

Depredation of gravid freshwater turtles by Raccoons (*Procyon lotor*)

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Abstract

During summer 2017, we found 19 dead or fatally wounded adult female turtles belonging to three at-risk species at a nesting site on the north shore of Lake Erie, Ontario. Individuals were found flipped onto their carapace, had similar holes in their body cavities, and were eviscerated. Their eggs had also been consumed. Although turtle nest depredation by Raccoons (*Procyon lotor*) is common, it is unusual for them to target large numbers of gravid turtles within a season. Depredated species included Snapping Turtle (*Chelydra serpentina*), Northern Map Turtle (*Graptemys geographica*), and Blanding's Turtle (*Emydoidea blandingii*). Our observation represents a spike in additive mortality for these populations, which could have long-term demographic consequences.

Key words: Additive mortality; depredation; predator; Raccoon; *Procyon lotor*; Blanding's Turtle; *Emydoidea blandingii*; Northern Map Turtle; *Graptemys geographica*; Snapping Turtle; *Chelydra serpentina*; Ontario

Introduction

Freshwater turtles typically exhibit high life expectancy and mortality rates that are inversely related to age (Iverson 1991). High depredation of eggs and hatchlings in the wild results in low recruitment of early life stages (Iverson 1991). Some North American freshwater turtle populations experience nest predation rates approaching 100% (63%: Congdon *et al.* 1983; 70%: Congdon *et al.* 1987; 84.2%: Burke *et al.* 1998). Elasticity (the proportional contribution of stage-specific demographic parameters to population growth) is low for turtle hatchlings relative to mature females. Populations with high adult survivorship can tolerate relatively high nest depredation as long as some recruitment is still occurring. In contrast, removing even a few mature individuals from a population may result in a disproportionately large decrease in population growth (Heppell 1998). Thus, additive mortality of adults can limit the growth of turtle populations, particularly those that are already in decline (Brooks *et al.* 1991; Stacy *et al.* 2014).

In North America, mammalian mesopredators are frequently observed depredating turtle nests. Common nest predators include Raccoon (*Procyon lotor*), Fisher (*Martes pennanti*), Gray Fox (*Urocyon cinereoargenteus*), Red Fox (*Vulpes vulpes*), River Otter (*Lutra canadensis*), American Mink (*Neovison vison*), Striped Skunk (*Mephitis mephitis*), Virginia Opossum (*Didelphis virginiana*), Eastern Wolf (*Canis lycaon*), and Coyote (*Canis latrans*; Wilhoft *et al.* 1979; Marchand *et al.* 2002; Geller 2012; Riley and Litzgus 2014). Adult turtles are more rarely targeted by predators because many species can retract into their shells for protection. Snapping Turtle (*Chelydra serpentina*) cannot fully retract,

but instead displays intimidating snapping behaviour when threatened (Ernst and Lovich 2009). Nevertheless, predation of adult turtles does occur (Brooks *et al.* 1991; Baxter-Gilbert *et al.* 2013).

Erickson and Scudder (1947) suspected Raccoons as the cause of death of 26 nesting Yellow-bellied Sliders (*Trachemys scripta scripta*) and four Eastern Mud Turtles (*Kinosternon subrubrum*). They reported that these turtles shared similar injuries to the neck, intestines, and oviducts, with some carcasses adjacent to egg shells and Raccoon tracks. Similar injuries were reported on 28 depredated adult Diamond-backed Terrapins (*Malaclemys terrapin*) found during the nesting season in Gateway National Recreation Area, New York, in 1998–1999 (Feinberg and Burke 2003) and on 24 Diamond-backed Terrapins found in Merritt Island, Florida, in 1977–1978 (Seigel 1980). These authors also considered Raccoons as the most likely predator.

In 2004–2005, 35 Wood Turtle (*Glyptemys insculpta*) deaths at a site in Quebec were attributed to depredation by Raccoons (Pouliot *et al.* 2013). In some cases, Raccoons were observed attacking nesting Wood Turtles, and some dead individuals had sustained injuries that suggested they were being targeted for the unlaidd eggs in their oviducts (Pouliot *et al.* 2013). Mustelids, such as American Mink and River Otter, may also depredate hibernating turtles during the winter (Brooks *et al.* 1991; Lanszki *et al.* 2006), when cold temperatures and potential hypoxia during hibernation reduce the turtle's ability to move quickly (Ultsch 1989). River Otters were recently implicated in a mass mortality of Blanding's Turtles (*Emydoidea blandingii*) on Manitoulin Island, Ontario, which increased the likelihood of extirpation for that population (Gasbarrini 2016).

Methods

In summer 2017, we conducted turtle nesting surveys at Rondeau Provincial Park (42.2808°N, 81.8525°W; Chatham-Kent County, Ontario, Canada) during an ongoing turtle conservation and research program. We monitored a nesting site (3.5 km long) daily from 5 June to 30 July 2017, with surveys typically running from 0900 to 1900. During this time, we observed semi-regular depredation of gravid or nesting females. In each case, we recorded specific injuries, measured the turtle's size (curved carapace length), and noted any evidence identifying potential predators. Following our first few observations of depredation, we also deployed Hyperfire trail cameras (Reconyx, Holmen, Wisconsin, USA) along the nesting site, in an effort to document potential predators.

