significantly larger home ranges than pre-flood conditions (Yagi and Litzgus 2012). Four Spotted Turtles tracked in a Lucas County wet prairie for 43–249 days had home ranges (MCP) of 0.25–4.65 ha (mean=1.84).

Like many turtles, much of a Spotted Turtle's activity is spent actively **thermoregulating**, with turtles preferring a body temperature of 20–26°C (Yagi and Litzgus 2013). Basking was the most common behavior (63% of observations) in a northwestern Pennsylvania population (Gray 2004). At most Ohio locales, Spotted Turtles are rarely observed openly basking on logs breaching the water or on the banks of the wetland, a common behavior of Painted Turtles (*Chrysemys picta*). Instead, it is more common for Spotted Turtles to slightly exit the water onto adjacent grass or sedge tussocks and remain mostly hidden by the vegetation (Figure 3-4). In addition to terrestrial basking, shallow water habitat can maintain turtle body temperatures higher than ambient (Haxton and Berrill 2001) and increases in this type of habitat can result in an increase in the quality of the thermal environment available to a population (Yagi and Litzgus 2013).

In Ohio, many of my encounters with Spotted Turtles have involved an individual sticking its head above the water, much like a periscope scanning the surrounding area (Figure 3-5). If the observer holds

Figure 3-5. A Spotted Turtle sticks its head above the water to investigate the intruder that interrupted her foraging (note the trail of bubbles on the surface). Portage County. Greg Lipps, Jr. photo.

completely still, the turtle will most often return to its activities, but the slightest movement will invariably cause the turtle to retreat underwater where it usually digs into the soft substrate to conceal itself.

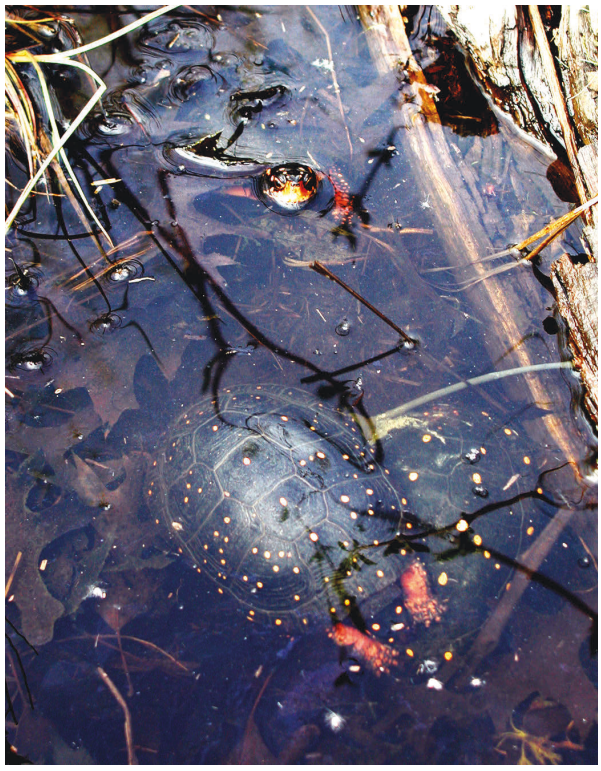

Figure 3-6. A female Spotted Turtle (on bottom with radio transmitter attached to shell) is courted by one male while another looks on. Lucas County. Greg Lipps, Jr. photo.

Courtship is most often observed in the spring, consisting of one or more males pursuing a female in shallow water and on land (Figure 3-6). In South Carolina, Spotted Turtles aggregated in early April of each year in a shallow water shore area (~ 10 m X 20 m) of a swamp forest, coinciding with a peak in courtship behavior (Litzgus and Mousseau 2006). Aggregations consisted of 6–8 individuals, with five individuals captured from aggregations at the same location in multiple years. While most (63%) courtship observations occurred in the spring (February 2–April 10), the remaining 37% were observed in the fall (September 9–December 16; Litzgus and Mousseau 2006).

Figure 3-7. A copulating pair of Spotted Turtles found on April 29. Lucas County. Greg Lipps, Jr. photo.

Ernst (1994) reported courtship lasting 15–30 minutes and covering 30–50 m, with water temperatures 8.8–18.9° C and air temperatures 10.0–22.3° C. Males will often bite at limbs and necks of females as well as other males (Ernst 1970). Spotted Turtles appear to be polygamous, with females being courted by multiple males, and males courting multiple females (Litzgus and Mousseau 2006).

Copulation takes only a few minutes, with the male mounting the female from the rear and wrapping his tail under that of the female (Figure 3-7). Ernst (1967) reports a mating aggregation consisting of 16 turtles and an L-shaped copulation position that occurs when dismounted males hang from the side of a female during copulation. Viable sperm may be stored by a female in the albumin region of the oviducts for up to 1 year (Gist and Jones 1989).

Nesting occurs most commonly in early June and has been observed twice in wild Spotted Turtles in Ohio (Figure 3-8; pers. obs.). On June 9, 2002 a female Spotted Turtle in a wet prairie in western

Figure 3-8. Nesting by a Spotted Turtle. **A.** Eggs are laid and **B.** positioned in the nest. **C.** The female uses her hind feet to reach out and **D.** grab soil to place back onto the nest. **E.** When filling of the nest is complete, she uses the distal portion of her plastron to smooth the nest site. Lucas County. Greg Lipps, Jr. photos.

