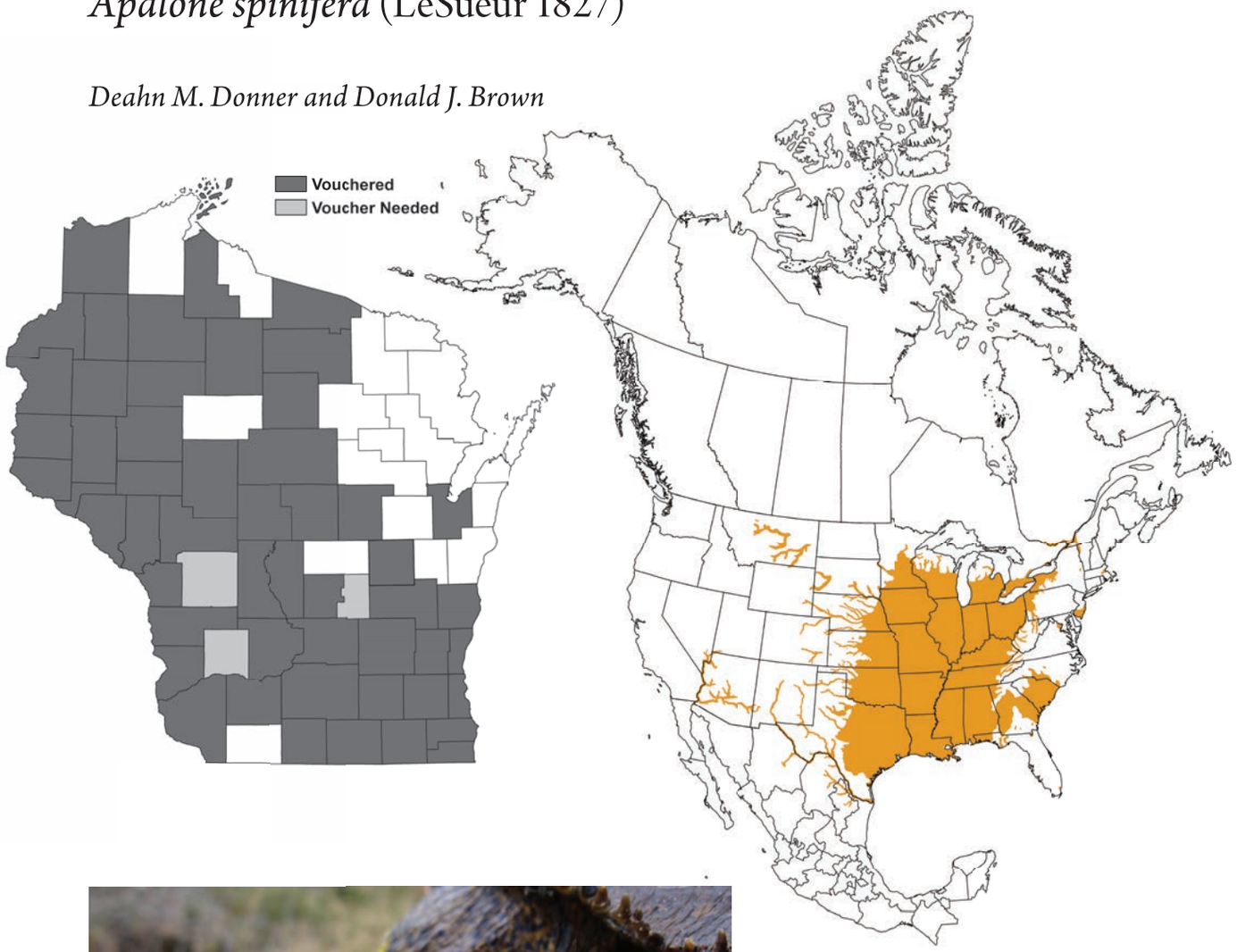
Spiny Softshell

Apalone spinifera (LeSueur 1827)

Deahn M. Donner and Donald J. Brown



Spiny Softshell (Sauk County; photo by C. Raimond).

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AT A GLANCE

The Spiny Softshell is one of two softshell turtles found in Wisconsin and is often found in the southern, western, and central portions of the state. It is a wary aquatic turtle with a narrow pointed snout, thin body, and relatively flat leathery shell. Mature females are significantly larger than males and differ in color and pattern. Spiny Softshells are active from May to October or November in Wisconsin. This species is capable of great speed both in the water and on land. It primarily eats crayfish, insects, and fishes and typically forages by crawling along the bottom of waterbodies searching for prey or by burrowing just below the surface of a soft bottom and ambushing passing prey. Spiny Softshells prefer moderate to large rivers and other large bodies of water in Wisconsin. Individuals are often found in sections of water with floating logs, which they use for basking, and with submerged trees, where they rest among the branches underwater in the evening. They move seasonally between wintering and nesting sites, sometimes traveling long distances in rivers and streams. Mating typically occurs in May, and nesting occurs in June and July. Nests are usually laid on sandy banks close to the water's edge, and hatchlings emerge from the nests in August or September. The Spiny Softshell has a reputation for aggressive behavior when handled; it will often attempt to bite and claw its captors. The species was given CITES Appendix III protection in 2016, allowing for improved regulation of international trade by requiring international exporters to have a permit. The Spiny Softshell is currently listed as a Least Concern species by the IUCN and is considered a common species by the WDNR.

