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Results of the Nest Protection Program for Blanding's Turtle in Kejimkujik National Park, Canada: 1987–1997

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Abstract. – We studied the nesting ecology of Blanding's turtle (*Emydoidea blandingii*) in Kejimkujik National Park, Nova Scotia, Canada, from 1987 to 1997, as part of the Park's annual nest protection program. We identified 36 individual females nesting in this 11-year period and recorded 124 nests of which we protected 101 with screened predator exclosures. Clutch size ranged from 4 to 16 and averaged 10.6 eggs (SD = 2.3, *n* = 91 nests). Nearly half (50 of 124; 40%) of the nests that we observed failed completely. Nest failure was due to depredation in 16 nests, vandalism in 1, flooding in 15, and other causes in 18. Predators destroyed only 1 protected nest. Over a third (39%) of 1054 eggs did not hatch. Of the 641 eggs that hatched, we confirmed that 310 hatchlings (48%) emerged from the nest, and we presume that another 129 (20%) emerged but were not observed because they escaped from beneath the protective screens. We excavated 175 live hatchlings and 27 dead hatchlings in the fall. Since we assumed that live excavated hatchlings would have perished in the nest during the winter because of ice and flooding of the nesting beaches, the total number of failed eggs (unhatched eggs plus live and dead excavated hatchlings) was 615 (58%). Cool temperatures, especially during emergence, are suspected of reducing emergence success.

Key Words. – Reptilia; Testudines; Emydidae; *Emydoidea blandingii*; turtle; nesting; nest failure; conservation; management; Canada

Blanding's turtle, *Emydoidea blandingii*, is of conservation concern throughout much of its range. Population declines and extirpations have been attributed primarily to habitat loss and degradation (Kofron and Schreiber, 1985; Congdon and Gibbons, 1996; Herman, 1997; Kiviat, 1997; McCollough, 1997; Taylor, 1997; Herman et al., 1999). High levels of nest failure have been implicated as major threats to some populations (Congdon et al., 1983; Ross, 1989; Herman et al., 1995; Linck and Moriarty, 1996).

The stability of Blanding's turtle populations depends on high survivorship of juvenile and adult turtles (Congdon et al., 1993). When Power (1989) expressed concern over apparently high rates of depredation of Blanding's turtle eggs in Kejimkujik National Park — the center of the species' range in Nova Scotia — Parks Canada Resource Management staff were quick to implement an annual nest protection program. The fear was that campgrounds in the vicinity of important nesting beaches attracted and sustained populations of nest predators, especially raccoons (*Procyon lotor*). Moreover, depredation of nests was identified as a major threat to the population, and was suspected of being responsible, at least in part, for the apparent lack of young turtles in the population (Power, 1989; Herman et al., 1995). Recognizing that the long-term management of the species in Nova Scotia would require emphasizing the survival of older age classes over that of eggs and hatchlings (Congdon et al., 1983; Iverson, 1991; Congdon and van Loben Sels, 1993; Doak et al., 1994; Heppell et al., 1996), the Park implemented a nest protection program as a precaution until a detailed recovery plan was developed. Nest protection was intended only as short-term mitigation of a suspected threat to the population.

Protecting nests has done more than deter predators and bolster nest success. The program has encouraged systematic monitoring of Blanding's turtles in the Park, and it has facilitated the collection of information on this population's nesting ecology, behavior, and habitat requirements. Also, the program has promoted public awareness of species at risk in Nova Scotia. Over the years nesting surveys have become an integral part of the province's Recovery Plan for Blanding's turtle (Herman et al., 1999).

We report on the surveys of nesting Blanding's turtles that we conducted for 11 years from 1987 to 1997 in Kejimkujik National Park. We supplement data presented elsewhere (Herman et al., 1995; Standing et al., 1999) with records from 6 additional years, and we provide a more complete understanding of nesting and hatchling success in this population.

METHODS

We collected data in Kejimkujik National Park, Nova Scotia, Canada, from 1987 to 1997, inclusive. We conducted daily nesting surveys from early June until early July each year on beaches and roadways identified as historically important nesting areas in the Park (Drysdale, 1983; Power, 1989). We also surveyed other areas in the Park for nesting females or signs of nesting activity (e.g., depredated nests).