Lucas County was observed digging at 10:00 PM. The digging was accomplished using her rear legs; one would extend down into the hole, scraping away at the sides and bottom for approximately 30–80 seconds before being pulled out along with the excavated soil. This process was then continued using the other rear leg, which had been supporting the body outside of the hole. The alternating legs continued digging until 10:53 PM when the first egg was deposited. A second egg came at 10:54 PM, and a third at 10:58 PM. In a surprising display of dexterity, the soil was returned to the hole using the rear feet to grab, lift, then drop soil on top of the eggs. By 11:40 PM, the eggs were no longer visible, although the topmost egg was covered by <2 mm of soil. The female used her feet and legs to knead and roll over the soil, occasionally pausing to pack the dirt with the posterior of her plastron. During this entire process, the female was always situated with her posterior end towards the nest. Nine days later, again in the evening, a second female was observed nesting within 3 m of the first, laying four eggs. The nesting location, between two tire ruts along a pipeline right-of-way, was routinely flooded in the early spring and consisted of a dark, sandy wetland soil. The entire nesting process witnessed was very similar to observations described by Adler (1961) for animals kept in an outdoor enclosure in Indiana and Ernst (1970) for a population in Lancaster County, Pennsylvania.

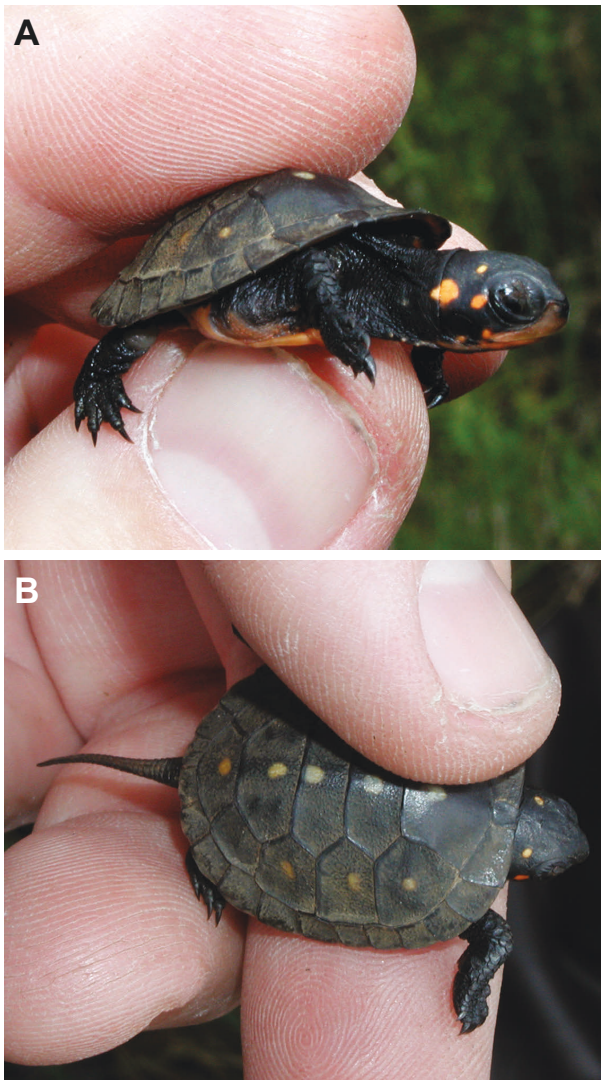

Figure 3-9. **A** and **B**. A hatchling Spotted Turtle found on May 5. Lucas County. Greg Lipps, Jr. photos.

The nesting season generally becomes shorter with increasing latitude possibly due to required incubation temperatures (Litzgus and Mousseau 2006; Table 3-1). During drought years when substrates may be particularly dry, turtles may delay nesting until after rainfall (Ernst 1970; Litzgus and Brooks 1998b). Nesting most commonly occurs after sundown (Litzgus and Brooks 1998b; Litzgus and Mousseau 2006) or in the early morning before 10:00 AM (Ernst and Zug 1994). Ernst (1970) described females on their way to nest exiting the water and pausing, possibly orienting themselves using the setting sun.

Nest sites are commonly described as having loamy soils and full exposure to sunlight (Ernst 1970), but in one northern population, nests were dug in soil, lichen, and grass on rock outcrops (Litzgus and Brooks 1998b). In Maine, 12 of 14 nests were located in upland areas <120 m from the nearest wetland (Joyal et al. 2001). The use of forested areas for nesting may be limited to southern populations of Spotted Turtles. In South Carolina, 17 of 21 nests observed over a 3-year period were constructed under forest canopy, most often in decaying woody debris, leaf litter, and moss (Litzgus and Mousseau 2006) and 80% of nests in a North Carolina pine plantation were deposited on the banks of roadside ditches (O'Bryan et al. 2016). Northern populations appear constrained to open canopy sites with the thermoregulatory potential for completing incubation (Litzgus and Brooks 2000). Utility right-of-ways and other clearcut areas are often utilized as nesting sites (Litzgus and Mousseau 2004b). In Portage County's Gott Fen, a Spotted Turtle was observed nesting in a rotting railroad tie (Brian Stenger, pers. comm.). Females that were observed nesting in two consecutive years at a site near Lake Huron showed fidelity to the substrate

Table 3-1. Dates of Spotted Turtle nesting from across their range.