SYSTEMATICS

Apalone spinifera (Spiny Softshell; Crother 2017), a member of the family Trionychidae, was historically included in the genus *Trionyx* (Webb 1962, 1990). A phylogenetic study by Meylan (1987) concluded that North American softshell turtles represented a monophyletic genus (*Apalone*), which is currently accepted (Crother 2017). There are two additional species of *Apalone*, including *A. mutica* (Smooth Softshell), which also occurs in Wisconsin, and *A. ferox* (Florida Softshell). Five subspecies of *A. spinifera* are currently recognized, with the subspecies found in Wisconsin being *A. s. spinifera* (Eastern Spiny Softshell). The remaining subspecies include *A. s. aspera* (Gulf Coast Spiny Softshell), *A. s. emoryi* (Texas Spiny Softshell), *A. s. guadalupensis* (Guadalupe Spiny Softshell), and *A. s. pallida* (Pallid Spiny Softshell). Historically, *A. s. spinifera* and *A. s. hartwegi* (Western Spiny Softshell) were considered to be distinct subspecies, with a zone of intergradation along the Mississippi River (Webb 1962). However, genetic research did not support subspecies separation of *A. s. spinifera* and *A. s. hartwegi* (McGaugh et al. 2008), and both are currently considered *A. s. spinifera* (Crother 2017).

DESCRIPTION

Adults: The carapace is flat, round, and leathery and lacks a keel. It has small conical spiny protuberances along the anterior edge (Figure 362). Females and males have distinct differences in the color and pattern of their carapace (Figure 363). The carapace of females is dark olive or tan with brown and gray mottling, and the carapace of males is olive gray with small black ocelli and is rough like sandpaper (Vogt 1981, Christoffel et al. 2002). There is a single

Figure 362. An adult Spiny Softshell female with small conical projections along the anterior edge of the carapace clearly visible. Note also the presence of numerous leeches in between these projections (Sauk County; photo by C. Raimond).

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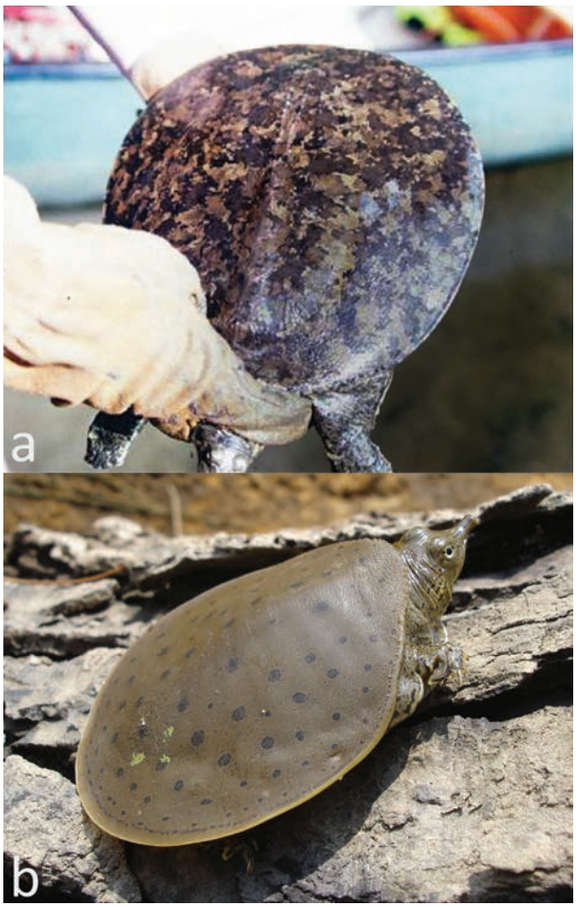

Figure 363. Carapace color and patterns typical of Spiny Softshells in Wisconsin. (a) A female displaying a mottled pattern on the carapace and neck striping (Polk County; photo by D. Donner). (b) A male displaying black ocelli and one marginal black line on the carapace (Jackson County; photo by T. Muehlfeld).

dark line interior to the side and rear margin of the carapace (Figure 363b) that distinguishes this subspecies from the others (Ernst and Lovich 2009). The plastron is small, hingeless, and a transparent white or yellow, which shows the underlying bones (Figure 364). The neck is long when extended; it can be stretched nearly as long as the carapace in small individuals (Donald Brown, West Virginia University / USFS, personal observation). The head, neck, and limbs have heavy yellow-green streaking and black spots against an olive-green background. All four feet are webbed. Two dark-bordered greenish-yellow stripes on each side of the head and neck extend backward from the eye and from the angle of the jaw (see Spiny Softshell Cover Photo). The tail of adult females has a mottled or blotched pattern and is short; the cloaca does not extend past the edge of the carapace. The tail of adult males has black spots and lines and is longer; the cloaca is near the tip of the tail, well beyond the edge of the carapace in fully grown individuals (Ernst and Lovich 2009). The nose is tubular and has a septal ridge.

