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Cases of freeze-dried freshwater turtles at the northern limit of their ranges in southern Ontario

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Abstract

Turtles in northern latitudes are at the limit of their ranges and display various strategies for surviving the winter, including moving under the ice and out of water. Anthropogenic disturbances are often at the root of local habitat changes that can cause turtles to move from underwater refugia onto land, sometimes resulting in freezing and death. Turtles may also leave the water under natural freeze–thaw cycles, with early exits potentially maladaptive and lethal. We document cases of freshwater turtles freezing out of water at all life stages. We give a brief description of the circumstances surrounding the discovery of freeze-dried carcasses and highlight some of the climatic challenges facing overwintering turtles in southern Ontario.

Key words: Brumation; winter; turtle; freeze–thaw cycle; Ontario; wetlands; anthropogenic disturbances

Introduction

Freshwater turtles in Ontario are near or at the northernmost limit of their ranges (Rhodin *et al.* 2021) and face a variety of difficult environmental conditions including shortened active season (Obbard and Brooks 1981) and a prolonged brumation, sometimes more than half their lives (Litzgus *et al.* 1999). All turtles are ectothermic and, therefore, rely on the environment to maintain body temperature. Overwintering turtles face two main threats: freezing and hypoxia, with resulting lactic acidosis (St. Clair and Gregory 1990; Ultsch 2006). Lactic acidosis is brought on by spending time under severely hypoxic conditions and switching to anaerobic metabolism. Turtles can avoid hypoxia and acidosis by selecting overwintering sites that are well oxygenated, by storing lactate in their skeletons (Jackson 2000), and by greatly reducing their metabolism.

Turtles in northern areas lay eggs in early summer, and the eggs hatch later that summer or early fall. Hatchlings of some species leave the nest to overwinter in water while others display delayed emergence, remaining in the nest cavity for their first winter and emerging the following spring. (For a comprehensive review of hatchling overwintering strategies see Costanzo *et al.* 2008.) Hatchlings are the age class most at risk from all types of mortality, with the risk of winter mortality by freezing and desiccation the greatest threat at northern latitudes (Iverson 1991).

Turtles in the northern latitudes use various overwintering strategies to avoid freezing and seek out aquatic hibernacula in water depths where the temperature will remain above 0°C. (See Ultsch 2006 for a comprehensive review of the ecology of overwintering in turtles.) Turtles that survive at these northern limits have behavioural and physiological adaptations, such as seeking near-freezing water to reduce metabolism (Edge *et al.* 2009) and, depending on the species, tolerating potentially severely hypoxic or anoxic water found under ice or in mud. Northern populations of Midland Painted Turtle (*Chrysemys picta marginata*; Reese *et al.* 2000; Jackson 2002) and Snapping Turtle (*Chelydra serpentina*; Reese *et al.* 2002) are the most tolerant of anoxia, more so than their southern conspecifics (Ultsch *et al.* 1985). Spotted Turtle (*Clemmys guttata*; Litzgus *et al.* 1999) and Blanding's Turtle (*Emydoidea blandingii*; Edge *et al.* 2009; Thiel and Wilder 2010) may also be anoxia tolerant while other turtles are less tolerant of anoxia. For example, Northern Map Turtle (*Graptemys geographica*), Eastern Spiny Softshell (*Apalone spinifera spinifera*), and Eastern Musk Turtle (*Sternotherus odoratus*; Reese

et al. 2001, 2003; Ultsch and Cochran 1994, respectively) cannot survive more than 45 days in anoxic waters at 3°C and must choose well-oxygenated hibernacula. In Ontario, Wood Turtle (*Glyptemys insculpta*) overwinters in well oxygenated shallow rivers where the water temperature is near freezing (Greaves and Litzgus 2007).

It is difficult to estimate how many turtles die annually by winterkill, but large mortality events are not uncommon. Ultsch (2006) reported an incident in Illinois where hundreds of turtles (consisting of Blanding's, Painted, and Snapping Turtles) and thousands of fish died (presumably by suffocation) in a winter when heavy snow and a thick layer of ice covered a wetland. Christiansen and Bickham (1989) reported a winterkill event caused by natural droughts where a shallow lake froze completely, from top to bottom, killing 186 turtles of five species. Bodie and Semlitsch (2000) describe 144 turtles dying over winter in dried wetlands and Seburn *et al.* (2021) report 25 Painted Turtles dying over the course of two winters in an artificial pond with a maximum depth of 1.7 m.