Location (Latitude)	Date(s) of nesting	Source
Francis Beidler Forest, South Carolina (33°N)	early-May–mid-July	Litzgus and Mousseau (2006)
Cedar Bog, Champaign County (40°N)	June 20	unpublished data
Lancaster County, Pennsylvania (40°N)	June–July*	Ernst and Zug (1994)
Toledo Zoo (outside), Lucas County (41°N)	June 11, 14	G. Lipps, Jr. (pers. obs.)
Kitty Todd Nature Preserve, Lucas County (41°N)	June 9, 18	G. Lipps, Jr. (pers. obs.)
Georgian Bay, Ontario, Canada (45°N)	June 14–29	Litzgus and Brooks (1998b)
Mer Bleue, Ontario, Canada (45°N)	June 29	Chippindale 1989

* June 1–14 for 14 of 22 nests

chosen for the nest site each year (gravel, sand, sphagnum, soil, or clay), but not to the locations (Rasmussen and Litzgus 2010b).

Clutch sizes range from 1–8 (Ernst 1970). Individuals in southern populations may have up to three clutches per year (mean=1.2 in South Carolina), but the average clutch size is reduced (mean=2.9), compared to Pennsylvania (3.9) and Ontario (5.3), resulting in similar reproductive output for northern and southern populations (Litzgus and Mousseau 2003). Egg measurements were reviewed by Litzgus and Mousseau (2006) who found that egg size varies by latitude, but is also partially explained by intraspecific variation in female body size. Females in Ontario produced eggs with a lower mass (mean=5.9 g) that were shorter (mean length=31.0 mm) than those of South Carolina females (6.8 g and 32.8 mm, respectively). Pennsylvania Spotted Turtle eggs had a mean width of 16.7 mm, making them narrower than either Ontario (17.8 mm) or South Carolina (18.4 mm) eggs (Litzgus and Mousseau 2006). When examined for a single year, female body condition correlated to the number, but not the morphometrics, of eggs (Rasmussen and Litzgus 2010b), while over a 3-year period, females with better body condition were found to have larger clutch masses and egg sizes (Litzgus et al. 2008).

In captivity, **incubation** may be as short as 44 days, but extends 70–83 days in the wild (reviewed by Ernst, et al. (1994)). Nests monitored in South Carolina had mean temperatures of 22.5–24.9° C (minimum recorded=12.0° C, maximum recorded= 32.0° C) and hatched after an incubation period of 72–90 days (mean=79; Litzgus and Mousseau 2006), while 26 nests in a northern population along Lake Huron had a mean temperature of 21.43° C (Rasmussen and Litzgus 2010b). A datalogger in a Lucas County nest recorded a mean temperature of 24.05°C (range=11.38–37.44°C) through August 9 (unpublished data). In Pennsylvania, the earliest hatching was August 18 (Ernst 1970). Spotted Turtles appear to employ a facultative delayed emergence strategy, with 28% found to overwinter in the nest, delaying emergence until the following spring (especially following rainfall) in one long-term study in Pennsylvania (Lovich et al. 2014). This contrasts with the findings of a New Hampshire study, though, where hatchling emergence over seven years ranged from August 20–October 16 (Carroll and Ultsch 2007). Of the five sympatric freshwater turtle species monitored in New Hampshire, only hatchlings of the Painted Turtle overwintered in the nest, but the proportion that did so varied, as did their mortality rate. The selective pressures related to these different strategies of emergence are one aspect of freshwater turtle life history in need of further study (Carroll and Ultsch 2007).

Spotted Turtles exhibit **temperature-dependent sex determination (TSD)**. Ewert and Nelson (1991) report males are produced from eggs incubated at 22.5–27.0° C, while 30° C produces all females. Nests in gravel substrate were significantly warmer during July and August than those in clay or soil and the resulting offspring had shorter CLs and lower masses, although researchers were unable to determine the sexes of the hatchlings (Rasmussen and Litzgus 2010b). In one island population where the sex ratio is highly skewed (1 male:3.58 females), nests are constructed in shallow soils over bedrock which may result in higher incubation temperatures (Reeves and Litzgus 2008). The variability in TSD needs further investigation, however, as the nest temperatures reported by Litzgus and Mousseau (2006) would be predicted to produce exclusively males, while the reported adult sex ratio of this population was 1:1.

Hatching success is variable as eggs are subject to a variety of insults. Predators consumed 8 of 11 nests at one site on the eastern shore of Lake Huron (Rasmussen and Litzgus 2010b). Over a three-year period, 33 hatchlings were documented emerging from 57 eggs laid in a South Carolina population (Litzgus and Mousseau 2006). The hatching success in a given year ranged from 48–100%. Annual nest survivorship did not differ between this population and two others in Pennsylvania and Ontario (mean=54.6%) (Enneson and Litzgus 2008).

Hatchling turtles have been found in Ohio on October 2, March 16 (Conant 1938), May 5, and June 8, perhaps indicating little growth in the short time between hatching and winter (Figure 3-9). Turtle **growth** rates have been investigated by several authors [reviewed by Ernst et al. (1994) and Litzgus and Brooks (1998a)], but many of the studies have relied heavily on counting scute annuli, a technique that is not entirely reliable (Litzgus and Brooks 1998c). Growth annuli may not be visible in males >14 years and females >18 years (Ernst 1975). Hatchling turtles measure 25.5–31.2 mm CL with a mass of approximately 4.7 g (Conant 1951; Ernst et al. 1994). Change in the PL in the first year ranges from 42.98% in southern Rhode Island (Graham 1970) to 66.93% in Pennsylvania (Ernst 1975). This slows to an 8.08% growth rate when PL is 57.0–83.8 mm (mean=72.92) at about 7 years old (Graham 1970).