Figure 364. Plastron color and patterning typical of Spiny Softshells (Polk County; photo by D. Donner). Note the transparency of the underside.

From 207 females captured along the St. Croix River in Minnesota and Wisconsin, mean MCL was 27.3 cm (10.7 in, range = 12.0–41.2 cm [4.7–16.2 in]), mean weight was 997.9 g (35.2 oz; Deahn Donner, USFS, unpublished data). From 275 males captured in the same study, mean MCL was 17.4 cm (6.9 in, range = 13.0–31.2 cm [5.1–12.3 in]), and mean weight was 226.8 g (8.0 oz; D. Donner, unpublished data). Dunson (1867) created a predictive relationship between weight and MCL in Michigan that did not appear to be affected by sex (weight [g] = 0.102 × length [cm]$^{2.95}$, $n = 34$).

Preadult stages: Eggs are smooth, white, brittle, and spherical (Figure 365). Ernst and Lovich (2009) reported that Eastern Spiny Softshell eggs range from 2.2 to 3.2 cm (0.9 to 1.3 in) in diameter ($\bar{x} = 2.7$ cm [1.1 in]) and weigh 6.7–11.9 g (0.2–0.4 oz, $\bar{x} = 10.3$ g [0.4 oz], $n = 50$). Feltz and Tamplin (2007) recorded mean egg diameter as 2.6 cm (1.0 in) from 28 eggs collected in Iowa.

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Figure 365. Spiny Softshell eggs (Chippewa County; photo by R. Sajdak).

Hatchlings and juveniles resemble adults in general shape and coloration. They also display sexual dimorphism in carapace patterns and coloration. Graham and Cobb (1998) observed that carapace spots in male hatchlings were bordered by a dark ring, while carapace spots in female hatchlings "had either an indistinct or absent ring" in Vermont. Laboratory-reared hatchlings in Wisconsin showed a similar pattern, with male carapace spots being larger and more well-defined, often bordered by a dark ring (n >20; Robert Hay, Turtles for Tomorrow, unpublished data; Figure 366). Graham and Cobb (1998) also observed that the base carapace coloration was gray in male hatchlings and brownish olive in female hatchlings. Hatchlings are small, and the mean MCL of recently hatched Wisconsin specimens in the MPM collection was 4.2 cm (1.7 in, $n = 32$).

Variation: Females attain a much larger size than males, with a maximum MCL of 54.0 cm (21.3 in), compared to 21.6 cm (8.5 in) for males (reviewed by Ernst and Lovich 2009). There is also sexual dimorphism in color and patterning (see Adults and Preadult stages subsections), but no significant geographic variation among Wisconsin populations is known.

Diagnosis: Juvenile and adult Spiny Softshells are characterized by a carapace lacking keratinized scutes and covered with leathery skin that has a texture similar to sandpaper, with the presence of spiny protuberances on the anterior edge of the carapace.

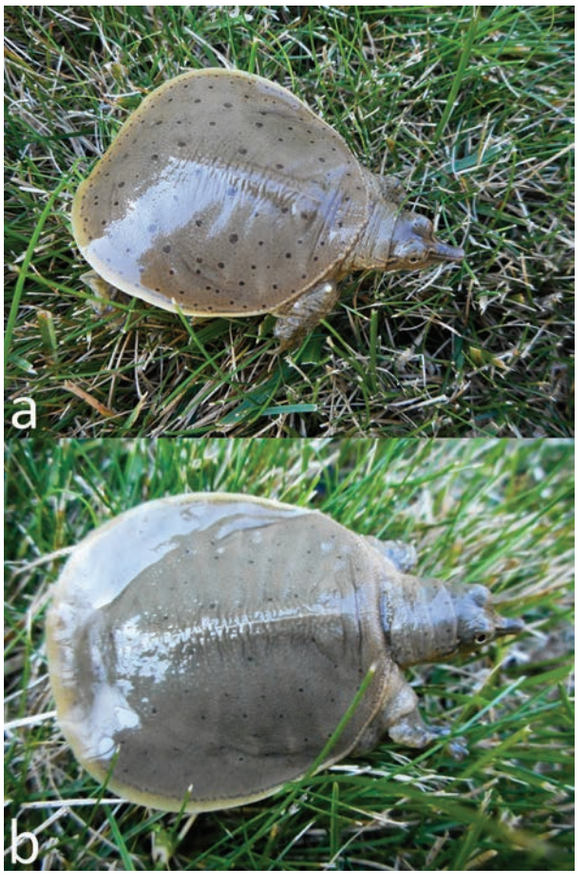

Figure 366. Carapace pattern of hatchling Spiny Softshells. (a) A male showing larger and more well-defined carapace spots with dark borders (Wisconsin; photo by R. Hay). (b) A female showing smaller and less well-defined carapace spots (Wisconsin; photo by R. Hay).