When we observed females nesting we recorded the date and time, the nest location, and when possible, we identified the nesting females by their unique notch code (see Power, 1989). We recorded the carapace length (CL) and plastron length (PL) of most of the females that we observed nesting. We determined clutch size by counting eggs as they were deposited, or based on our records of hatchling emergence and nest excavations (see Standing et al., 1999). We made intensive efforts to find and protectively screen as many Blanding's turtle nests as possible. However, in 1997, as part of a study of predator behavior, we screened only 2 of the 15 nests that we found.

Two sizes of square, wooden framed cages, screened with hardware cloth, were used to protect nests in this study: 1 x 1 m, or 0.5 x 0.5 m. These predator exclosures also served as pens for emerged hatchlings. We centered a screen over each nest and secured it in place with rocks. We left the screens in place throughout incubation and emergence, removing them to collect and release hatchlings.

We monitored nests, including unprotected nests in 1997, regularly throughout the summer. At the first signs of hatchling emergence in our sample, we monitored the nests daily. We recorded any depredation, vandalism, and flooding of the nests, and we weighed and measured emerged hatchlings. Beginning in 1994, we notched hatchlings in the marginal scutes for identification (see Standing, 1997). When emergence appeared to have ceased (i.e., more than 7 days with no emergence from a nest) we discarded the protective screen, excavated the nest, and counted the remaining eggs and hatchlings, dead and alive.

RESULTS

We found 124 Blanding's turtle nests in Kejimkujik National Park between 1987 and 1997, and identified the individual female for 106 of those nests. We identified a total of 36 individual turtles nesting during this study. We protected 101 nests (Table 1).

The onset and duration of the nesting season differed slightly among years. Data summarized in Table 2 represent the interval in which we observed nest construction. The earliest and latest observed nests were found on 12 June and 5 July, respectively. Each year, over 70% of the recorded nests were constructed in the last 15 days of June.

Most nesting in this population is initiated in late afternoon or early evening, and is completed before dawn. We found only one female that nested in the morning; we first observed her at 0800 hrs and she completed her nest at 0940 hrs.

Nesting habitats in Kejimkujik National Park include cobble beaches, gravel roads, and unpaved road shoulders and parking lots. Most of the nests that we observed were constructed along beach habitat, within 15 m of water. However, we encountered 4 females nesting only at inland sites.

Females in this population show high fidelity to nesting centers. All but 1 of the 28 females that we confirmed nesting in more than one year of this study nested in the same general area (e.g., beaches adjacent to the mouth of a brook) from one year to another. The 1 turtle that we recorded alternating between nesting centers (> 2 km apart) consistently used the same beach in 5 of 6 years in which she was found nesting.

We recorded the body size measurements of 20 of the 36 females that we confirmed nested. The mean CL was 207.6 mm (SD, 10.4; range, 189–231 mm) and the mean PL was 199.3 mm (SD, 11.0; range, 177–223 mm). The smallest reproductive female that we recorded had a CL of 189 mm and PL of 177 mm. Based on the premise that 1 growth annulus is deposited each year in juveniles and young adults, we estimated that she was 19 years old when she was first seen nesting.

Females produced a single clutch in a season. We observed 8 of the 36 females identified nesting only once. Of the 20 that we observed nesting in at least three years between 1987 and 1997, 8 nested three times, 5 nested four times, 4 nested five times, 2 nested six times, and 1 nested seven times.

We determined the clutch size of 91 nests. Clutch size ranged from 4 to 16 eggs, and averaged 10.6 eggs (SD = 2.3). We found no relationship between clutch size (egg number) and female body size (PL) ($r = 0.457$; $p > 0.05$; $n = 15$).

Table 1. Results of the nesting surveys and the annual nest protection program for Blanding's turtle in Kejimkujik National Park, Canada, 1987–97.

