The overwintering struggles of freshwater turtles in Ontario

Andrea O'Halloran - December 2021

Photo by Alicia Chen

Harsh Ontario winters present unique problems for non-migratory animals. Ectotherms, such as freshwater turtles, need to employ strategies to avoid freezing while living in cold conditions for extended periods of time because the external temperature determines their body temperature. There are two strategies turtles are known to use to survive severe winter conditions: freeze avoidance and freeze tolerance (Cantrell et al., 2014). Freeze avoidance is considered a behavioural strategy. Turtles will spend the winter below the water surface, in areas where temperatures do not dip below freezing, to avoid ice penetration (the entry of ice crystals from the environment into their body) (Costanzo et al., 2008; Valerio et al., 1992). All adult freshwater turtles in Ontario do this. The second strategy, freeze tolerance, is the ability to survive the physical freezing and thawing of one's body without injury or death (Costanzo & Lee, 2013). This strategy is known to be employed by Painted turtle hatchlings (Cantrell et al., 2014).

When overwintering in a body of water where the surface freezes over, oxygen availability is limited. To survive in these conditions, turtles need to find a habitat with stable oxygen supply and temperature, to which they show site fidelity (they return to the exact same sites year after year because they have these specific conditions). In addition, they shift to anaerobic metabolism. This is only practical during overwintering because metabolic rates are extremely slowed during this process, and require very little energy. However, anaerobic metabolism causes increased lactic acid production and depletion of glycogen stores, which can threaten the survival of an overwintering turtle (Cantrell et al., 2014). Additionally, oxygen dispersal (availability) is not uniform throughout the water column, so a turtles' position in the body of water has significant effects on physiological processes such as metabolism and respiration (Cantrell et al., 2014).

Adult turtles are known to adjust their position in the water, despite choosing the same sites each year (hibernation site fidelity), in order to avoid freezing temperatures (Bodie & Semlitsch, 2000) and to minimize acidosis (excess acid present in body fluids) (Greaves & Litzgus, 2008). Taylor and Nol (1989) observed multiple occasions where three Painted turtles readjusted their positioning after ice formed over their overwintering pond. They also found that an individual moved within the water column to an area of higher oxygen availability when the environment became anoxic (void of sufficient oxygen levels), suggesting that turtles, despite their vulnerability and slowed movements are capable of relocating from a low to high quality area within their dedicated hibernation site, however, scientists did not observe such adjustments (of greater than 1 m) after ice cover developed over the water bodies (Edge et al., 2009). Unfortunately, hatchlings and juveniles tend to occupy shallower overwintering grounds and readjust less often than adults. Because young turtles are less able to adjust to changing conditions, they are sometimes unable to respond accordingly, and do not survive through the winter (Bodie & Semlitsch, 2000). Some hatchlings are able to forgo the dangerous search for an ideal overwintering location and instead wait out the winter in their nest cavity (Ultsch, 2006); Painted turtle hatchlings are known to employ this freeze tolerance strategy (Cantrell et al., 2014), while snapping turtles are not known for this adaptation. Adult turtles also have a bit of an edge over juveniles, as their shells are a source of calcium which act to remove some lactic acid build up during hibernation, while hatchlings don't have the same advantage (Ultcsh, 2006).

However, there are other reasons for adult turtle mortality in winter such as anoxia (the loss of oxygen), predation, freezing temperatures (Ultcsh, 2006), and immunosuppression (Refsnider et al., 2015) where, because temperatures determine both metabolic processes and immune system function, turtles may succumb to disease or infections during hibernation. Surprisingly, however, winter turtle mortality rates are lower than mortality rates in spring and summer.

The ability for a species to survive in an environment with very low oxygen availability is called anoxia-tolerant. Different species of turtles have varying degrees of tolerance/intolerance; some turtles are anoxia-intolerant, while others are anoxia-tolerant. For example, Western Painted turtles are considered the tetrapod with the best anoxia-tolerance, while Map and Wood turtles are considered anoxia-intolerant. For this reason, Map and Wood turtles are known to select hibernation sites where dissolved oxygen is elevated and the water surface does not completely freeze over (such as flowing streams and lakes) (Cantrell et al., 2014); These environments allow them to maintain aerobic respiration while hibernating (Reese et al., 2002). Anoxia-intolerant turtles need to overwinter in an area with a higher partial pressure of oxygen, which would restrict the number of overwintering sites a turtle can occupy.

Regardless of the level of tolerance a species has to low oxygen conditions, all turtles are immuno-supressed during the winter, and also are unable to use their lungs to acquire oxygen during hibernation, and instead, will use either their cloaca (end of digestive tract) or skin for respiration (Edge et al., 2009).

Hibernation site fidelity (the returning to the same hibernation sites annually) is high for both anoxia tolerant and intolerant turtles, because the site must have very specific conditions for overwintering. Therefore the conversion, contamination, or loss of small wetland habitats and shoreland areas threatens turtle survival and therefore the success of future generations. Without access to crucial habitats, turtles are unable to survive the cold winter months. A lack of information and attention to these areas, and increased land development means that turtles will have little hope moving forward.