Their front feet possess three claws, two yellow-green stripes occur on each side of the head, and the nasal septum has horizontal protuberances (Figure 367).

The Smooth Softshell is the only species in Wisconsin that could be confused with the Spiny Softshell, as the other turtle species in the state all have keratinized shells. Superficially, Smooth Softshells appear similar to Spiny Softshells. However, they lack spines on the anterior border of the carapace and horizontal ridges on the nose septum. Smooth Softshells also have one black-bordered peach-colored neck stripe rather than the two black-bordered yellow-green neck stripes (see Smooth Softshell, *Apalone mutica* species account). Spiny Softshell eggs are round, similiar to the eggs of Smooth Softshells and Snapping Turtles

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Figure 367. The horizontal protuberances of the nasal septum of Spiny Softshells (Sauk County; photo by C. Raimond).

(*Chelydra serpentina*), making them difficult to distinguish when encountered in the wild. Yet these round eggs can be differentiated from the more elliptical eggs of most other Wisconsin turtles.

DISTRIBUTION AND HABITAT

Global distribution: The Spiny Softshell is the most widespread softshell species in North America, ranging from east-central Mexico to southern Quebec. In the US, it is primarily found throughout the eastern half of the country, with notable absences in southern Florida and most of the land base within ca. 400 km (250 mi) of the Atlantic Ocean in northeastern states (Ernst and Lovich 2009). In addition, this species currently occupies at least 12 isolated regions in the United States and southern Quebec (Ernst and Lovich 2009). Successful introductions have occurred in New Jersey and the Colorado River system in the western United States (Webb 1962).

Distribution in Wisconsin: County records indicate that the Spiny Softshell is primarily distributed throughout the southern, western, and central portions of the state. The species appears to be absent from numerous counties bordering Lakes Michigan and Superior and is particularly underreported in blocks of contiguous counties from the northeastern region of the state. Of the published county records, vouchers could not be found for Green Lake, Monroe, and Richland (see the Appendix), although Spiny Softshells are likely present in all of them.

Localities of possible occurrence: Several county record gaps exist for the Spiny Softshell in Wisconsin that could be filled with additional survey effort. Based on presence in surrounding counties, this species could occur in Calumet, Lafayette, Outagamie, Shawano, Taylor, and Waushara Counties (and possibly other bordering counties).

Habitat: The Spiny Softshell is a highly aquatic turtle that appears to prefer moderate-sized to large rivers with slow-moving backwater areas, but it will readily use large open lentic waterbodies and sometimes even smaller ponds, streams, and irrigation ditches (Lagler 1943, Knudsen 1957c, Vogt 1981; see Amphibians and Reptiles in Wisconsin Plant Communities chapter). Extensive webbing on both the forelimbs and hind limbs, a streamlined body shape, and physiological and morphological adaptations for life in well-oxygenated water make this species particularly suited for flowing aquatic systems (Pace et al. 2001; see Activity section). DonnerWright et al. (1999) investigated turtle relative abundance along habitat gradients in the St. Croix River in Minnesota and Wisconsin and found that Spiny Softshell relative abundance was positively associated with river depth and velocity but that the species was present across a wide range of habitat characteristics. Radiotracked individuals in the Missouri River moved from the main stem to tributaries during peak river flow periods, but it was unclear if the individuals were selecting for reduced velocity or warmer temperature (Tornabene 2014).

Some studies indicate that this species avoids locations within large lotic systems that possess the strongest currents (Williams and Christiansen 1981, Barko and Briggler 2006). For example, in the upper Mississippi River near Minnesota and Wisconsin, Spiny Softshells were commonly found in slower-moving open backwater habitats adjacent to the main channel (Cochran 1977, Tucker et al. 2008). Several studies have further determined that individuals often used tributaries and closed side channels adjacent to the

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Figure 368. Example of a sandy bank used commonly for nesting and basking by Spiny Softshells in Wisconsin (Polk County; photo by D. Donner).

main channels of the middle Mississippi River in Missouri and Illinois (Barko and Briggler 2006, Braun and Phelps 2016). Spiny Softshells typically nest on open sandbars or shorelines (Webb 1962; Figure 368).

Spiny Softshells are frequently found in aquatic systems with ample woody debris, including submerged or floating logs (Williams and Christiansen 1981, Ernst and Lovich 2009). Rizkalla and Swihart (2006) determined that relative abundances were positively associated with number of woody stems and wetland proximity in an agriculture-dominated landscape of Indiana. Despite an association with woody debris and vegetation, Spiny Softshells may avoid areas with dense stands of emergent plant species (Vogt 1981). They further appear to prefer waterbodies with soft bottoms composed of sand, silt, or mud, as they spend much of their time underwater buried in the sediment (Plummer and Burnley 1997, Plummer et al. 1997, Tornabene 2014). For example, in Lake Champlain (Quebec, Canada, and Vermont, United States), this species spent most of its time immobile and underwater (86.5% and 73.5% of time for males and females, respectively; Galois et al. 2002). Whether the turtles are submerged or not, microhabitat selection is likely influenced by environmental temperatures and thermoregulatory needs (Tornabene 2014). Spiny Softshells typically overwinter in the sediment of well-oxygenated waterbodies (see Activity section).

