Note

Adult Snapping Turtle (*Chelydra serpentina*) Feeding on Goldeneye Embryos of Pumpkinseed (*Lepomis gibbosus*) in Defended Nests

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Rarely observed predatory behaviour of adult Snapping Turtles (*Chelydra serpentina*) was recorded using remote video technology. We observed turtles inspecting and, in one case, apparently feeding on goldeneye stage embryos (< 3 mm) from defended nests of Pumpkinseed (*Lepomis gibbosus*). This novel behaviour was limited to nests in a secluded bay and was not observed at nests located along exposed shorelines or on shallow shoals in the deep open water habitat of an inland oligotrophic lake. The benefit of feeding on small prey is likely enhanced by embryos being clustered in nests and by an abundance of sunfish nests. Low-cost and low-intrusion video technology provides excellent opportunities, even in aquatic systems, to document novel predator and prey behaviours.

Key Words: Remote video recording; predator–prey interaction; fish embryos; nesting Pumpkinseed; *Lepomis gibbosus*; Snapping Turtle ram-feeding; *Chelydra serpentina*

Snapping Turtle (*Chelydra serpentina)* originated 40 million years ago (Van Devender and Tessman 1975) and has one of the largest geographic ranges of any freshwater turtle in the Americas (Ernst and Lovich 2009). It swims and walks along the bottom in a variety of lentic and slow-moving lotic waters. A diverse foraging ecology may contribute to its evolutionary persistence and extensive range. Fish, birds, anurans, crayfish, and many small benthic invertebrates can all occur in their diet (Herrel *et al.* 2002; Spotila and Bell 2008; Lawrence and Peterson 2010). Although direct evidence in the field is rare, adults are thought to use sit-and-wait ambush tactics to capture live fish (Punzo 1975; Spotila and Bell 2008; Ernst and Lovich 2009), but they also scavenge dead prey (Schneider 1998; Spotila and Bell 2008). Vegetation frequently appears in the diet (Ernst and Lovich 2009), particularly when animal prey are rare and vegetation is abundant (Moldowan *et al.* 2015) and more frequently in the southern part of the range (Spotila and Bell 2008). However, ingesting vegetation may also occur when feeding on high densities of attached invertebrates (Harper and Bolen 1996). In large adults, it is unclear whether the eggs of fishes, salamanders and frogs, tiny aquatic insect larvae, benthic invertebrates, and duckweed (Lemnaceae) are ingested as a consequence of feeding on gravid females, on the benthos, or in some other habitat that concentrates these items (Ratz *et al.* 1999; Spotila and Bell 2008). Recent advances in digital cameras can provide opportunities to observe active predation by such elusive animals to clarify their feeding behaviour.

Snapping Turtles capture their prey solely with their mouths, but have a variety of specializations that permit a diverse diet, including a strong biting force (Herrel *et al.* 2002), rapid prey strike (Lauder and Prendergrast 1992), and rapid protein digestion (Spotila and Bell 2008). Prey cannot be consumed out of water, although it can be captured there (Summers *et al.* 1998; Ernst and Lovich 2009). The feeding kinematics of turtles is challenging to assess (Bels *et al.* 2008), but in water, Snapping Turtles predominantly use a ram-feeding mode (Lauder and Prendergrast 1992; Summers *et al.* 1998) contrary to earlier theories suggesting that suction feeding dominates (Lagler 1943; reviewed in Ernst and Lovich 2009). Ram feeding is typically characteristic of predators that feed on elusive prey that can detect and escape rapid predator strikes, whereas suction feeding is often used to capture smaller prey in water (Wainwright *et al.* 2001). Thus, a ram-feeding mode raises questions about how and why Snapping Turtles may feed on small prey.