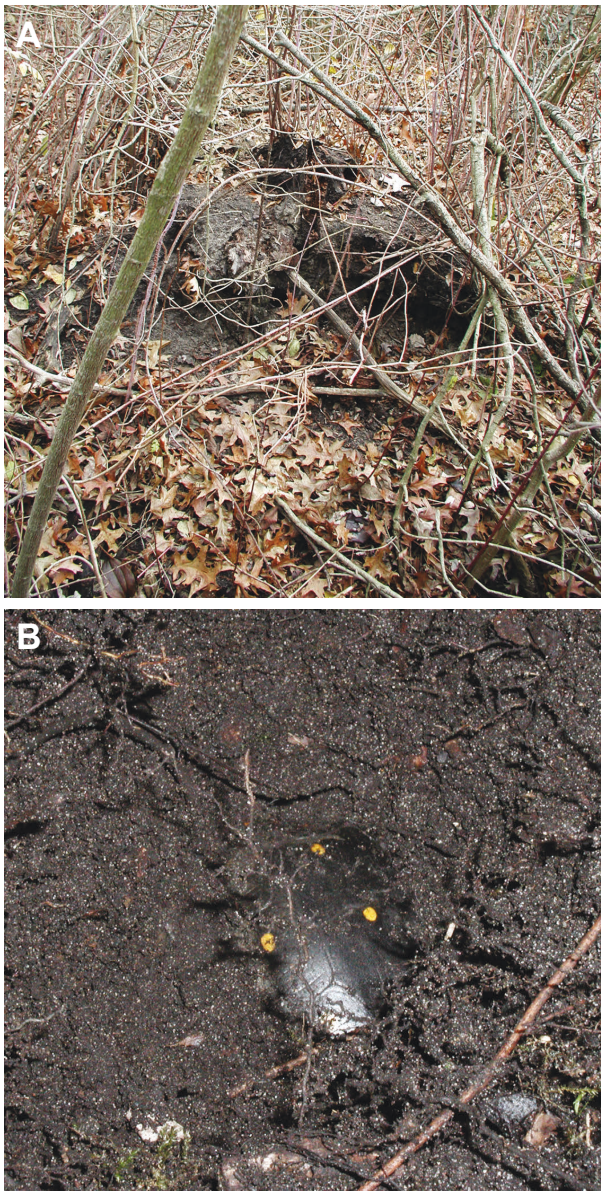

Figure 3-10. A site used during summer dormancy and overwintering by a Spotted Turtle. **A.** The turtle was tracked to the base of the uprooted tree. **B.** The carapace of the turtle is visible after soil was removed. Lucas County. Greg Lipps, Jr. photos.

Reptiles are often considered to have indeterminate growth, but this doesn't appear to be true for Spotted Turtles. Growth was not detectable for recaptures of the largest turtles in Pennsylvania [PL >90 mm (Ernst 1975); and CL=98.7–116.6 mm (Gray 2004)], Georgian Bay, Ontario [(CL > 110 mm (Litzgus and Brooks 1998a)], or Portage County [CL=103.34–120.91 (G. Lipps, Jr., unpublished data)].

Spotted Turtles usually reach **sexual maturity** at age 7–12 years (Ernst et al. 1994; Litzgus 2006). A small male Spotted Turtle (CL: 82.95 mm; PL: 70.55 mm; mass: 90 g) having six growth annuli was observed courting a female on June 11, 2002 in a wet prairie in western Lucas County and was the smallest individual I have been able to positively assign a sex. The smallest mature female in a sample of 11 females in a Pennsylvania population was an 8-year old with a CL of 94.2 mm (Ernst and Zug 1994).

The apparent disappearance of Spotted Turtles during the warmer months left early authors searching "in vain during the summer in localities where they were found abundantly in spring" (Conant 1938). Individuals do not retire to deeper water, become nocturnal, or wander on land in search of food as previously hypothesized, but instead enter into a **summer dormancy**. This has sometimes been referred to as **estivation** or **aestivation**, but these terms are often defined by specific behavioral and physiological changes that may not apply to Spotted Turtles (Litzgus and Mousseau 2004b). The summer dormancy usually begins by the end of June (Ernst 1982), and Spotted Turtles are increasingly difficult to find after this time. Dormancy lasted 2–93 days at two Massachusetts sites (Milam and Melvin 2001), 15–89 days at a site in Maine (Joyal et al. 2001), and 5–30 days at a Lake Huron site in Canada (Rowe et al. 2013). Lovich (1988) found that Spotted Turtles were least active during the month when mean ambient temperatures first exceed 22.61°C, corresponding to July in Ohio.

Summer dormancy sites are usually located adjacent to areas of activity, often in secondary paludal woods (Ernst et al. 1994). Turtles create and crawl into "forms," depressions in heavy organic soils, leaf litter, *Sphagnum* mounds, and/or vegetation (Ernst et al. 1994; Joyal et al. 2001; Milam and Melvin 2001; Rowe et al. 2013); muskrat burrows and lodges; the soft substrate of streams (Ernst 1982); the edges of pools (Ward et al. 1976); or, the root balls/stumps at the base of fallen trees (Litzgus and Mousseau 2004b). Ernst (1994) states that dormant turtles are almost always completely underwater with the exception of the top of the carapace and Beaudry et al. (2009) reported the use of a floating *Sphagnum* mats during inactivity. Others, however, have found forms are often created in upland areas 80 m (Joyal et al. 2001) to 412 m (Milam and Melvin 2001) from the nearest wetland, including on rock outcrops and in prairies and forests (Graham 1995; Litzgus and Brooks 2000; O'Bryan et al. 2016). In general, there appears to be a pattern of terrestrial dormancy in northern locales versus aquatic dormancy in southern locales, although both may be used across their range (Litzgus and Brooks

2000). In a wet prairie in western Lucas County, two radiotracked Spotted Turtles used forms in terrestrial situations (pers. obs.). One was located 15 m into a secondary forest adjacent to a wet prairie, while the other burrowed into the soil beneath a patch of shrubs in the prairie (Figure 3-10).