REPRODUCTION AND DEVELOPMENT

Mating in Wisconsin typically occurs in May following emergence from winter dormancy (Vogt 1981). During this period, males actively search for females in the water and at basking sites. Ernst and Lovich (2009) summarized mating behavior of Smooth Softshells and indicated that Spiny Softshell mating behavior was similar. According to Ernst and Lovich (2009), to gauge whether or not a female is receptive to mating, a male will probe under the edge of her carapace with his snout. If the female is not receptive, she may turn and bite the male. In water, receptive females remain passive as males mount them. On land, receptive females may move to the water followed by several males or may chase after a single male to initiate mating. Copulation occurs at the bottom of the waterbody and typically lasts ≥30 minutes.

According to Vogt (1981), nesting occurs in June and July in Wisconsin, consistent with observations in Quebec (Daigle et al. 2002, Galois et al. 2002, Lazure et al. 2019) and Tennessee (Robinson

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Figure 369. An example of the flask-shaped nest with eggs deposited by a female Spiny Softshell (Chippewa County; photo by R. Sajdak).

and Murphy 1978). According to Ernst and Lovich (2009), nesting activity can extend to August in some regions. Individuals rarely make long-distance movements over land for any purpose, including egg deposition (Plummer et al. 1997). As such, nests are usually located within ca. 3 m (10 ft) of water but can be as far as 100 m (328 ft) and placed in sandy or (less frequently) clay-loam soil (Vogt 1981, Daigle et al. 2002, Moler 2006, Bolton and Brooks 2010). Females dig nests in late afternoon or early evening using their hind feet, and they often void their bladder water to help soften the soil for excavation (reviewed by Ernst and Lovich 2009). In Quebec, a female completed the nesting process in less than an hour (Daigle et al. 2002). Females deposit 3–39 eggs ($\bar{x} = 17.9$, $n = 82$) in a flask-shaped nest that is 10–25 cm (3.9–9.8 in) deep, with a 2.5–7.5 cm (1.0–3.0 in) neck, and an egg chamber 7.5–12.5 cm (3.0–4.9 in) wide (Figure 369; Ernst and Lovich 2009). According to Ernst and Lovich (2009), Spiny Softshells commonly lay two and sometimes three clutches each year, but to our knowledge females laying three clutches per year has not been documented in Wisconsin.

Hatchlings typically emerge in August or September after an incubation period of 55–85 days (Vogt 1981). The latest reported emergence date in Wisconsin occurred on 25 November 2016, when ≥12 hatchlings emerged from a single nest in Washburn County (Damian Vraniak, private landowner, personal observation). Sex is determined genetically (Vogt and Bull 1982, Greenbaum and Carr 2001), and hatchling sex ratio was ca. 1M:1F in a laboratory investigation using eggs collected in Vernon County (Vogt and Bull 1982). Breckenridge (1955) estimated size-based growth rates for a Spiny Softshell population in Minnesota. For both males and females, annual MCL growth decreased as MCL increased. For females, annual MCL growth was ca. 3.5 cm (1.4 in) when MCL was ca. 8 cm (3 in) and decreased to ca. 0.7 cm (0.3 in) when MCL was ca. 28 cm (11 in). For males, annual MCL growth was ca. 1.5 cm (0.6 in) when MCL was ca. 13 cm (5 in) and decreased to ca. 0.25 cm (0.1 in) when MCL was ca. 18 cm (7 in). Plummer and Mills (2015) also found that hatchling and young juvenile growth was rapid but slowed as body size increased, with male growth rates slowing at a younger age than female growth rates. Females and males typically reach sexual maturity at a PL of 18–20 cm (7.1–7.9 in) and 8–10 cm (3.1–3.9 in), respectively (reviewed by Ernst and Lovich 2009). In Arkansas, females matured at 12–13 years of age, while males matured at 4–5 years of age (Plummer and Mills 2015). Longevity in the wild is unknown, but a female Spiny Softshell lived to be 25 years old at the Racine Zoo (Snider and Bowler 1992).

ACTIVITY

In Wisconsin, Spiny Softshells become active in May (Vogt 1981). According to Ernst and Lovich (2009), adults are active earlier in spring than juveniles. In Minnesota, activity was highest from June to August, with moderate activity in May and September and very low activity in April and October (Schneider et al. 2019). Diel activity is primarily diurnal, although nocturnal activity has been reported (Lagler 1954, Wade and Gifford 1964, Schneider et al. 2019). Galois et al. (2002) observed activity patterns in Lake Champlain (Quebec, Canada, and Vermont, United States) between April and November between 1996

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Figure 370. Female Spiny Softshell basking near the shoreline (Burnett County; photo by E. Wild).