Year	No. Nests Observed	No. Nests Protected	No. Nests Failed	No. Failed Nests Depredated (or Vandalized)	No. Failed Nests Flooded	Identified Nesting Females
1987	2	2	1	1	—	2
1988	13	12	5	1	4	13
1989	16	8	8	7	—	9
1990	2	2	1	1	—	1
1991	4	4	3	—	1	—
1992	5	5	3	—	—	2
1993	12	12	2	1	—	12
1994	17	17	3	—	—	16
1995	16	16	2	1	—	16
1996	22	21	11	—	10	20
1997	15	2	11	5	—	15
TOTAL	124	101	50	17	15	106

Table 2. Nesting and emergence times of Blanding's turtles.

Year	Nesting Period	First Emergence	Emergence Time (days)
1987	19–24 June	1 Oct	104
1988	15–24 June	11 Sep	85–100
1989	15–28 June	15 Sep	82–120
1990	19–24 June	17 Sep	90
1991	18–29 June	2 Oct	106
1992	13–25 June	—	—
1993	17 June–2 July	11 Sep	83–99
1994	15–25 June	6 Sep	83–103
1995	16–29 June	13 Sep	80–128
1996	12 June–5 July	2 Sep	107
1997	18 June–2 July	19 Sep	90–118

Of the 124 nests that we recorded, 50 (40%) failed completely (Table 1). Depredation and vandalism accounted for 17 (34%) of the failures. Of the 16 depredated nests, only 1 had been screened (in 1995). Vandals destroyed 1 nest that we had protected in 1990. Flooding accounted for 15 (30%) nest failures, and was the main cause of failure in 1988 and 1996. Another 18 nests, 13 of which had been screened, failed due to causes other than depredation, vandalism, or flooding. In 1997, 5 of 13 unscreened nests and 1 of 2 protected nests failed due to causes other than depredation, flooding, or vandalism. The suspected cause of these nest failures was cool incubation conditions.

Hatchling emergence began in mid-September in most years (Table 2). Emergence time, defined as the number of days elapsed from nesting to the day the first hatchling emerged from the nest, ranged from 80 to 128 days (mean = 95.6 days, SD = 11.1, n = 53 nests). Hatchlings measured as follows: mean CL = 32.9 mm (SD = 1.8, n = 283); mean PL = 29.2 mm (SD = 2.3, n = 283); mean mass = 8.1 g (SD = 1.1, n = 272).

Hatching success and emergence success are summarized in Table 3. Of 1054 recorded eggs, over a third (413, 39%) did not hatch. This does not include eggs from clutches of unknown size that were destroyed by predators and ice action, etc. Of the 641 eggs (61%) that hatched, we confirmed that 310 (48%) hatchlings emerged from the nest. We presume that 129 (20%) additional hatchlings emerged but were not found because they escaped from beneath the protective screens. We excavated a total of 202 hatchlings in the fall, of which 175 were alive and 27 were dead. Since it is likely that excavated hatchlings would have perished in the nest because of winter ice action and flooding of the nesting beaches, we have included them as failed in this analysis. Thus, the total number of failed eggs (unhatched eggs plus live and dead excavated hatchlings) was 615 (58%).

We have few records of neonates surviving into the next season. We traced all yearlings (i.e., hatchlings that emerged the previous fall) bearing notches to their nest of origin. Each one originated from a nest protected on a nearby beach adjacent to the waterway in which it was found. In late June 1995, we found 2 yearlings (1 of which was notched) on the surface of dense floating mats of *Sphagnum*. In 1996, we found 5 yearlings. We found 1 yearling dead on the road on 13 May 1996 that we believe spent the winter in a nearby flooded ditch. Also in the spring, we found 1 yearling in the *Sphagnum*-rich floodplains adjacent to a nesting beach. In early July we found 3 yearlings exposed on muddy, unvegetated substrates in shallow aquatic habitat. Yearlings measured as follows: mean CL = 39.6 mm (range = 33.6–43.0, n = 4); mean PL = 34.6 mm (range = 30.0–36.7, n = 4); mean mass = 12.2 g (range = 11.5–13.0, n = 3).