The triggers and adaptive significance of summer dormancy are not fully understood. The timing and length of dormancy have been positively correlated to the decline in the availability of standing water (Joyal et al. 2001; Rowe et al. 2013), although this was not true in a two-year study of a Rhode Island population (Buchanan et al. 2017). Environmental temperatures are not different during dormant and active periods (Rowe et al. 2013), nor are turtle body temperatures different from surrounding environmental temperatures (Litzgus and Brooks 2000; Haxton and Berrill 2001) indicating that this behavior can't be explained as merely attempting to avoid high temperatures. Further evidence that temperature alone does not explain this behavior is the fact that Spotted Turtles activity is very limited in the fall (Ernst et al. 1994), when temperatures drop and ephemeral wetlands once again fill with water. Graham (1995) suggested two possible reasons for summer dormancy. First, much like spring breeding amphibians, Spotted Turtles may be a species adapted to take advantage of the abundant food supplies that are found in ephemeral wetlands and a reduction in food supplies may trigger dormancy (Ward et al. 1976). Another explanation is that this behavior is possibly a holdover adaptation that was once of much greater importance during past drier climates. When Beaver activity resulted in an increase in the amount of available aquatic habitat at a Canadian site previously mined for peat, the proportion of turtles entering a summer dormancy significantly decreased, indicating some plasticity in this behavior, even within a population (Yagi and Litzgus 2012).

Spotted Turtles, like all reptiles, do not truly hibernate, but instead they **survive winter** by decreasing their activity while remaining in areas unlikely to freeze. In central Ontario, 15 radiotracked turtles had moved to their overwintering grounds when the mean ambient temperature dropped to or below 13°C (Haxton and Berrill 2001). At a southern Ontario site, turtles predominately overwintered where temperatures fluctuated the least, at the bottom of drains (Yagi and Litzgus 2013). At Prairie Road Fen in Clark County, Spotted Turtles were studied during the winter from 1991–1996 (Lewis and Ritzenthaler 1997). Turtles arrived at overwintering sites from September 25–February 1 [mean dates=November 14 (males) and November 25 (females)]. Fifty percent of the estimated population overwintered within an 85 m^2 area, in vertical holes 7 cm in diameter <70 cm deep located in the saturated, organic muck layer of the fen. Temperatures in the holes reached a minimum of 2.73°C at the bottom and 0.43°C in the upper end. A hole in the ice up to 2 cm in diameter was present during most winters and turtles were observed moving in the water column below the ice but above the mud layer during each visit. Seven of the nine identified sites had >4 turtles, with one hole having 34, 29, and 14 individuals in successive years. Some turtles traveled 1.5 km from their areas of activity to reach the overwintering sites, and the probability of a turtle returning to the same site in subsequent years was estimated at 0.5.

Congregations of overwintering Spotted Turtles have been noted in other populations (Bloomer 1978; Milam and Melvin 2001; Rasmussen and Litzgus 2010a; Buchanan et al. 2017) but the adaptive significance of this behavior is not entirely understood. There is no evidence that the aggregations themselves serve any thermal function (Lewis and Ritzenthaler 1997) and it is more likely this is a reproductive strategy, making it easy for turtles to find mates in the early spring.

Other overwintering sites utilized by Spotted Turtles include: a bog with a stream flowing through it (Haxton and Berrill 2001); in a permanent Red Maple-*Sphagnum* swamp within underwater passageways between tree roots and in the *Sphagnum* mats (Graham 1995); in the burrow complex of Muskrats (Bloomer 1978; Rasmussen and Litzgus 2010a); in a dilapidated springhouse (Bloomer 1978); in matted cattail mounds (Rasmussen and Litzgus 2010a); in *Sphagnum* hummocks and the roots of woody shrubs (Buchanan et al. 2017); and, 10–25 cm underwater, in the soft bottom of streams that never freeze completely and thaw quickly in the spring (Ernst et al. 1994). In western Lucas County, two Spotted Turtles overwintered in terrestrial situations, one burrowed into the ground beneath a shrub in a wet prairie (the same location where it spent its summer dormancy), and the other under a hurricane tip-up (large tree downed by wind) alongside a ditch (pers. obs.). Terrestrial overwintering by Spotted Turtles has also been reported in South Carolina during a severe drought (Litzgus and Mousseau 2004b) and at a Lake Huron wetland, where some turtles buried into the substrate near the bases of shrubs or small trees (Rasmussen and Litzgus 2010a). Spotted Turtles have exhibited both fidelity, returning to the same overwintering site in consecutive years, and

plasticity, overwintering in different locations and habitats, a subject worthy of further study (Rasmussen and Litzgus 2010a).

Longevity of wild Spotted Turtles has been documented to exceed 30 years and a captive specimen lived to 42 years (Ernst 1975). Based on a long-term mark-recapture study in Ontario, however, the maximum longevity of Spotted Turtles was estimated to be 65 years for males and 110 years for females (Litzgus 2006). The same study estimated adult annual **survivorship** of 94.2% for males and 96.5% for females with similar estimates for a North Carolina population (O'Bryan et al. 2016). Females tend to use sites with greater amounts of cover during the nesting and post-nesting season, perhaps reducing predation chances and explaining their longer lives (Rasmussen and Litzgus 2010a).