and 1999. They found that while active, individuals frequently remained submerged, and ca. 6% and 13% of male and female time was spent basking out of the water, respectively. Basking primarily occurs in the afternoon, and locations with preferred thermal properties are targeted for this behavior (Smith and Iverson 2004; Figure 370). Galois et al. (2002) observed this species basking primarily on shorelines (56%), followed by logs (20%), rocks (14%), and floating vegetation (10%). The body temperature of Spiny Softshells in Arkansas ranged from 19.9°C to 29.3°C (67.8°F to 84.7°F), depending on turtle behavior (e.g., buried in sediments, swimming, or basking; Plummer et al. 2005). Graham and Graham (1991) found that water temperature near Spiny Softshell burial locations was up to 30.5°C (86.9°F), while mean water temperature at other sample locations was 22°C (71.6°F). Feltz and Tamplin (2007) performed a thermal-selection lab experiment with juvenile Spiny Softshells in Iowa. They found that individuals preferred the warmest temperature available (30°C [86°F], gradient = 15°C–30°C [59°F–86°F]).

In Lake Champlain (Vermont and Quebec, Canada), annual home range was significantly larger for females (3,206 ha [7,922 ac], $n = 11$) than for males (275 ha [680 ac], $n = 4$; Galois et al. 2002). In a stream system in Arkansas, mean linear home ranges for females and males were 1.8 km (1.1 mi, $n = 9$) and 1.4 km (0.9 mi, $n = 7$), respectively (Plummer et al. 1997). In Montana, mean linear home range size did not differ between females and males, but female movement rates were greater than male movement rates (Tornabene et al. 2017). Homing behavior was displayed by five individuals from Michigan after being released 25–45 km (16–28 mi) from their point of capture (Otten and VanDeWalle 2014). Spiny Softshells sometimes undertake long bouts of movement seasonally during migration to nesting sites or overwintering locations. Daigle et al. (2002) documented a female in the Lake Champlain region that moved 7 km (4.3 mi) upstream in three days to nest. Daily activity patterns recorded during this movement included basking and short-distance movements in the morning, long-distance movements in the afternoon, and short-distance movements during the evening. These same activity patterns were exhibited by three females on the Lamoille River in Vermont, but much smaller distances were traveled to reach their overwintering site (3–4 km [1.9–2.5 mi]; Graham and Graham 1997). In a small stream in Arkansas, ten individuals of both sexes made long-distance movements of >0.90 km/day (0.56 mi/day) and returned within a few days to the original point of capture (Plummer et al. 1997).

Galois et al. (2002) found that Spiny Softshells entered hibernation beginning in mid-September in Vermont. In contrast, individuals in Arkansas were active until November (Plummer and Burnley 1997). Spiny Softshells will move to well-oxygenated water to hibernate (Galois et al. 2002, Ultsch 2006), as they are intolerant of anoxic conditions (Reese et al. 2003). However, when they are in water that is adequately aerated, they can remain completely submerged and rely on uptake of oxygen across the skin for extended periods of time (Jackson et al. 2001). This is facilitated in part by the nature of their 'soft' shells, which allows for O_2/CO_2 exchange with their surroundings and creates a large surface area across which this exchange can occur (Stone et al. 1992, Stone and Iverson 1999). Spiny Softshells are also capable of cloacal respiration via water moving over the cloacal tissues, as well as buccopharyngeal respiration, during which they suck water into their mouth and push it out through the nostrils while submerged (Dunson 1960). As the water passes over the delicate cloacal or oral tissues, oxygen is extracted into the blood, allowing Spiny Softshells to remain underwater for extended periods if aquatic oxygen

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levels are adequate (Dunson 1960, reviewed by Ultsch 2006). During hibernation, Spiny Softshells bury themselves under the water in sediment, most often mud (reviewed by Ultsch 2006). In Arkansas, individuals buried themselves an average of 4.8 cm (1.9 in, $n = 14$; Plummer and Burnley 1997). Tornabene et al. (2017) reported that hibernation locations differed by a mean of 1.70 km (1.06 mi, range = <0.05–25.90 km [0.03–16.09 mi], $n = 41$) between years in Montana, with 46% of individuals hibernating within 0.05 km (0.03 mi).

PREY AND PREDATORS

Spiny Softshells are diurnal foragers that actively search for prey using visual cues, with olfactory cues used secondarily (Webb 1962). Direct observations showed that individuals crawl or swim along the bottom and use their snout to explore under stones or masses of aquatic vegetation, usually swallowing their prey whole rather than tearing off pieces (Webb 1962, Herrel et al. 2002). Spiny Softshells also reportedly burrow just below the surface of soft aquatic sediments in shallow water and wait to ambush passing prey (Breckenridge 1944, Webb 1962). Spiny Softshells are primarily carnivorous but are considered generalists because of the wide variety of prey consumed (Cochran and McConville 1983). Plant material is often incidentally ingested (Williams and Christiansen 1981). Most diet studies for this species have been conducted in riverine systems, primarily the upper Mississippi River and several rivers in Michigan. These studies found that Spiny Softshell diets consisted largely of crayfish, aquatic insect nymphs and larvae, and fishes (Lagler 1943, Breckenridge 1944, Cochran 1977). However, individuals also prey on earthworms, snails, clams, amphibians, carrion, and small snakes (Cahn 1937, Anderson 1965, Williams and Christiansen 1981, Jensen 1998). Cochran and McConville (1983) reported that male stomachs contained mostly dragonfly naiads, while female stomachs contained mostly fish remains, with no differences between sexes for crayfish consumption, based on 28 turtles collected from backwaters of the upper Mississippi River in Minnesota. Knudsen (1957c) observed a Spiny Softshell on land consuming a young Killdeer (*Charadrius vociferus*) it had just captured.

