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Predation of Neonate Blanding's Turtles (*Emydoidea blandingii*) by Short-Tailed Shrews (*Blarina brevicauda*)

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Blanding's turtle (*Emydoidea blandingii*) is a North American freshwater species with a range centered south of the Great Lakes (Herman et al., 1995). Isolated populations occur outside the main range in Wisconsin (Cochran and Lyons, 1986; Ross, 1989), Massachusetts (Butler and Graham, 1995), New York (Breisch, 1997; Kiviat, 1997), Minnesota (Sajwaj et al., 1998), New Hampshire (Taylor, 1997), Maine (McCollough, 1997), and Nova Scotia (Herman et al., 1995). Populations in Nova Scotia have been designated nationally Threatened (Herman et al., 1995) and provincially Endangered (Nova Scotia Government, 2000); recent research is being applied to the development of conservation strategies appropriate for this population (Herman et al., 1999).

Like many turtles, Blanding's turtles are long-lived (Brecke and Moriarty, 1989; Congdon and van Loben Sels, 1993; Herman et al., 1995), reach sexual maturity late (Petokas, 1986; Congdon et al., 1993), and populations are vulnerable to increases in both juvenile and adult mortality (Iverson, 1991; Congdon et al., 1993). In Nova Scotia, concern over the scarcity of sexually immature Blanding's turtles and the low recruitment into the breeding population contributed to the status designation for this population (Herman et al., 1995). A nest protection program was implemented in Kejimkujik National Park, Nova Scotia, in order to bolster recruitment by mitigating nest destruction by predators, and to learn more about other factors influencing clutch failure in this population (Herman et al., 1999; Standing et al., 2000). To date, nest protection is the most important aspect of the headstart program for this population, although an experimental evaluation of the feasibility of captive rearing and release of headstarted hatchlings is currently underway. Since the objective of hatchling headstart programs is to raise neonates to a size sufficiently large to reduce their vulnerability to predation, the identification of local predator species is of interest. Such information will help managers determine the minimum size requirements necessary for an effective headstart program. We report observations on the predation of neonate Blanding's turtles (*E. blandingii*) by short-tailed shrews (*Blarina brevicauda*) in Kejimkujik National Park, Nova Scotia, Canada.

Methods and Results. — Data were collected in 1994 and 1995 during a study of the early postemergence behavior of neonates in this population (Standing et al., 1997). Detailed descriptions of the study site are available elsewhere (Power, 1989; Power et al., 1994; Herman et al., 1995; McNeil, 1996; McMaster, 1996; Standing et al., 1997).

During the nesting season (June and July), 23 freshly laid Blanding's turtle nests were protected against predation. A solid wood frame (50 cm^2 x 10 cm high) screened with one-inch (2.5 cm) hardware cloth was centered over each nest. The box frame was placed in a shallow trench dug around the nest, such that the screen was about 10 cm above the nest surface. The protective box was secured in place by large rocks. These screened boxes effectively guarded against predation of eggs and served as pens for emergent hatchlings.

Hatchling emergence occurred throughout September and October. Within clutches, hatchling emergence was mostly asynchronous (i.e., occurring over several days). Hatchlings emerged during the day and were diurnally active. Upon emergence, numerous hatchlings were measured, weighed, powdered with tracking-pigment, and their trails tracked from 1 to 11 days after release (Standing et al., 1997). Most hatchlings were released on the day of emergence, although some hatchlings spent one night after emergence in the enclosures.

After release, hatchlings used terrestrial and aquatic forms (sleeping and resting sites) both during the day and overnight. While in terrestrial forms neonates usually were well concealed beneath vegetation and roots, or between beach cobble, although sometimes hatchlings remained completely exposed on the beach overnight (McNeil, 1996; Standing et al., 1997).

In 1994, five hatchlings from two nests were found dead at the end of their trails. Four of these were nestmates that were found near the nest of origin shortly after their release. These hatchlings were severely bitten by ants and they presumably died from these bites since their carcasses were intact when found. A fifth hatchling, from another nest, was released at ca. 1300 hrs on 25 September. Shortly after having been located alive at the end of its trail at ca. 2200 hrs, it was seized by a predator. Although its carcass was not found, we heard the predator emerge from nearby shrubs and concluded that it was a medium-sized mammal, possibly a raccoon (*Procyon lotor*). Four additional, unpowdered hatchlings from three nests were depredated while still in their screened enclosures and two others survived with signs of attempted predation (i.e., superficial bites taken from their shells).

Between 19 and 25 September 1995, eviscerated carcasses of four powdered hatchling were found at, or near, the end of their marked trails. These hatchlings were nestmates and were within 20 m of their nest of origin when killed; predation occurred up to 6 days after release. On 19, 20, and 23 September, three additional unpowdered hatchlings from the same clutch were depredated inside the protective nest

screen. On the night of 19 September, shortly after finding one eviscerated hatchling within the nest enclosure, we interrupted a predator while it ate one of the released, powdered hatchlings (at ca. 2040 hrs). While eating this hatchling the predator became covered in tracking powder and we followed its trail for a short distance. Footprints were discernible and were identified as those of the short-tailed shrew (*Blarina brevicauda*).

