

Population Structure, Growth, and Age Estimation of Spotted Turtles, *Clemmys guttata*, Near their Northern Limit: an 18-Year Follow-up

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Mark-recapture and radio telemetry data were collected from 1999–2001 on a population of Spotted Turtles, *Clemmys guttata*, near their northern limit in Ontario, Canada, and compared with a similar study conducted from 1983–1986. In 1999–2001, 32 Spotted Turtles were caught, 27 of which were adults. Females outnumbered males 3.5:1. The carapace length (CL) of adult males (108.5 ± 5.7 mm) and adult females (106.4 ± 6.0 mm) did not differ significantly. A minimum of 22% of juveniles and 40% of adults marked in 1983–1984 were still alive in 1999–2001. Adult population size was estimated to be 45 (95% confidence interval: 34–78). The average size of individual adults marked in 1983 (105.6 ± 6.0 mm CL) and recaptured during 1999–2001 (106.3 ± 5.9 mm CL) did not differ significantly. There was also no significant difference in the number of growth lines on adults caught in 1983 (12.9 ± 2.0) and 1999 (14.0 ± 2.3). Based on the number of growth lines in 1983, these turtles averaged a minimum of 28.9 years in 1999, but actual ages are likely greater. Summer range length averaged 233 m (range: 200–275 m), while total range length averaged 327 m (range: 275–375 m).

Key Words: Spotted Turtle, *Clemmys guttata*, demographics, growth, home range, hibernation.

The global status of the Spotted Turtle (*Clemmys guttata*) is Vulnerable, indicating the species faces “a high risk of extinction in the medium-term future” (Hilton-Taylor 2000). In Canada, the Spotted Turtle is listed as a species of Special Concern (Oldham 1991*). Canadian populations are limited to Ontario, where populations are believed to be declining as a result of habitat loss, degradation and fragmentation, as well as collecting for the pet trade (Seburn and Seburn 2000).

Spotted Turtles are small (<15 cm carapace length, CL) and secretive. They frequently make use of a wide variety of habitats in wetland complexes over the course of the year (Ernst et al. 1994); however, populations in eastern Ontario appear to be limited to bogs (Cook et al. 1980). Spotted Turtles can live for over 30 years (Ernst et al. 1994), yet most studies are only a few years long (but see Litzgus and Brooks 1998a). The present study follows up on an intensive mark-recapture study which resulted in 39 Spotted Turtles (9 juveniles, 12 males and 18 females) being marked in an isolated population at Mer Bleue Bog (Chippindale 1984*, 1985*). A follow-up study was undertaken to determine a current population estimate for management purposes. In addition, recapture data from turtles marked by Chippindale provide an opportunity to determine minimum survivorship and to test whether growth lines accurately reflect age.

Study Area

Research was carried out at Mer Bleue Bog, a 2500 ha sphagnum bog within the city of Ottawa, Ontario, Canada ($45^{\circ}25'N$, $75^{\circ}25'W$). Mer Bleue Bog is owned by the National Capital Commission and public access is strictly controlled. An internationally significant wet-

land, Mer Bleue has been designated a Ramsar site. In the centre of the bog the peat is 3.5–6.5 m thick and it is here that five sandy islands rise through the bog mat (Brunton 1984*). Around and connecting three of the five islands are small (<1 m wide) aquatic channels. There are also a number of ponds (<3 m in diameter) created by practice bombing during World War II. The area around the islands is open bog mat with scattered Black Spruce (*Picea mariana*) and Larch (*Larix laricina*). The islands also have Trembling Aspen (*Populus tremuloides*), Largetooth Aspen (*P. grandidentata*) and Red Maple (*Acer rubrum*) growing on them. Common plant species in the bog include sphagnum (*Sphagnum* spp.), Leatherleaf (*Chamaedaphne calyculata*), Buckbean (*Menyanthes trifoliata*), Small Cranberry (*Vaccinium oxycoccus*), and Large Cranberry (*V. macrocarpon*; Brunton 1984*).

Methods

Field studies were undertaken from 26 April 1999 until 25 May 2001, with the majority of field work concentrated in the spring and summer of 1999 and the spring of 2001. Turtles were caught by hand. Upon first capture, each turtle was weighed with a Pesola scale (± 2 g) and carapace length (CL) and width and plastron length (PL) and width were measured with vernier calipers (± 0.5 mm). The number of growth lines were counted (when possible) on the left humeral or pectoral scute of the plastron. Unmarked turtles were notched using the system used by Chippindale (Cagle 1939). The sex of adults was determined by examining secondary sex characteristics: males have a pronounced concave plastron and the vent is posterior to the carapace's edge. Raw data are on file with the

Natural Heritage Information Centre of the Ontario Ministry of Natural Resources in Peterborough.