Estimates of Spotted Turtle **population sizes** range from 26–1,204 turtles with densities of 0.05–79.6 individuals/ha [reviewed by Litzgus and Mousseau (2004a)]. In a 10.6 ha twigrush wet prairie at The Nature Conservancy's Kitty Todd Preserve in Lucas County, a population estimate of 73 (95% CI=56–102) corresponds to a density of 6.9 turtles/ha (Harms 2008).

Estimates of population **demographics** are available for Spotted Turtles, thanks in large part to a 30-year capture-mark-recapture study in eastern Georgian Bay, Ontario (Litzgus and Brooks 1998a; Litzgus and Brooks 1998b; Litzgus et al. 1999; Litzgus and Brooks 2000; Litzgus 2006; Enneson and Litzgus 2008; Enneson and Litzgus 2009). Annual survivorship is estimated to be 0.546 for eggs, 0.816 for juveniles, 0.942 for adult males, and 0.956 for adult females. Assuming a stable stage distribution, the population is estimated to consist of 28% eggs/hatchlings, 55% juveniles, and 17% adults. Most researchers report catching far fewer juveniles (Litzgus and Mousseau 2004a), which may indicate differences in habitat use or effectiveness in survey methods. At two sites in the Oak Openings Region of Lucas County, 42% of the captures were juveniles (Harms 2008).

The Spotted Turtle has an omnivorous **diet**, feeding on the abundant aquatic life found in wetlands including frogs, earthworms, grubs, and grass (Conant 1938), as well as cranberries, aquatic insect larvae, crustaceans, snails, salamanders, fish, birds, algae, and tadpoles (Ernst 1976). A quantitative analysis of foraging in one population near Lake Huron found aquatic invertebrates (snails, trichopterans, leeches, and crayfish) made up 74% of observations, followed by fish (rainbow trout, carp, small cyprinids) at 16% of observations (Rasmussen et al. 2009). Hard-shelled snails were repeatedly bitten so that the soft body could be consumed, leaving behind the hard shell. Spotted Turtles have been observed feeding on amphibian egg masses and larvae (Milam and Melvin 2001; Rasmussen et al. 2009) and were associated with wetlands having abundant Wood Frog (*Lithobates sylvaticus*) egg masses in the spring (Beaudry et al. 2009). Although most feeding takes place in the water, Conant (1938) observed two individuals seizing meat and swallowing it while resting at some distance from the water, and Rasmussen et al. (2009) observed an individual biting at the remains of a spider's web hung between rushes.

Natural **predators** of Spotted Turtles include birds, Raccoons, and skunks (Ernst et al. 1994). Evidence of attempted predation can often be seen as parallel scars on the shell, spaced as far apart as the canine teeth of a Raccoon (Figure 3-11). By far, predators take the greatest toll on the eggs and hatchling turtles. Of 43 eggs observed by Ernst (1970), 6 were destroyed by predators or drought. In a Pennsylvania population, only 58% of eggs and hatchlings were estimated to survive their first year (Iverson 1991). Up to 100% of freshwater turtle nests may be predated by Raccoons (Browne and Hecnar 2007). Nest excavations appear to be most common where nesting sites are concentrated and easily accessible to predators (e.g., railroad beds through wetlands). In South Carolina, Spotted Turtle eggs were consumed by fire ants and possibly a ratsnake [*Pantherophis* sp. (Litzgus and Mousseau 2006)]. A hatchling Spotted Turtle (CL=24.7 mm; mass=3.5 g) with an affixed radiotelemetry transmitter was consumed by a large female Green Frog (*Lithobates clamitans*) in a semi-permanent wetland 15-days post-hatching (DeGraaf and Nein 2010).

Leeches are common **parasites** of Spotted Turtles. Ernst (1976) reported Smooth Turtle Leeches on 12.1% of the 207 individuals captured in Pennsylvania. In southwest Ontario, Ornate Turtle Leeches were found on two of four Spotted Turtles (Davy et al. 2009). At Portage County's Gott Fen, all 12 Spotted Turtles captured in 2003–2004 had leeches (species not identified), while none of the 14 captured in 2017 had leeches (pers. obs.).

In the laboratory, Spotted Turtles have developed measurable levels of Eastern Equine Encephalitis virus in their blood when experimentally infected (Smith and Anderson 1980). Both Emydid herpesvirus 2 (Ossiboff et al. 2015a) and a *Mycoplasma* sp. (Ossiboff et al. 2015b) associated with several emydid turtle species have been