Almost all Ontario turtle species have been reported to be sporadically active under the ice: Snapping Turtle (Brown and Brooks 1994), Painted Turtle (Taylor and Nol 1989), Northern Map Turtle (Graham and Graham 1992), Wood Turtle (Greaves and Litzgus 2007), Blanding's Turtle (Newton and Herman 2009), and Eastern Spiny Softshell (Galois *et al.* 2002). This activity may be related to their seeking air-breathing opportunities in times of ice melt (Meeks and Ultsch 1990), seeking well oxygenated areas of a wetland, or maintaining an optimal water depth (Greaves and Litzgus 2008). Turtles may also relocate if local conditions change. In a study of overwintering Snapping Turtles in a managed wetland in Toronto, Ontario, a sudden drop in the water level for beaver dam management in late November caused turtles that had already entered brumation to reawaken and move to deeper areas (Dupuis-Desormeaux *et al.* 2018).

During the winter, air temperature can increase to well above freezing and then drop back to below zero in the evenings. These freeze–thaw cycles are frequent in southern Ontario (Ho and Gough 2006) and, combined with local micro-habitat features (e.g., hills, large boulders) that can reflect and concentrate the sun's radiation, can cause some areas of a wetland to become temporarily ice-free. These short-term air temperature changes and sunny conditions combined with specific habitat features can create false spring-like weather that might be enough to lure turtles out of water. Snapping Turtles at a study site in Toronto selected overwintering sites that were close to wetland edges (Dupuis-Desormeaux *et al.* 2018), thus giving them early access to any edge thawing. Limitrophe overwintering locations permit short distance forays to the edge of the wetlands for opportunistic air breathing (Meeks and Ultsch 1990; Brown and Brooks 1994). Bolder turtles might even move onto land or the ice to sun themselves. Although this strategy can have some benefits, such as access to more oxygen and increased body temperature from the warmth, it also involves risks, especially if the turtle does not return to safety before the air temperature drops below freezing. Adult freshwater turtles do not tolerate freezing and will die if frozen (Ultsch 2006). The behavioural impetus to exit the water and take advantage of a warm sunny winter day can, therefore, prove maladaptive in northern latitudes and lead to severe injury or death.

As field biologists in southern Ontario, we have come across freeze-dried adult, juvenile, and hatchling turtle carcasses. The intent of this short communication is to document our observations and consider some of the perilous winter conditions experienced by turtles at the northern limits of their ranges.

Methods

The cases presented below are a combination of our personal discoveries and a sample from turtles brought to the Ontario Turtle Conservation Centre, Selwyn, Ontario, home of the Kawartha Turtle Trauma Centre (KTTC). Cases of lethargic or wandering turtles brought in during the winter are rare but not uncommon.

Results and Discussion

During 2016–2020, 17 turtles of various ages (nine adults, two juveniles, five hatchlings, and one undetermined) of three species (Midland Painted, Snapping, and Northern Map) were admitted from various parts of Ontario (including Waterloo, Lindsay, Collingwood, Plympton-Wyoming, Oshawa, and MacTier). Of 4896 admissions at the hospital, these 17 (0.3%) had severe frost injuries or were dead from freezing. Frost injuries and death by freezing was determined by S.J.C., a veterinarian, based on clinical presentation of necrotic tissue. Most of these turtles were found on the snow, on ice, or frozen on beaches or pathways near wetlands. We suspect the small number of admittances probably underestimates the number of turtles that are found frozen and dead because most people would not bother driving a dead turtle to the KTTC.

We present the cases in two broad categories: turtles frozen out of water and hatchlings freezing inside the nest cavity.