Telemetry equipment obtained from Holohil Systems (Carp, Ontario) consisted of modified SI-2 transmitters. The transmitters were approximately 10×30 mm and weighed 10 g. Only turtles weighing approximately 200 g or more had transmitters attached to them. Transmitters were attached to the posterior marginal scute above the hind leg of the turtle using brass screws. Turtles were tracked using a TRX-2000S receiver and a three-element folding Yagi antenna.

Spotted Turtle movements were confined to channels within the bog, hence area was not meaningful and home range lengths were calculated. Summer range lengths were defined as the maximum straight line distance crossing the mapped observation points during May to July. Total range lengths included the hibernaculum in the calculation. Adult population size and the 95% binomial confidence interval were calculated using the program CAPTURE (Rexstad and Burnham 1992*). Size at maturity was based on the smallest turtle I caught that was first marked in 1983. This female was 97.2 mm CL and a minimum of 28 years old in 1999, based on the presence of 12 growth lines in 1983. The smallest male with obvious secondary sexual characteristics was 100.5 mm CL. Statistical analyses were conducted using MINITAB (Ryan and Joiner 1994). Although Chippindale marked 49 Spotted Turtles (Chippindale 1989) data are only available on the 39 turtles marked in 1983 and 1984 (Chippindale 1984*, 1985*). Research was conducted under the approval of the Wildlife Animal Care Committee of the Ontario Ministry of Natural Resources, protocols #99-52, 00-52, 01-52.

Results

I caught 32 Spotted Turtles, 27 of which were adults (Figure 1). The sex ratio of adults was strongly female biased (21 females to 6 males; 3.5:1; $\chi^2 = 8.3$, $p < 0.005$). The average CL of adult males (108.5 ± 5.7 mm, $n=6$) and adult females (106.4 ± 6.0 mm, $n=21$) did not differ significantly ($t=0.79$, $p=0.45$). Similarly, the average weight of males (187 ± 21 g, $n=6$) and females (192 ± 30 g, $n=21$) did not differ significantly ($t=0.49$, $p=0.64$). The average CL of adults from Mer Bleue (106.9 ± 5.9 mm, $n=27$) and elsewhere in Ontario (121.4 ± 7.4 mm, $n=26$; Haxton 1998) differed significantly ($t=7.92$, $p < 0.0001$).

The adult population size was estimated to be 45 (95% confidence interval: 34-78) using the 1999-2001 and 58 (95% confidence interval: 41-108) using Chippindale's 1983-1984 data.

Fourteen of the adults (52%) I captured were marked by Paul Chippindale in 1983. While 67% of the males caught had been previously marked, only 48% of the females were marked. I did not recapture any of the six turtles Chippindale marked in 1984. Twelve of the adults I caught were marked as adults in 1983, hence

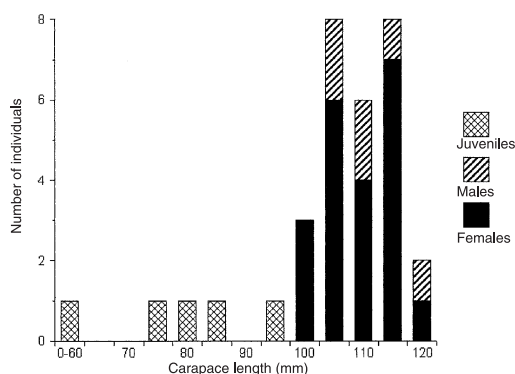


FIGURE 1. Frequency distribution of Spotted Turtles captured at Mer Bleue Bog, Ontario in 1999 and 2001.

a minimum of 40% of the adults marked in 1983-1984 were still part of the population 16 years later. In contrast, I captured only 22% of the juveniles marked by Chippindale in 1983-1984. Although the five smallest turtles Chippindale marked were not recaptured there was no statistically significant difference in the size of the turtles recaptured versus those not recaptured ($W=310.0$, $p=0.52$).

The average size of nine adults marked in 1983 (105.6 ± 6.0 mm CL) and recaptured during 1999-2001 (106.3 ± 5.9 mm CL) did not differ significantly over time ($t=0.28$, $p=0.79$; Figure 2). Two juveniles captured during both time periods grew an average of 7.3 mm (Figure 2). The number of growth lines on seven adults caught in 1983 (12.9 ± 2.0) and in 1999 (14.0 ± 2.3) did not differ significantly over time ($t=0.93$, $p=0.37$). Based on the number of growth lines in 1983 and the elapsed time until they were recaptured, these turtles average a minimum of 28.9 years and one turtle was at least 33 years old. There is no reason to assume the number of growth lines in 1983 accurately reflected ages and hence it is likely that these turtles are even older.

Growth data were also collected on one yearling caught on two different occasions. On 20 May 1999, the turtle was 28.4 mm CL and 23.0 mm PL. It was recaptured 41 days later, at which time it was 33.3 mm CL and 26.8 mm PL, an increase of 0.12 mm/day CL and 0.09 mm/day PL.