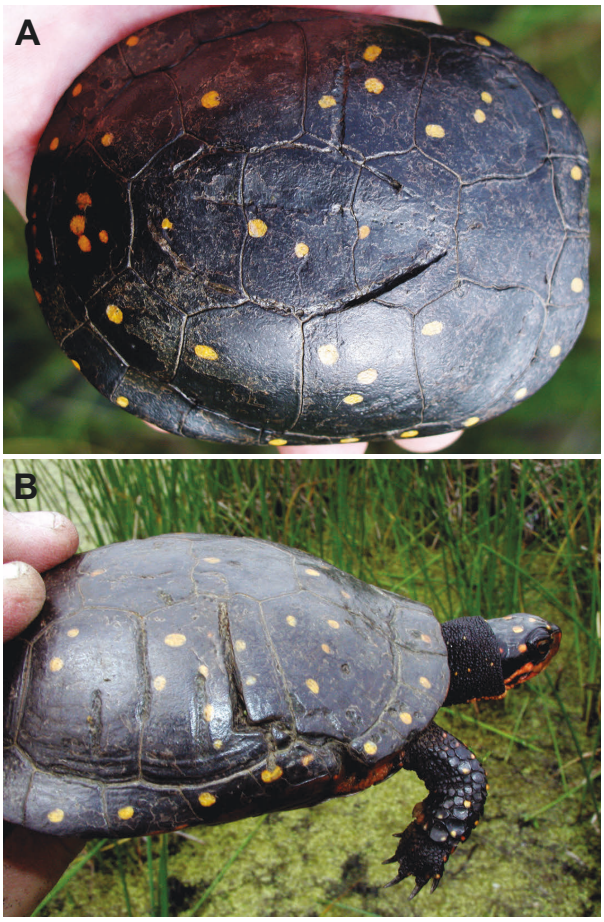

Figure 3-11. Scars are often visible on the shells of Spotted Turtles, many of which are caused by predation attempts. A. Lucas County. B. Portage County. Greg Lipps, Jr. photos.

detected in wild Spotted Turtles, although positive individuals were asymptomatic.

Conservation—The International Union for the Conservation of Nature (IUCN) considers the Spotted Turtle to be globally endangered (van Dijk 2011). At the state level, it is listed as a **Threatened** species and species of greatest conservation need (Ohio Division of Wildlife 2015). A review of threats facing 48 historical Spotted Turtle sites in Ohio was conducted by Lewis et al. (2004) who found 8 had been developed, 57% had significant invasive plant species (i.e., bush honeysuckle, buckthorn, or cattails only), 64% were regionally fragmented with major obstacles separating habitats, and 51% had local or intrasite fragmentation hindering movements of turtles from one part of the habitat to another and facilitating predator related edge effects. Only one site was found to have no site-specific threats.

At Cedar Bog in Champaign County, the decline of the Spotted Turtle has been well documented (Lovich 1989). In 1929, as many as 24 individuals were captured in a single day, but intensive surveys in 1984–1985 resulted in only three captures. The amount of habitat available to Spotted Turtles at Cedar Bog is estimated to have been reduced from 3,450 acres to 2.5 through dredging, a lowered water table, and ecological succession (Lovich 1989). These alterations may have also helped to concentrate individuals making them easier to capture. In his revision to Reptiles of Ohio, Conant (1951) made the unusual request that no more collections be made from "the cedar swamp in Champaign County" (Cedar Bog) as it "would seem needless to deplete this population further." In total, at least 65 Spotted Turtles from Cedar Bog were deposited into museums. Staff at Cedar Bog collected data on a total of 14 individual Spotted Turtles at Cedar Bog in the seven years following Lovich's (1989) work, although concerted surveys were not carried out during this time (unpublished data).

At the nearby Prairie Road Fen Nature Preserve in Clark County, the Spotted Turtle population has experienced a similarly drastic decline. In the mid-1990's, Lewis and Ritzenthaler (1997) observed as many as 34 individuals overwintering in a single burrow. Recent surveys resulted in 51 captures of only 12 individuals (Phillips 2017) in the entire preserve. This site was known to be visited by poachers (Jeff Davis, pers. comm.), and it's not difficult to imagine that the detailed descriptions of dozens of easily accessible turtles–worth hundreds of dollars each in the reptile trade–made the population extremely vulnerable. The Ohio Division of Wildlife now prohibits those permitted to work with sensitive species such as the Spotted Turtle from disclosing location information, as the exploitation of wildlife facilitated by the spread of such data is now well documented (Lindenmayer and Scheele 2017). On a more positive note, the capture of a 2-year old Spotted Turtle in 2017 (Richard Phillips, pers. comm.) is a hopeful sign that this population may still be viable.

Spotted Turtles have apparently been extirpated from Mentor Marsh in Lake County, with the last known observation occurring in 1979 (Matson et al. 2017). This 361-ha coastal wetland is located at the previous mouth of the Grand River before it carved a new path to the present-day Fairport Harbor, sometime within the past 4,000 years. The marsh was polluted with sodium chloride from salt mining tailings, resulting in the die-off of native vegetation and replacement with the invasive *Phragmites*. The Cleveland Museum of Natural History is currently leading efforts to restore this site.

It appears that the population of Spotted Turtles at Perry Nuclear Power Plan in Lake County may also have been extirpated. Capture-mark-recapture surveys in 1981–1986 reported a population estimate of 148 turtles (NUS Corporation 1986), and at the time this was believed to be the largest population in the state. The number of individuals captured generally declined during the study, though, from a high of 40 in 1981 to a low of 20 in 1986. A gravel road constructed through the area in 1986 resulted in the loss of 10–20% of the wetland habitat (NUS Corporation 1986). I conducted visual encounter surveys at Perry in 2005 and trapped the aquatic habitats in 2014, although some areas where the turtles were previously found were in a secure location for which I was not granted access. Succession into forest as well as the establishment of thick stands of the invasive *Phragmites* has further degraded and eliminated suitable habitat.

Raccoons are a serious threat to turtle populations, and populations of this predator around Prairie Road Fen were estimated to have increased 700% in one decade (Lewis and Ritzenthaler 1997). A predated nest and adults with shell damage indicating attempted predation have been observed recently at the fen (Jeff Davis, pers. comm.). A retrospective study at Cedar Bog found that only 13% of Spotted Turtles collected before 1941 showed signs of attempted predation, but that increased to 55% for those collected after 1941 (Lovich 1989). The removal of 115 Raccoons from 2011–2016 at Gott Fen resulted in a concurrent increase in the number of young Spotted Turtles captured during surveys (Lipps and Smeenk, unpublished data). Turtle nests are concentrated along a railroad corridor at this site, making them more vulnerable to predation, but also facilitating Raccoon removal. This level of management may not be necessary or feasible at other occupied sites.