Turtles frozen out of water

Case 1—An adult male Snapping Turtle (Figure 1a) was found stuck in the ice near Peterborough,

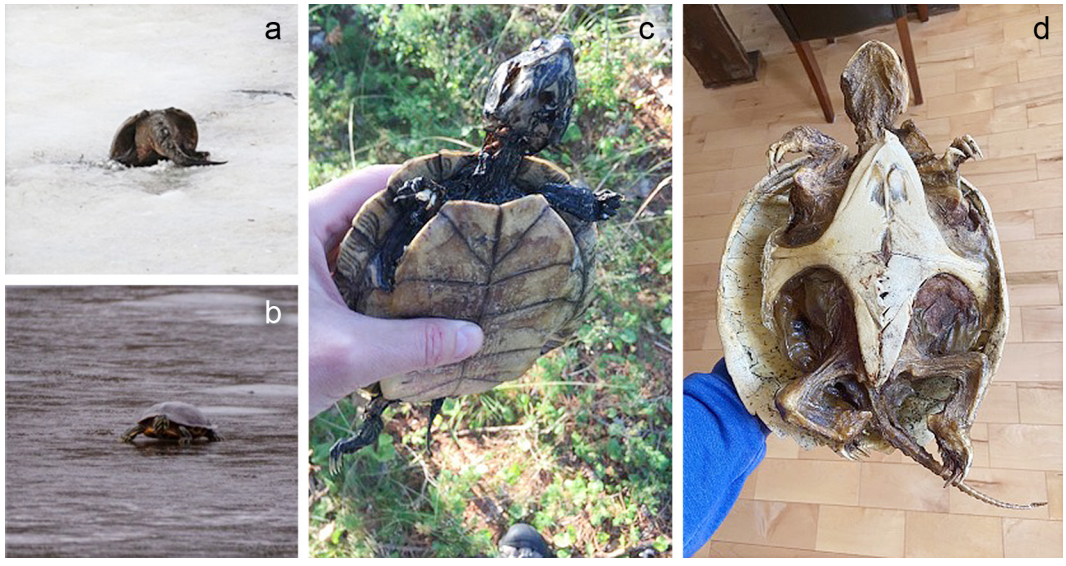

FIGURE 1. Examples of adult turtles frozen out of water: a. male Snapping Turtle (*Chelydra serpentina*), b. female Red-eared Slider (*Trachemys scripta elegans*), c. female Northern Map Turtle (*Graptemys geographica*), and d. female Snapping Turtle. Photo a: S.J.C. Photo b: I. Drury. Photo c: M.D.D. Photo d: S.G.

Ontario. A passerby alerted the KTTC, and a volunteer went out on the ice to rescue the stranded, live turtle.

Case 2—An adult female Red-eared Slider (*Trachemys scripta elegans*; Figure 1b) was spotted by a photographer on the ice in the middle of Heart Lake in Brampton, Ontario, in January. Firefighters rescued it and sent her to KTTC with signs of necrotic tissue on her extremities. This species is not native to Ontario and is present in many urban wetlands as a result of pet releases (Seburn 2015).

Case 3—A mummified female adult Northern Map turtle (Figure 1c) was discovered desiccated on land in early July on an island in Stony Lake, Douro-Drummond municipality, Ontario, with no signs of predation. The cause of death was not evident, and it is uncertain when the death occurred. Its outstretched neck and hind leg are typical of basking.

Case 4—A freeze-dried adult female Snapping Turtle (Figure 1d) was collected at a southern Ontario wetland near London that is subject to annual winter dewatering. It is uncertain whether the death was a result of the dewatering or poor choice of overwintering site.

Case 5—An adult Spotted Turtle (Figure 2a) was collected after overwintering in a shallow wetland, where water receded quickly during the winter. Bilateral corneal opacity was observed along with necrotic tissue around the eyes, consistent with freeze damage previously observed by S.G. in both captive and wild turtles. In this case, keeping the turtle in a clean, warm enclosure allowed time for the eyes to heal and vision returned. This was a recaptured turtle of a known population with no known health issues the previous season.

Case 6—A subadult Midland Painted Turtle (Figure 2b) was found in southern Ontario in early March, apparently frozen and desiccated. The reservoir along the Thames River where this turtle was found is partly dewatered each fall, reducing the extent of appropriate overwintering habitat.