Spiny Softshells are likely most vulnerable to predation when in the egg and juvenile stages. In the lower Wisconsin River, Raccoons (*Procyon lotor*) were the primary predators at nesting sites (92%, $n = 561$), followed by Striped Skunks (*Mephitis mephitis*), Virginia Opossums (*Didelphis virginiana*), and Coyotes (*Canis latrans*; Geller 2012c). Hatchlings and juveniles are also eaten by large fishes, other turtles, snakes, wading birds, and mammals (Webb 1962). As adults, this species' best defense could be its ability to escape predators. Spiny Softshells not only are rapid swimmers but also can move extremely quickly on land (D. Brown, personal observation). In addition, Spiny Softshells can quickly bury themselves in aquatic substrates by plunging headfirst into soft sediments and 'shimmying' back and forth so sand or muck settles on top of the carapace (Graham and Graham 1991). Spiny Softshells are aggressive when captured and readily strike with their long neck and sharp beak (Natural History Box: The "Pugnacious" Turtle). Despite their speed and aggressiveness, predation of adults does occur. Watermolen (2004) documented 36 softshell turtle shells in a single Bald Eagle (*Haliaeetus leucocephalus*) nest in southeastern Wisconsin. American Alligators (*Alligator mississippiensis*) could be important predators of adults in the southern portion of their distribution (Ernst and Lovich 2009; also see Aresco 2009).

CONSERVATION

Status: Globally, the Spiny Softshell is listed as a Least Concern species by the IUCN. It is considered a common species in Wisconsin by the WDNR. In response to continued exploitation for the international turtle trade, the species was given CITES Appendix III protection in 2016, allowing for improved regulation of international trade by requiring international exporters to have a permit.

Populations: No studies exist that have rigorously investigated Spiny Softshell population dynamics in Wisconsin. Furthermore, throughout the Spiny Softshell's range, reported estimates of basic population parameters, such as density, are rare. Dreslik et al. (2005) reported a mean density of 0.39/ha (0.96/ac)

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NATURAL HISTORY BOX: The "Pugnacious" Turtle

"Spiny softshells are very pugnacious, readily offering to inflict injury with their sharp beaks. Their agility and long necks pose a definite problem in holding one safely. I have found a firm hold between the anterior portion of the hind leg sockets: by inserting thumb in one side and forefinger in the other you can restrain a very large turtle and keep out of reach of the snapping beak. If not careful, however, you are left at the mercy of the thrashing claws. The only serious bite I have received from a turtle came from a large female spiny softshell. I had climbed inside the hoops of a large fyke net and grasped the turtle in the manner described. After handing it to my assistants at the opening of the net, I bent down again to readjust the bait. Simultaneously, I felt a sharp pain in my lower leg and heard my assistants saying, 'We dropped the turtle!' I removed the turtle from my leg and again dispensed it to my assistants, but this time I didn't turn around until the turtle was out of the net!"

Excerpt from Vogt (1981)

over six years of surveys in a 30 ha (74 ac) lentic system in Illinois, although this estimate was based on few captures. Some information can be extrapolated from studies that reported Spiny Softshell captures relative to other turtle species. For example, this species was among the most frequently captured species from 1992 to 1995 along the Mississippi River near Minnesota and Wisconsin (>300 captures of >1,900 total turtle captures across seven species; Tucker et al. 2008). Spiny Softshells were also the most frequently captured species from 1994 to 1995 along the St. Croix River in Minnesota and Wisconsin (47% of 1,369 total captures across seven species; DonnerWright et al. 1999). Statistically unbiased adult sex ratios have been reported in many studies across the species' distribution (reviewed by Ernst and Lovich 2009). However, DonnerWright et al. (1999) found adult sex ratios at 12 sites in the St. Croix River in Minnesota and Wisconsin varied from 0.36M:1F to 4.05M:1F (total $n = 448$, site-level $n = 13–96$), and 8% of captures in the study were juveniles. In addition, Barko and Briggler (2006) found that sex ratios skewed toward females (1M:2F, $n = 55$) in the middle Mississippi River in Illinois. Survival rates reportedly increased as individuals matured in an Arkansas population, with an average adult and juvenile annual survival of 0.84 and 0.72, respectively (Plummer et al. 2008).