Simply protecting wetlands where Spotted Turtles are seen may not ensure the survival of populations. In Point Pelee National Park along the northern shore of Lake Erie, a population described as large and healthy in 1973 was extirpated by 2001 (Browne and Hecnar 2007). The demise was attributed to the isolation of the park and the loss of shallow water areas due to canals constructed in the early 1900's. Linear canals, ditches, and drains may also increase predation rates on populations relegated to using these inferior habitats (Yagi and Litzgus 2012). Research has also found that wetlands are more likely to be occupied by Spotted Turtles when they are located closer to other wetlands (Joyal et al. 2001) and that dispersal of turtles between wetlands significantly contributes to population persistence (Enneson and Litzgus 2009). Together, this information argues for conservation efforts to be directed at a larger scale, encompassing entire wetland complexes, to ensure long-term population viability.

Spotted Turtles require areas of early successional vegetative communities and the habitat heterogeneity that comes from disturbances (Litzgus and Mousseau 2004b). Gaps in forests caused by wind damage and ice storms can provide important habitats for Spotted Turtles, as can prescribed burns and mowing. Habitat use may change considerably with changes in environmental conditions, and long-term persistence of populations requires that turtles have access to areas that may only be rarely used, such as deeper water areas during drought (Litzgus and Mousseau 2004b). Beaver, a source of disturbance that returned to the Ohio landscape in the mid-20th century (Chapman 1949), can contribute to creating additional habitat and perhaps even connecting disjunct populations through the creation of dams and the resulting increase in flooded areas (Yagi and Litzgus 2012). Spotted Turtles often make large movements between wetland, nesting, summer dormancy, and overwintering sites and utilize upland habitats extensively (Joyal et al. 2001), all of which must be considered when designing conservation plans that include this species.

Conservation efforts for the Spotted Turtle in Ohio should focus on maintaining shallow water wetland complexes and surrounding upland habitats, controlling the spread of invasive species, especially those like *Phragmites* and buckthorn that choke out shallow water areas, managing for early successional habitats and heterogeneity, creating corridors to provide access to additional habitat and for gene flow, and managing populations of Raccoons and other meso-predators and their access to turtle nesting areas.

Remarks—The spatial ecology of Spotted Turtles is one of the most studied aspects of this species, fueled in part by the technological advances in radiotelemetry. In contrast, we know virtually nothing about the population dynamics of most populations in Ohio and have only a single observation for most township records. Research focusing on determining the size and demographics of populations is needed to effectively monitor Spotted Turtle populations in Ohio. Equally important is research to determine the factor(s) responsible for limiting populations sizes, so that we may ensure management strategies are effectively addressing these issues and are not simply "halfway technologies" (Frazer 1992).

Many Ohio sites occupied by Spotted Turtles are located in close proximity to one another, often in complexes of wetlands separated by an anthropogenic-dominated landscape. Determining gene flow and habitat corridors is important for understanding the relative isolation of these populations or metapopulations, predicting future population viability, and developing management strategies. Studies are also needed to understand and monitor genetic diversity, genetic drift, and the risks of inbreeding depression (Parker and Whiteman 1993; Davy and Murphy 2014; Anthonysamy et al. 2018).

Spotted Turtle Locality Records—
ASHTABULA: Andover (AMNH, CMC). Cherry Valley (CMC). Conneaut (CMNH, OSM). Geneva (CMC, CMNH). Monroe (OSM). Morgan (CMNH). Orwell (CMC). Richmond (AMNH, CMNH). **CARROLL:** Washington (Conant 1951). **CHAMPAIGN:** Johnson (DATM). Urbana (DATM, OHS, OSM, UCC, UMMZ). **CLARK:** Bethel (CMC). Harmony (OEPA). Moorefield (CMC). Pleasant (CMC). Springfield (CMC). **CUYAHOGA:** Middleburg (CMNH). Solon (CMNH). Warrensville (CMNH). **ERIE:** Margaretta (Conant 1951, OSM). **FULTON:** Swan Creek (OSM). **GEAUGA:** Bainbridge (CMNH). Burton (CMNH, FSL, OSM). Hambden (CMNH). Munson (CMC, CMNH). **GREENE:** Beaver Creek (OSM, USNM). Spring Valley (CMC). **HARDIN:** McDonald (CMC). **HENRY:** Washington (AMNH, CMC, CMNH, UMMZ). **HURON:** Peru (AMNH). **LAKE:** Madison (CMNH). Mentor (AMNH, CMNH). **LICKING:** Union (OSM, OUVC). **LOGAN:** Liberty (OSM). Richland (AMNH). **LORAIN:** Camden (OC). Russia (OC). Sheffield (OSM). **LUCAS:** Adams (AMNH). Harding (CMC, CMNH). Spencer (CMC, CMNH, UMMZ). Springfield (AMNH). Swanton (AMNH, OSM). Washington (AMNH, CMC). **MONTGOMERY:** Mad River (KU). **PORTAGE:** Aurora (CMNH). Brimfield (CMC). Streetsboro (CMC). Suffield (CMNH). **RICHLAND:** Plymouth (FSL). **ROSS:** Green (CMC, OSM). **SENECA:** Big Spring (CMNH). **SUMMIT:** Green (OSM). Northampton (CMNH). **TRUMBULL:** Kinsman (CM). Mecca (CMC). **WARREN:** Wayne (CMC). **WILLIAMS:** Florence (AMNH). **WOOD:** Grand Rapids (Conant 1951).