DISCUSSION

Since its discovery in 1953, the Blanding's turtle population in Nova Scotia has been considered enigmatic because of its geographic isolation and its restricted distribution within the province (Bleakney, 1958). Of the four freshwater turtle species that occur in Nova Scotia, *Chelydra serpentina*,

Table 3. Hatching and emergence success of Blanding's turtle eggs.

Year	Total Eggs	Hatchlings: Emerged (Confirmed)	Hatchlings: Emerged (Presumed)	Hatchlings: Excavated Alive	Hatchlings: Excavated Dead	Eggs Unhatched*
1987	7	5	—	1	—	1
1988	133	31	16	9	1	76
1989	83	26	26	10	1	20
1990	20	12	—	—	—	8
1991	13	5	—	—	—	8
1992	48	—	—	6	—	42
1993	112	46	23	24	1	18
1994	165	73	27	21	7	37
1995	159	90	24	17	3	25
1996	222	8	5	85	14	110
1997	92	14	8	2		68
TOTAL	1054	310	129	175	27	413
% total		29%	12%	17%	3%	39%

* We have included eggs from clutches of known size that failed because of predators, etc. Standing et al. (1999) reported 29 unhatched eggs in 1994; this did not include 8 eggs presumed to have failed overwinter that we have included here. Also, they excluded 4 eggs that were depredated in 1995. Standing et al. (2000) records referred to eggs that failed to hatch but that were not depredated.

Chrysemys picta, *Clemmys insculpta*, and *Emydoidea blandingii*, only the Blanding's turtle is restricted to the southwestern interior of the province, in and around Kejimkujik National Park (Cook, 1984; Herman et al., 1999).

In Kejimkujik National Park Blanding's turtles are found in slow-flowing waters in association with floating mats of *Sphagnum* (Power, 1989; Power et al., 1994). Blanding's turtles in the Park concentrate in areas of relatively high secondary productivity (Power et al., 1994). Although the species is primarily carnivorous (Bleakney, 1963; Rowe, 1987; Congdon, 1989; Power et al., 1994; Sajwaj et al., 1998), high secondary productivity (i.e., food abundance) does not satisfactorily explain the severely restricted distribution of Blanding's turtle in Nova Scotia. More likely, the species' restricted range in the province reflects thermal constraints (Bleakney, 1958; Power, 1989; Herman et al., 1995, 1999). This is supported by the congruency between the population's distribution and the warmest region of the province (Power et al., 1994; Herman et al., 1995).

The species' northern range and its limited distribution in Nova Scotia have been attributed to the high critical thermal minimum for successful embryonic development (Bleakney, 1958; Gutzke and Packard, 1987). Although 14% of nests failed because of depredation and vandalism, and 12% failed because of flooding, 15% of the nests (36% of the failures) failed because of other, undetermined reasons. Possible causes of failure include egg infertility, poor maternal nutrition (Noble, 1991; White, 1991), environmental contaminants such as mercury (see Nocera, 1998), and cool incubation conditions.

Over the years, we have maintained that the level of partial and complete failure of nests protected against depredation and the incidence of developmental abnormalities in Nova Scotia result from thermal constraints during incubation (Power, 1989; Herman et al., 1995, 1999; Standing et al., 1999; Standing et al., 2000). Suitable, warm inland nesting habitat, present elsewhere (Congdon et al., 1983; Butler and Graham, 1995; Petokas, 1986; Ross and Anderson, 1990; Rowe and Moll, 1991), may be limited in Nova Scotia (Herman et al., 1995). By nesting in relatively warm sites on exposed beaches (Standing, 1997) females in Nova Scotia may be able to maximize hatching success in a cooler climate (Bobyn and Brooks, 1994; Herman et al., 1995, 1999). Nevertheless, egg failure is high in this population.