I tracked one male and two females periodically during the summer and fall of 1999 using radio telemetry. The number of observations for each turtle varied from 9 to 10. Turtles appeared to remain within small aquatic channels surrounding and connecting the islands in the bog mat. Summer range length averaged 233 m (range: 200-275 m) and total range length averaged 327 m (range: 275-375 m). All three turtles hibernated outside of their summer range.

On 15 November 1999, after the turtles had entered hibernation, all three turtles bearing radio transmitters

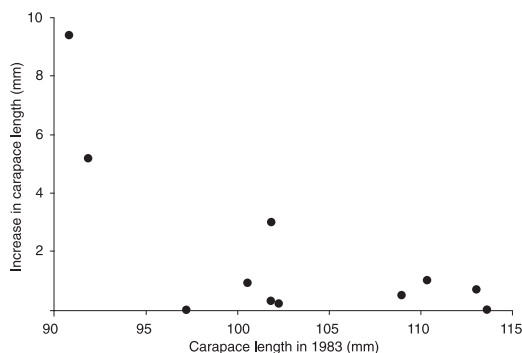


FIGURE 2. Growth of Spotted Turtles marked originally in 1983 and recaptured in 1999 or 2001 at Mer Bleue Bog, Ontario.

were tracked to the same shrubby hummock. It is highly unlikely that only Spotted Turtles with transmitters chose to overwinter in this hummock and this site likely represents a major communal hibernaculum for this population. On 10 April 2001, with some snow still on the ground, six turtles were caught in the vicinity of the known hibernaculum: one turtle was within 10 m of it, while the other five were approximately 30 m from it around another hummock. One of these turtles had overwintered at the known hibernaculum in 1999.

Discussion

Monitoring turtle populations for conservation purposes is challenging. Abundance estimates for adults alone are inadequate to determine the viability of populations given the longevity of adults, hence reproductive rates and age structures should also be monitored (Gibbs and Amato 2000). In the current study, the adult population at Mer Bleue may have declined by 20% (from 58 to 45) from 1983 to 2001, although this decline is not statistically significant. At the same time the sex ratio became increasingly female biased. Based on the population estimates and sex ratios for the two time periods, there were approximately 35 females and 23 males in 1983-1984, and 35 females and only 10 males in 1999-2001. This suggests a decline in the number of adult males; however, it is also possible that these missing males are merely undetected due to differential catchability. The confirmed presence of juveniles recruited into the adult population and the ongoing presence of juveniles is suggestive of a healthy population. Nonetheless, uncertainty remains: assuming that the 1983-1984 adult population estimate is approximately correct, then I captured roughly 47% of the adults in 1999-2001. Despite having data on roughly half of the adult population it is not possible to determine if the population has declined by 20%.

The age of turtles has often been estimated by the use of growth lines on the plastron, yet few studies have tested the validity of this method. Adults marked at Mer Bleue in 1983 showed essentially no growth or increase in the number of growth lines over 16-18 years. Similarly, Litzgus and Brooks (1998a, 1998b) found adult Spotted Turtles did not grow appreciably and that the number of growth lines added was consistently less than the number of years that had elapsed. Even in subadult turtles, growth lines are not always produced annually (Brooks et al. 1997). Hence, growth lines appear to be of little value in estimating age after maturity has been reached.

An average total home range length of 327 m is similar to mean home range lengths of 302 and 320 m for two populations of Spotted Turtles in Massachusetts (Milam and Melvin 2001). Maximum total range length in the current study was only 375 m, whereas it was over 1000 m elsewhere in Ontario (Haxton 1998) and in Massachusetts (Milam and Melvin 2001). The difference in movements is likely explained by differences in habitat. Turtles at the other sites were moving among wetlands, whereas the Mer Bleue turtles are confined to the centre of one large bog.

Spotted Turtles at Mer Bleue demonstrate fidelity to a hibernation area, however, not necessarily to the same hibernaculum. Similarly, nine Spotted Turtle hibernacula with up to 34 individuals were found in an 85 m² area of a fen in Ohio (Lewis and Ritzen-thaler 1997). Results from the previous study at Mer Bleue suggest the known hibernation area has been used since at least the winter of 1983-1984 (Chip-pindale 1985*). Such fidelity to a hibernation area emphasizes the importance of certain habitats. At Mer Bleue, a circle with radius 400 m centred on the known hibernation area would enclose the activity areas of the three turtles with transmitters. Given the fact that there was very little movement of turtles among some of the islands and that turtles have been captured at other areas of the bog early in the season, it is most probable that there is more than one hibernation centre. Other studies of Spotted Turtles also support the notion of multiple hibernation centres. Individuals in one population hibernated in at least three different small bogs (Haxton and Berrill 1999), while in another population 18 hibernacula were found in five different sphagnum swamps (Litzgus et al. 1999). Effective management of Spotted Turtle populations should focus on identifying and ensuring the protection of all major hibernacula and the habitat that connects them.

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