Case 7—A juvenile male Eastern Spiny Softshell Turtle (Figure 2c) was found in the floodplain of the Thames River, apparently trapped on land after a significant mid-winter flooding event. Water eventually receded leaving multiple fish and this turtle on land to freeze and desiccate.

Case 8—An adult male Eastern Spiny Softshell (Figure 2d) was found in an oxbow lake along the Thames River, likely trapped when river levels swelled and then receded during the winter after a storm event. The oxbow section became isolated from the river, and we assume oxygen levels dropped, eventually leading to a series of events that caused mortality and freezing/desiccation.

Overwintering in nest

Case 9—Snapping Turtle hatchlings typically emerge from the nest to overwinter in water and do not overwinter successfully in the nest (M.D.D. unpubl. data; S.G. pers. obs.). For example, Obbard and Brooks (1981) found only 0.8% (1/129 clutches) successfully overwintered in the nest with 60% (16/27)

Figure 2. a. Live adult Spotted Turtle (*Clemmys guttata*) with freeze damage in and around its eye. b. Freeze-dried subadult Midland Painted Turtle (*Chrysemys picta marginata*). c. Freeze-dried juvenile Eastern Spiny Softshell (*Apalone spinifera spinifera*). d. Freeze-dried adult male Eastern Spiny Softshell. Photos: S.G.

of the hatchlings surviving overwinter. A predator-excavated nest containing 25 freeze-dried Snapping Turtle eggs (some close to if not hatched) was discovered at Tommy Thompson Park, Toronto, Ontario, in early August (Figure 3a). The nest was discovered after a predator partly excavated it. We suspect that the substrate above the nest might have become compacted by a vehicle (there were deep tire marks over the nest), thus making emergence after hatching impossible and dooming the eggs and hatchlings to freeze and desiccate over winter in the nest. Dozens of predated turtle nests are discovered at this location annually (M.D.-D. pers. obs.), but this was the only nest found with desiccated eggs and hatchlings.

Cases 10–13—Over a 23-year period along a stretch of the Thames River in southern Ontario, four Snapping Turtle nests were discovered that showed apparent failure because of freezing. Although over 50 successful Snapping Turtle nests were monitored during the same time at the site (S.G. pers. obs.), all of which hatched in late summer and early fall, the four nests in question were discovered in May and early June, approximately a year after the eggs were laid. Two of the nests contained fully developed hatchlings outside the egg (Figure 3b) that had died inside the nest chamber. Two additional nests were found with a small number of living hatchlings, all too weak to emerge and with what appeared to be necrotic tissue on the skin and eyes consistent with freeze damage. The turtles were slowly warmed up and kept in captivity for a short period, but all died soon after discovery.

Case 14—One of dozens of Eastern Spiny Softshell nests found along a stretch of the Thames River in southern Ontario appeared to have been frozen during the winter, with dead/desiccated but fully developed hatchlings (Figure 3c) outside the egg but in the nest chamber. Eastern Spiny Softshell Turtles are not known to survive freezing in the nest chamber (Tornabene *et al.* 2018), and a late clutch of eggs may have resulted in too few days of appropriate heat for hatching and emergence before winter.

Case 15—A Midland Painted Turtle nest found in a backyard garden in London, Ontario, in early April had fully formed dead/desiccated hatchlings, outside the egg (Figure 4a) but still in the nest chamber. Although hatchling Midland Painted Turtles usually successfully overwinter within the nest chamber (Ultsch 2006), these individuals apparently succumbed to the elements.

Cases 16 and 17—Two Northern Map Turtle nests were found along the north shore of Lake Erie in southern Ontario in June with dead hatchlings outside the egg (Figure 4b), but in the nest chamber. The shallow nests were along the edge of an eroded dune, and it is likely that wind erosion reduced the thickness of the substrate layer above the nest the previous year, lessening protection from exceptionally cold temperatures. Although Northern Map Turtle hatchlings can successfully survive freezing in the nest chamber, it is likely that many still succumb to environmental conditions that cause dehydration (Baker *et al.* 2003).

Case 18—A Blanding's Turtle nest was discovered along an eroded dune on the north shore of Lake

FIGURE 3. Evidence of hatchling turtles freezing in the nest over winter: a. Snapping Turtle (*Chelydra serpentina*) hatchlings in their eggs, b. Snapping Turtle hatchlings found in nest cavity, and c. Eastern Spiny Softshell (*Apalone spinifera spinifera*). Photo a: M.D.D. Photos b and c: S.G.