Diet diversity in Snapping Turtles is enhanced by the ability to modulate ram-feeding kinematics depending on the prey (Lauder and Prendergrast 1992), although strike performance is also affected by temperature (Vervust *et al.* 2011). For large predators, the energetic and opportunity costs of feeding on small and dispersed prey increasingly outweigh the nutritional gain and, thus, the profitability of small prey can be enhanced when prey are aggregated, such as egg masses of frogs and salamanders (Spotila and Bell 2008; Moldowan *et al.* 2015), or have a high local density, such as blooms of duckweed (Kadlec 1962).

Here, we report field observations made via remote videotaping of adult Snapping Turtles inspecting the defended nests of Pumpkinseed (*Lepomis gibbosus*) and

in one case apparently feeding on goldeneye-stage embryos (i.e., non-mobile post hatch "free" embryos, < 3 mm total length, with yolk sacs, that have not yet started to feed exogenously; Auer 1982). This is the first time this feeding behaviour has been reported in adult Snapping Turtles.

Observations of Snapping Turtles and nesting Pumpkinseed were made in Ashby Lake (45°05'N, 77°21'W) in the Addington Highlands of Ontario, Canada, a 259-ha oligotrophic Canadian Shield lake with a maximum depth of 36.6 m (Jastrebski and Robinson 2004) as part of ongoing studies of the reproductive biology of Pumpkinseed. Waterproof 'Gideon' action sports camcorders by Wasp cameras (Cedar Electronics, Chicago, Illinois, USA) attached to bricks were deployed for 4 h on the lake bottom, about 1 m from nest-guarding male Pumpkinseeds whose nests contained either fertilized eggs or hatched goldeneye-stage embryos based on inspection by a skin diver. In this and other post-glacial lakes, Pumpkinseed males construct, maintain, and defend nests in the littoral habitat of secluded bays, along more open shorelines exposed to deeper open-water lake habitat, and on shallow submerged rocky shoals in deep open-water habitat (Jastrebski and Robinson 2004). Cameras in littoral and open shoreline habitats were positioned on the shoreward side of each nest facing toward deeper water for the largest field of view of potential aquatic predators. Approximately 600 h of video capturing 125 nesting Pumpkinseed from three lake habitats were obtained between 1 June and 25 July 2015.

We define nest inspection by a Snapping Turtle as its presence at a Pumpkinseed nest with at least one head-down posture within a few centimetres of the substrate inside the nest perimeter. This is consistent with either visual or olfactory searching behaviour. We also recorded Snapping Turtles in the field of view but not visiting the focal nest. Turtles were not marked or otherwise handled in this study. Observations followed animal care and use guidelines at the University of Guelph developed in accordance with the standards of Good Animal Practice certification by the Canadian Council on Animal Care.

Snapping Turtles appeared in ten of the 125 recordings. Nine sightings occurred in 49 recordings made in a single 1-ha bay (one sighting 10 June, four on 25 June, four on 7 July); one sighting in 37 recordings from open shoreline nests (11 June); and none in 39 recordings of nests on shoals in open waters. Turtles could be clearly seen in seven recordings and were in the background in the other three.

At least two different adult turtles were involved in the greatest number of nest inspections in the bay: one could be identified by a distinct deformation on the second claw on its front left leg (see Video S1). This individual was observed in three recordings (involving two nest inspections and one swim-by, all on 25 June). One or more individuals without obvious distinguishing features were observed at close proximity in three additional recordings, all involving nest inspections (one on 10 June and two on 7 July). The individual observed in a recording of the nest in the open shoreline habitat could also be distinguished by a prominent white patch on top of its head (not observed elsewhere); it swam in close proximity to the sunfish nest, but did not inspect it.

The turtles observed were large, with carapace lengths equal to or exceeding the diameter of the Pumpkinseed nests, which are typically 25–40 cm in diameter. The frequency of nest visits by turtles did not depend on time of day (six observations in the morning versus four in the afternoon, 1-sample $z = 0.63$, $P = 0.74$) and the time spent inspecting a nest varied from 5 s to 14:32 min:s (mean duration of five visits = 3:59 min:s, SE 2:47). None of the nest-guarding male Pumpkinseeds permanently abandoned its nest after any turtle inspection. Sunfish also did not engage in "mobbing" behaviour in response to Snapping Turtles as reported for Bluegills (*Lepomis macrochirus*; Dominey 1983).