Results

We observed 19 cases of depredation on gravid or post-nesting turtles: 10 Snapping Turtles, eight Northern Map Turtles (*Graptemys geographica*), and one Blanding's Turtle. All were mature females (mean curved carapace length \pm SD for Snapping Turtles:

242.89 \pm 13.50 mm; Northern Map Turtles: 313.13 \pm 16.13 mm; Blanding's Turtle: 218 mm). The pattern of attacks was consistent among incidents. Each turtle was found flipped onto its carapace and with similar wounds (Figure 1). Snapping Turtles sustained a single hole approximately 5–8 cm in diameter above the right, hind leg, which provided access to the internal organs. Northern Map Turtles and the Blanding's Turtle exhibited multiple entry wounds around the legs and cloaca and sustained lacerations to their necks and heads. The turtles' internal organs (oviduct, intestines, and sometimes liver) were removed. If the turtles had recently nested, the nests were also depredated. If the turtles had not yet nested, the eggs were pulled from the oviduct and eaten. In both cases, eggshells were left scattered around the carcasses. Not all carcasses were found immediately post mortem because some were concealed in vegetation and were found only after the carcass had already undergone some degree of autolysis.

We observed Raccoon tracks adjacent to several carcasses, and our wildlife cameras detected Raccoons patrolling the nesting site during the day and at night.



FIGURE 1. Six depredated Snapping Turtles (*Chelydra serpentina*) exhibiting entry wounds (5–8 cm diameter) characteristic of Raccoons (*Procyon lotor*), some with eggshells adjacent. Upper left example (a) shows Raccoon tracks adjacent to the carcass (white dotted circle). Photos: Christina Davy and Alyson Karsons.

During nesting surveys, we also made several observations of a Raccoon approaching, biting, or dragging gravid Northern Map Turtles. We suspect that a single Raccoon may have been responsible for all the observed mortalities, because the cluster of depredation events and the consistent locations of the entry wounds suggests a single individual and because the locations of the observed mortalities fall within a typical Raccoon home range (~200–400 ha; Šálek *et al.* 2015). The greatest distance between two depredated turtles was 3.25 km between a Northern Map Turtle and a Blanding's Turtle, which were depredated on 11 July and 12 July, respectively.

Discussion

The injuries we observed are consistent with those described for other depredation events in which Raccoons have been implicated (e.g., Seigel 1980; Pouliot *et al.* 2013). Gravid reptiles may be more susceptible to predation during extended overland movements toward nesting sites (Schwarzkopf and Shine 1992; Cox and Calsbeek 2009), but this is the first predator-related mortality of gravid or nesting females recorded at our study site in seven years of monitoring. It is unclear what prompted this Raccoon to expand its repertoire from nest depredation (>90% at our study site) to also preying on adult turtles. To our knowledge, this depredation event specifically targeted reproductive females, which are critical to population persistence (Brooks *et al.* 1991).

Nest depredation can be high even in relatively unimpacted, "natural" areas, and predation rates may increase in anthropogenically impacted habitats where mesopredators experience increased food supply (e.g., Raccoon or Coyotes scavenging from waste bins or agricultural fields). Subsidized mesopredators can live at higher densities, because the excess food increases the carrying capacity of those habitats (Smith and Engeman 2002). This in turn puts greater pressure on prey populations, and high nest predation rates resulting from subsidized predation can severely reduce recruitment into freshwater turtle populations (Marchand *et al.* 2002). If adult survivorship is high, the population may tolerate low recruitment rates (Heppell 1998). However, the addition of additive mortality in the form of depredation of adults would increase the probability of the population's eventual extirpation (Heppell 1998).

Our observations suggest that the additive mortality we describe here may have been caused by a single Raccoon, rather than an overabundance of Raccoons at Rondeau Park. A general overall reduction (i.e., culling) of this Raccoon population is unlikely to decrease rates of turtle or turtle nest predation. Experimental removal of Raccoons from areas adjacent to a sea turtle nesting beach did not decrease rates of nest predation because of rapid dispersal into the target site by individuals from nearby areas, coupled with rapid recruitment of juveniles to the surviving Raccoon population (Barton and

Roth 2007). Even a cull of 50% of the Raccoons present at a sea turtle nesting site failed to reduce nest depredation (Ratnaswamy *et al.* 1997). However, targeted removal of specific, predatory Raccoons and Armadillos (*Dasypus novemcinctus*) from another sea turtle nesting site managed to reduce nest loss from 95% to 9.4% (Engeman *et al.* 2005), suggesting that in some cases, ongoing adaptive predator control may be a useful tool for protecting turtle nests. As our observations appear likely to be caused by only one or a few Raccoons, targeting these specific individuals might alleviate future predation pressures on vulnerable females. However, although there is undoubtedly a relationship between subsidized mesopredator abundance and nest predation, we caution that Raccoons quickly learn new skills from one another and that the intense, targeted efforts required to effectively protect nesting females and their eggs would be costly to maintain.

The observed Snapping Turtle depredation ($n = 10$) represents ~1% of the estimated 800 females that nest at this site (C.M.D. unpubl. data), and our observations likely underestimate mortality because we may not have found all depredated individuals. Recurring predation events like this one could have rapid, cumulative effects on population viability, because turtle populations recover slowly or not at all from mass mortality events (Brooks *et al.* 1991). Mature females have the highest value in terms of population growth in freshwater turtles. Thus, the most critical conservation efforts may be those aimed at saving as many individual nesting turtles as possible (Heppell 1998), provided recruitment is also occurring (Bennett *et al.* 2017). Nevertheless, predation is an inevitable part of functioning ecosystems, and there is no way to eliminate this pressure completely. Considering rapid increases in additive mortality is essential to evaluating population viability, and pulses in depredation of adult turtles can have long-term effects on a population (Brooks *et al.* 1991). However, from the perspective of recovering threatened turtle populations, it is likely more effective to focus on the mitigation of the most consistent, significant sources of mortality, such as road mortality, or ongoing harvest in jurisdictions where turtles are still managed as game species.

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