Threats: Many general threats to lotic aquatic systems likely apply to Spiny Softshells, such as habitat loss, pollution, eutrophication, and proliferation of invasive species (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). River alterations due to dams, pollution, or a change in water flow regimes that impede or restrict movement can result in habitat fragmentation for Spiny Softshells (Shively and Jackson 1985, Dodd 1990, DonnerWright et al. 1999). Control of water levels in lotic aquatic systems that limits the availability of open sandbars or open sandy beaches required for thermoregulation and nesting likely impacts this species. The influence of aquatic pollution could also have serious but largely unknown effects on Spiny Softshell populations. Intolerance of anoxic conditions, for example, makes Spiny Softshells inherently vulnerable to aquatic eutrophication (Jackson et al. 2000, Ultsch 2006). Van Dyke et al. (2013) also found higher concentrations of bioaccumulated heavy metals, such as selenium, in Spiny Softshells than in other turtle species at disturbed sites in Tennessee. Impacts due to human recreation in aquatic systems are also documented, as Galois and Ouellet (2007) reported injuries and mortality due to boat propellers and fishing equipment in Lake Champlain.

Egg predators such as Raccoons can be problematic in areas where their population densities are particularly high and lead to excessive predation of turtle nests. Dieter et al. (2014) recorded 180 "softshell species" nests that were destroyed by predators

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along the Missouri River over two nesting seasons, which was greater than the nest mortality observed for other turtles. Bolton and Brooks (2010) found that in Ontario, Canada, the presence of the Common Reed (*Phragmites australis*), an exotic invasive species also found throughout Wisconsin, negatively impacted the hatching success of Spiny Softshells. The rapid growth of Common Reed shaded out some of the nests, and the root system grew through the nests, causing nests to either fail or produce fewer hatchlings.

The full impact of accidental or intentional human harvest of Spiny Softshells is largely unknown in Wisconsin. However, Barko et al. (2004) summarized incidental turtle captures along the Mississippi River adjacent to southern Illinois as part of fish surveys for the Upper Mississippi River Restoration (UMRR) Long Term Resource Monitoring (LTRM) program. During this study, 36% of captured Spiny Softshells accidentally died in survey nets from 1996 to 2001. If similar mortality rates occur in commercial fishing operations, the overall impacts to Spiny Softshell populations could be substantial, but further investigation is necessary. Zimmer-Shaffer et al. (2014) performed a demographic modeling study for softshell (i.e., Spiny Softshell and Smooth Softshell) harvest in Missouri and found that no field-estimated harvest levels were sustainable using mean demographic values from the literature. Furthermore, estimated proportion of individuals taken at three sites through a mock harvest were 0.062, 0.219, and 0.792, respectively (Shaffer et al. 2017). The life-history characteristics of turtles (naturally low recruitment but high adult survival and delayed sexual maturity) make them difficult to manage as a game species, and probable harvest impacts on populations have been found in several studies (Warwick et al. 1990, Close and Seigel 1997, Gamble and Simons 2004, Brown et al. 2011a).

Management: Many general concepts associated with management of flowing aquatic ecosystems likely apply to this species, such as control of erosion, pollution, and problematic native or invasive species (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). Spiny Softshells appear to be fairly tolerant of structural modifications to their aquatic and surrounding terrestrial habitats (VanDeWalle 1993, Rizkalla and Swihart 2006, Plummer and Mills 2008). However, maintaining aquatic connectivity among different landscape features used by Spiny Softshells (e.g., hibernacula and nesting sites) is important, given that they rarely use terrestrial habitat as movement corridors (Plummer et al. 1997, Galois et al. 2002). Adopting aquatic resource management strategies for large rivers that encourage variable flow rates and variation in depths at appropriate times of year (to maintain open sandbars for thermoregulation and nesting) is likely critical to the persistence of many riverine turtle populations (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter). In addition, although Spiny Softshells can inhabit eutrophic environments during their active months, well-oxygenated areas must be accessible for winter hibernation (reviewed by Ultsch 2006).

Habitat management through control of invasive aquatic plants could be beneficial for Spiny Softshell conservation but difficult to achieve. Often, aquatic plants are controlled through application of herbicides, the effects of which are largely unknown for reptiles. Laboratory studies have found that herbicides (i.e., diquat and potassium endothall) used to control invasive aquatic plants such as Eurasian watermilfoil (*Myriophyllum spicatum*) do not have observable toxic effects on Spiny Softshells after short-term exposure (Paul and Simonin 2007). Despite this result, further research is necessary to assess possible sublethal impacts due to long-term exposure to biocides before these chemicals can be deemed safe for Spiny Softshells.

Possible impacts of accidental and intentional harvest can be mitigated through adherence to state regulations on such activities and use of commercial fishing equipment that excludes turtles (e.g., Barko et al. 2004). It is currently legal to harvest Spiny Softshells in Wisconsin between 15 July and 30 November (WDNR 2015a). The current harvest regulations include a possession limit of five individuals on the Mississippi River and three individuals in the remaining waterbodies of Wisconsin. It is illegal to sell any live native species of turtle in Wisconsin (see Introduction to Conservation and Management of Wisconsin's Amphibians and Reptiles chapter).

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