But while hatching success may not be compromised in this population relative to others, hatchling quality (Standing et al., 2000) and emergence success may be. Emergence time (mean 95.6 days) is somewhat longer in Nova Scotia than has been reported from other populations (Ewert, 1979; Congdon et al., 1983; Butler and Graham, 1995; Sajwaj et al., 1998). This could indicate cooler conditions and longer incubation times (Ewert, 1979; Sajwaj et al., 1998). However, hatchlings do not emerge immediately upon hatching, and the longer emergence times observed in Nova Scotia may reflect a longer post-hatching interval spent in the nest. Our observations of low emergence success (Table 3) suggest that low hatchling emergence compromises nest success.

We predict that cooler conditions, especially late in the season, reduce nest success by restricting hatchling activity and emergence. Although Blanding's turtles have the ability to withstand short-term freezing (Packard et al., 1999), and can survive winter in natural nests (J. Lang, *pers. comm.*)., extensive ice action and spring flooding destroy overwintering nests in Nova Scotia (Standing, 1997). Thus, most, if not all, of the live hatchlings that we excavated in the fall likely would have perished in the nest cavity over winter.

The lack of relationship between female body size and clutch size that we observed suggests that reproductive output is more constrained in Nova Scotia than in populations where clutch size is significantly positively related to female body size (Petokas, 1986; MacCulloch and Weller, 1988; Congdon and van Loben Sels, 1991). We predict that reproductive output in Nova Scotia is constrained by the abundance and quality of food, and the short and cool active season at the northeastern limit of the species' range (Congdon, 1989; Power, 1989; Gibbons and Greene, 1990; Power et al., 1994; Herman et al., 1995). Clutch size in this population falls within the range reported from other populations (Gibbons, 1968; Graham and Doyle, 1979; Petokas, 1986; DePari et al., 1987; MacCulloch and Weller, 1988; Congdon and van Loben Sels, 1991; Sajwaj et al., 1998), but females in Nova Scotia appear to reproduce less than annually, and perhaps less frequently than previously suggested (Power et al., 1994; Herman et al., 1995). Females in this population may have lower lifetime reproductive potential than elsewhere.

Perhaps a more serious problem faced by this population is that females appear to reach maturity later than elsewhere. Juvenile growth is positively related to the attainment of sexual maturity (i.e., faster growing turtles mature earlier than slower growing ones) (Congdon and van Loben Sels, 1991). Subadult turtles in Nova Scotia gain on average 54.9 g and grow 8.2 mm CL per year, and turtles aged 17 yrs have similar growth rates as turtles aged 6 yrs (Standing, 1997). In contrast, in Michigan juvenile turtles gain 75.3 g per year between ages 4 and 13 yrs, and grow 10.4 mm CL annually from ages 1 to 13 yrs (Congdon and van Loben Sels, 1991). Sexual maturation of females is evident between ages 13 and 15 yrs in Massachusetts (Graham and Doyle, 1977), 14 yrs in Ontario (Petokas, 1986; MacCulloch and Weller, 1988), between 14 and 20 yrs in Michigan (Congdon and van Loben Sels, 1991, 1993), and 18 yrs in Wisconsin (Ross, 1989). In Nova Scotia, 13 yr-old females are not mature (Standing, 1997). Females in Nova Scotia may not reproduce until their late teens and early twenties, and this could explain the absence of mature turtles aged 16–25 yrs as reported by Herman et al. (1995). In Nova Scotia, female Blanding's turtles may reach maturity late enough to cause recruitment problems. Average annual juvenile survivorship may need to be higher in this population than elsewhere to compensate for delayed maturity and lower embryo success. Thus, the population would be especially vulnerable to increases in adult and juvenile mortality (Congdon et al., 1983; Iverson, 1991; Congdon et al., 1993; Heppell et al., 1996).

The protection of nests has successfully mitigated what was believed to be a major threat to Blanding's turtle in Kejimkujik National Park: depredation of eggs. The stabilization and recovery of this population will also require greater emphasis on the protection and management of older turtles and their habitat. Already, we have begun studies of the habitat requirements of juvenile turtles in Nova Scotia (see Herman et al. 1999; McMaster and Herman, 2000), and future recovery efforts will also focus on the description and characterization of critical habitat for young turtles, and the identification and mitigation of causes of mortality.

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