Active inspection of a sunfish nest occurred in five out of ten recordings. In one of these, we observed a turtle making a very long inspection and apparently feeding on goldeneye embryos in a nest at a water depth of about 1 m (Video S1). We estimate the anterior carapace width of this turtle to be 25–30 cm (based on an *in situ* estimate of the size of the nest-guarding male sunfish by a diver). The animal remained submerged and in view for 14:32 min:s, where 13:32 min:s was spent inside the perimeter of the focal sunfish nest. The turtle came into view from deeper water and stopped at a distance of 2–3 m, after which it changed direction and approached the nest. The turtle stopped with its front legs resting inside the nest perimeter and directed its head to bite at the substrate in the nest centre. It raised its head up in a forward-facing position, made gulping actions, and wriggling embryos escaped from its nostrils and rapidly sank to the nest substrate. At this point, the guarding male sunfish darted at the head of the turtle and retreated over an interval of less than 0.25 s. The turtle jerked its head downwards two more times at the nest substrate during the time inside the nest, but it was not clear whether embryos were taken in or escaped from its nostrils during these additional actions. During the 810 s the turtle was inside the nest, it spent only 134 s "nosing" at the nest bottom and swallowing (17% of total time); during the remainder of the time, it raised its head to a forward position and remained still. At high playback speeds, its eyes can be seen following the nest-guarding male and other Pumpkinseeds hovering nearby until it leaves.

Predator–prey interactions are difficult to observe because they are unpredictable in time and space and often occur over short intervals (Lawrence and Peterson 2010). We confirm the utility of remote cameras for observing undiscovered or rare behaviour in aquatic

habitats by providing the first direct observations of adult Snapping Turtles visiting and inspecting active Pumpkinseed nests and, in one case, apparently feeding on the clustered embryos there. Large turtles feeding on very small prey demonstrates the diverse feeding repertoire of adult Snapping Turtles.

Sunfish embryos could be a valuable source of nutrients for Snapping Turtles, especially in this oligotrophic lake with its low density of aquatic plants. Sunfish males typically construct nests in shallow inshore habitats well within the diving range (< 2 m) of these turtles. Eggs and embryos are rich in fat and usually aggregate in the centre of a nest depression where they are defended from predators (Scott and Crossman 1998). From 500 to 5000 embryos can be available in a nest over a 3–5-day interval before larvae disperse (Scott and Crossman 1998). Nests are spatially and temporally predictable and, thus, could be visited repeatedly by a nest predator over the 2-month spawning season (starting when waters reach 20°C and ending here in early August). Pumpkinseed nests are common: 30–50 active nests were present in the 1-ha bay where turtle activity was highest and well within the summer home range size of 2–10 ha reported for adult Snapping Turtles elsewhere (Pettit *et al.* 1995). These features reduce the costs to a Snapping Turtle of foraging for embryos, particularly as the abundance of active sunfish nests increases.

This predatory behaviour may be rare, as we observed a feeding attempt at only one of the five nests inspected among 49 nests recorded in the shallow bay. It is also not clear what factors influence whether a turtle will feed on larvae during a nest inspection or why larvae leaked from the turtles nostrils after being taken in. A forward-facing camera attached to the carapace of a Snapping Turtle could be used to estimate the prevalence of this foraging behaviour and, possibly, reveal other novel interactions between Snapping Turtles and nest-guarding male Pumpkinseed that affect whether fish larvae are consumed.

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SUPPLEMENTARY MATERIAL:

VIDEO S1. A mature Snapping Turtle (*Chelydra serpentina*) inspects a Pumpkinseed (*Lepomis gibbosus*) nest in the littoral habitat of Ashby Lake (Addington Highlands region, Ontario, Canada) where it apparently feeds on goldeneye-stage sunfish larvae. https://www.youtube.com/watch?v=gNOVM30q_Cc.