The most prevalent form of mutilation of these hatchlings was evisceration. Typically, a section of the plastron was eaten, beginning at the axillary scutes, proceeding medially to the midline suture of the abdominal scute, and posteriorly to the inguinal region. Otherwise, a disk centered on the umbilical region was removed. Hatchlings were also eviscerated through the carapace. Either a circular area centered on the suture between the second and third vertebral scutes and extending laterally to the middle of the adjoining costal scutes was removed, or a crescent extending medially from the axillary and inguinal regions was removed. One hatchling that had been eviscerated through the plastron also had the foot and skin eaten from its left hind leg. Two hatchlings were decapitated. Those hatchlings that survived attack had bites taken from the carapace and marginal scutes 5, 6, and 7.

Discussion. — Turtles, including Blanding's turtle, are characterized by a Type III survivorship curve in which the rate of mortality is inversely related to age (Iverson, 1991). Presumably, this results from intense predation on early life stages, particularly eggs (Iverson, 1991). Numerous authors have attributed high clutch failure in *E. blandingii* and other freshwater turtles (*Chelydra serpentina*, *Chrysemys picta*, *Clemmys insculpta*, *Kinosternon flavescens*) to predation by raccoons (*P. lotor*), skunks (*Mephitis mephitis*), foxes (*Vulpes fulva* and *Urocyon cinereoargenteus*), badgers (*Taxidea taxus*), hognose snakes (*Heterodon nasicus*), rodents, and small, unidentified mammals (Congdon et al., 1983; Petokas, 1986; Power, 1989; Iverson, 1990; Ross and Anderson, 1990; Brooks et al., 1991; Herman et al., 1995). While nest screening programs such as the one implemented in Nova Scotia improve clutch survival, these programs are, in themselves, inadequate conservation measures (Heppell et al., 1996). Nest screening is only one element of a headstart program; threatened turtle populations would also benefit by the headstarting of hatchlings and from the protection of sexually immature turtles in the wild (Iverson, 1991; Heppell et al., 1996). In addition to bolstering recruitment, nest screening facilitates the collection of accurate data of hatching success (Standing, 1997). In addition, headstarted hatchlings may help researchers locate and describe important habitat used by immature turtles and actually lead to juvenile turtles in the wild.

It is widely accepted that, like eggs, small turtles are most vulnerable to predation pressure. Since this is the underlying premise of headstart programs (Heppell et al., 1996), the design of effective management strategies requires a thorough knowledge of causes of mortality in small size classes. Confirmed predators of hatchling freshwater turtles of various species include gulls (*Larus* spp.), crows (*Corvus* spp.), raccoons (*P. lotor*), bullfrogs (*Rana catesbeiana*) (Lefevre and Brooks, 1995), water snakes (*Nerodia* sp.) (Janzen et al., 1992), coyotes (*Canis latrans*) (Minckley, 1966), American Kestrel (*Falco sparverius*) (B. Butler, *pers. comm.*), and larger turtles (Sloan et al., 1996); putative predators include dogs, cats, toads, bears (Ehrenfeld, 1979), unknown shrew species (T. Graham, *pers. comm.*), squirrels (J. McNeil, *pers. comm.*), mink, otter, wading birds, and large, predatory fish (Congdon et al., 1992). Our data indicate that the short-tailed shrew (*B. brevicauda*) should be added to the growing list of predators of small freshwater turtles.

Short-tailed shrews (*B. brevicauda*) are common throughout Nova Scotia. They are opportunistic predators that primarily feed on invertebrates, although they have been known to catch and eat small lizards and mammals (Churchfield, 1990). It is reasonable to suspect them of being able to eat small, hatchling Blanding's turtles, especially since the shells of neonates are not heavily calcified or ossified. Though the foraging of *B. brevicauda* tends to be undirected, shrews will return to a concentration of prey until the supply is exhausted (Churchfield, 1980) and this might explain the apparent exploitation of individual nests in our study. In addition to the style of mutilation and the observed identifiable footprints, other evidence suggestive of predation by *B. brevicauda* is that short-tailed shrews are small enough to fit through one-inch hardware cloth; that is, without disturbing or digging beneath the screened predator exclosures, shrews could have accomplished the observed predation of hatchlings within the enclosures.

As well as providing necessary information for the development of effective headstart programs, identifying species that prey on hatchling freshwater turtles provides insight into the behavior (Janzen et al., 1992; Butler and Graham, 1995; Lefevre and Brooks, 1995) and habitat selection (Congdon et al., 1992; Pappas and Brecke, 1992) of neonate freshwater turtles, and their antipredator mechanisms (Britson and Gutzke, 1993). Combined, such information will help in the development of comprehensive management plans for the protection of young, vulnerable age classes in the wild.

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