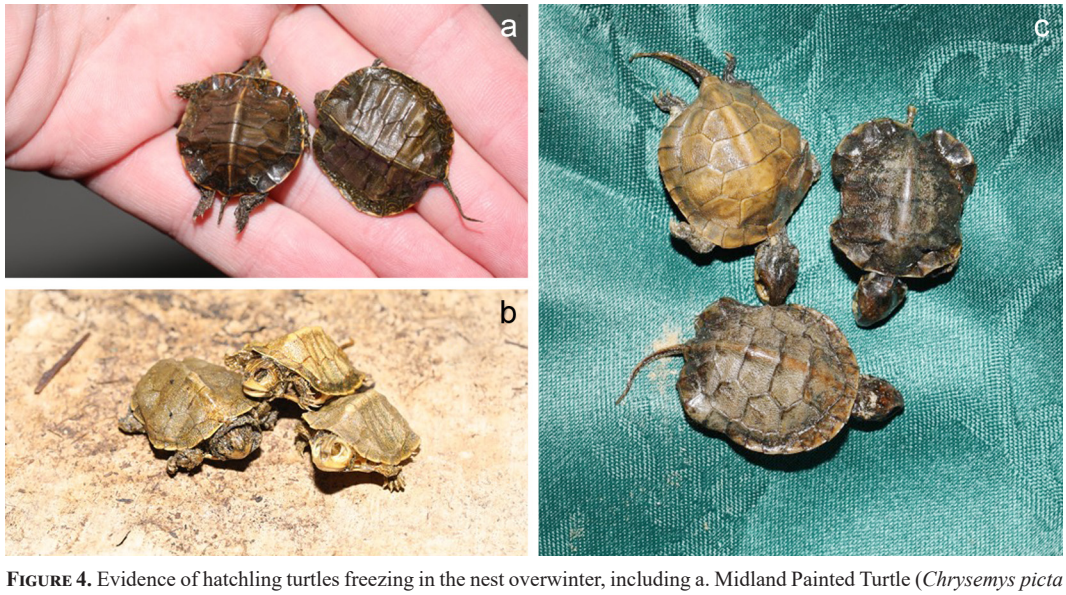

FIGURE 4. Evidence of hatchling turtles freezing in the nest overwinter, including a. Midland Painted Turtle (*Chrysemys picta marginata*), b. Northern Map Turtle (*Graptemys geographica*), and c. Blanding's Turtle (*Emydoidea blandingii*). Photos: S.G.

Erie in early April. All hatchlings were out of the egg, but still in the nest chamber, and were dead/desiccated (see Figure 4c). Blanding's Turtle hatchlings that successfully overwinter on land probably do so in drier terrestrial microhabitat that limits dehydration and permits supercooling (Baker *et al.* 2003).

Conclusions

We present 18 cases of turtles in southern Ontario caught or frozen and desiccated outside water or of eggs and hatchlings frozen/desiccated while overwintering in nests. Some of these deaths could be a result of maladaptive behaviour: erroneous overwintering or nest site selection or seeking mid-winter basking opportunities. However, others could be related to anthropogenic or natural water level fluctuations with or without forced dispersal. It is not possible to relate specific cases to local weather or habitat conditions, given that we do not know exactly when the deaths occurred. The most obvious examples of maladaptive adult behaviour e.g., cases 1 and 2, may be extremely rare and their discoveries were dependent on opportunistic observations.

The population effects of the mortalities are uncertain because it is difficult to quantify the number of mortalities or percentages of nesting failures in relation to the turtle populations or number of nests laid. Winter conditions can be challenging for turtles at the northern end of their ranges, as winter freeze affects eggs, hatchlings, juveniles, and adults. As climate change modifies local freeze-thaw cycles and precipitation levels, it is important to track turtle winterkill events, especially in managed wetlands that undergo annual water level changes, particularly in the winter months when turtles are dormant. We encourage the public to continue to report all discoveries of freeze-dried turtles to KTCC.

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