Another threat to overwintering adults is predation; in a study of intact hibernation sites conducted by Brooks and colleagues (1991), it was found that the majority of turtles that did not

survive the winter were casualties of predation. This was deduced because turtle carcasses that were found were mutilated and had wounds indicating that they had been attacked by a predator. Predation is a threat to turtles in the spring as well; when emerging from overwintering grounds, turtles are at an elevated risk of predation because hypoxia (insufficient oxygen available for body tissues) (Newton & Herman, 2009) and related metabolic acidosis which make them sluggish and slow moving. They are therefore less able to avoid predators at this time by fleeing (Greaves & Litzgus, 2007). Again in the late autumn before ice over, turtles are again at an increased risk of predation (Greaves & Litzgus, 2007). During this stage, the water's temperatures are low and therefore turtles are less able to mobilize; the cold initiates a torpor (inactivity) state (Newton & Herman, 2009).

Another threat to the health of turtles during hibernation is immune system depression which is exacerbated by low energy reserves. Again, when emerging from overwintering grounds there can be a delay in the immune system "rebooting" as this depends on body temperature. At this time turtles will be more susceptible to infection. In an overwintering study, Brown & Brooks (1994) found that of the four turtles that died after emergence, two of them had succumbed to bacterial infections most likely due to their lowered immune function.

The vulnerability of turtles due to cold temperatures is an issue of growing concern as climate change affects seasonal temperatures, and where unusual temperature fluctuations are becoming more common. Therefore, the chances of a turtle emerging early (when ambient temperatures are too low to kick-start immune function) are increasing, and especially as the spring migration to return to home ranges elevates a turtle's exposure to risks of infection. Furthermore, the undulating weather patterns in late autumn also make the onset of freezing temperatures dramatic and erratic. (Refsnider et al., 2015).

Ontario turtles face many challenges including habitat loss, contamination, and alterations; and anoxia, predation, and immune suppression when overwintering. Identifying and conserving critical hibernation sites is essential for turtle survival. Understanding the effects habitat destruction and climate change on turtle overwintering sites and behaviours, especially here in The Land Between bioregion (the northern range of many species' habitats) will have important influence on conservation strategies to protect turtle overwintering areas and turtle populations as a whole (Litzgus et al., 1999).

Sources:

Bodie, J. R., & Semlitsch, R. D. (2000). Size-specific mortality and natural selection in freshwater turtles. *Copeia*, *2000*(3), 732-739.

Brooks, R. J., Brown, G. P., & Galbraith, D. A. (1991). Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (Chelydra serpentina). *Canadian Journal of zoology*, *69*(5), 1314-1320.

Brown, G. P., & Brooks, R. J. (1994). Characteristics of and fidelity to hibernacula in a northern population of snapping turtles, Chelydra serpentina. *Copeia*, *1994*(1), 222-226.

Cantrell, E. A., Dong, C. M., Hill, C. A., & Warren, D. E. (2014). Buoyancy control in cold-submerged painted turtles: implications for overwintering physiology and behavior. *Herpetologica*, *70*(4), 388-394.

Costanzo, J. P., & Lee Jr, R. E. (2013). Avoidance and tolerance of freezing in ectothermic vertebrates. Journal of Experimental Biology, 216(11), 1961-1967.

Costanzo, J. P., Lee Jr, R. E., & Ultsch, G. R. (2008). Physiological ecology of overwintering in hatchling turtles. *Journal of Experimental Zoology Part A: Ecological Genetics and Physiology*, *309*(6), 297-379.

Edge, C. B., Steinberg, B. D., Brooks, R. J., & Litzgus, J. D. (2009). Temperature and site selection by Blanding's Turtles (Emydoidea blandingii) during hibernation near the species' northern range limit. *Canadian Journal of Zoology*, *87*(9), 825-834.

Greaves, W. F., & Litzgus, J. D. (2007). Overwintering ecology of wood turtles (Glyptemys insculpta) at the species' northern range limit. *Journal of herpetology*, *41*(1), 32-40.

Greaves, W. F., & Litzgus, J. D. (2008). Chemical, thermal, and physical properties of sites selected for overwintering by northern wood turtles (Glyptemys insculpta). *Canadian Journal of Zoology*, 86(7), 659-667.

Litzgus, J. D., Costanzo, J. P., Brooks, R. J., & Lee, Jr, R. E. (1999). Phenology and ecology of hibernation in spotted turtles (Clemmys guttata) near the northern limit of their range. *Canadian Journal of Zoology*, *77*(9), 1348-1357.

Newton, E. J., & Herman, T. B. (2009). Habitat, movements, and behaviour of overwintering Blanding's turtles (Emydoidea blandingii) in Nova Scotia. *Canadian Journal of Zoology*, *87*(4), 299-309.

Refsnider, J. M., Palacios, M. G., Reding, D. M., & Bronikowski, A. M. (2015). Effects of a novel climate on stress response and immune function in painted turtles (Chrysemys picta). *Journal of Experimental Zoology Part A: Ecological Genetics and Physiology*, *323*(3), 160-168.

Reese, S. A., Jackson, D. C., & Ultsch, G. R. (2002). The physiology of overwintering in a turtle that occupies multiple habitats, the common snapping turtle (Chelydra serpentina). *Physiological and Biochemical Zoology*, *75*(5), 432-438.

Taylor, G. M., & Nol, E. (1989). Movements and hibernation sites of overwintering painted turtles in southern Ontario. *Canadian Journal of Zoology*, *67*(8), 1877-1881.

Ultsch, G. R. (2006). The ecology of overwintering among turtles: where turtles overwinter and its consequences. *Biological reviews*, *81*(3), 339-367.

Valerio, P. F., Kao, M. H., & Fletcher, G. L. (1992). Fish skin: an effective barrier to ice crystal propagation. *Journal of Experimental Biology*, *164*(1), 135-151.