Ecology of *Thamnophis sauritus* (Eastern Ribbon Snake) at the Northern Limit of its Range

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Abstract - In Canada, *Thamnophis sauritus* (Eastern Ribbon Snake) is found only in southern Ontario and a small area of southwestern Nova Scotia. Although the Nova Scotia population is nationally designated as threatened, its distribution, seasonal activity, movement patterns, and over-wintering sites remain undescribed. We used radio-telemetry, capture-mark recapture, and direct observation to: 1) assess abundance, summer activity, and movement; and 2) to locate and characterize a hibernaculum for Eastern Ribbon Snakes in Kejimkujik National Park, NS. A total of 105 individuals were marked; among these, 13 free-ranging adults were surgically implanted with radio-transmitters and tracked from June until mid-November 2001. From late May to September, snakes were always found within 5 m of water, with summer ranges on land that rarely exceeded 5 x 10 m. From September to mid-October, snakes moved up to 173 m away from the shoreline. Eleven observations of snakes feeding on anurans (Ranidae) and fish (Cyprinidae) were made at temporary pools, marginal to the lake. Despite the use of radio-telemetry, only one hibernaculum was found. Our observations indicate that the Eastern Ribbon Snake is relatively sedentary; its low activity rate and small activity range may make it vulnerable to local extinction.

Introduction

In Nova Scotia, *Thamnophis sauritus septentrionalis* Rossman, northern subsp. (Eastern Ribbon Snake) is apparently restricted to a narrow range of habitats in two watersheds in the southwest interior (Gilhen 1984). This highly disjunct, post-glacial relict population was recently designated as threatened (COSEWIC 2002), primarily due to its small size and range, its susceptibility to environmental and demographic stochasticity, and its potential for divergence.

Elsewhere, ribbon snakes are diurnal, semi-aquatic, and normally found along the water's edge, amongst dense vegetation. Amphibians constitute their main prey (Rowe et al. 2000) although different diet profiles have been reported for different localities (Carpenter 1952, Tinkle 1957). It is not clear whether this is due to regional differences in preference by snakes or differences in prey availability at different sites. The Eastern Ribbon Snake is viviparous; mating occurs following emergence in spring (Clark 1974, Tinkle 1957), although fall mating has also been suspected in Nova Scotia (J. Gilhen, Nova Scotia Museum,J. Gilhen, Nova Scotia Museum, Halifax, NS, Canada, pers. comm.).

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Despite the species' threatened status in Nova Scotia, its distribution, seasonal activity and movement patterns, and over-wintering sites remain largely undescribed. At the northeast edge of the species' range, this population is subject to long, harsh, and variable winters and short, cool summers, which may constrain reproduction and survival (Gregory and Larsen 1993, Larsen et al. 1993). To better gauge the risks that this population faces, we used radio-telemetry, capture-mark-recapture, and direct observation to assess abundance, summer activity, and movement, and to locate hibernacula for ribbon snakes in Kejimkujik National Park, NS.

Materials and Methods

Study site

Fieldwork was conducted from mid-May to mid-November 2001, at Grafton Lake, Kejimkujik National Park (KNP; 38,100 ha), in southwestern Nova Scotia (44°23'N, 65°11'W). Grafton Lake was dammed from 1938 until 1996; in 1996, the dam was breached in an effort to restore the lake and surrounding habitats to pre-dam conditions, including natural water levels and fluctuations. The sampling area encompassed approximately 33.5 ha of wetland adjacent to the outlet of the lake. The site was chosen because of a concentration of previous sighting reports and ease of access.

The terrestrial portion of the sampling area chiefly comprised emergent lakebed with slate outcrops, granite erratics, tree stumps, and rapidly revegetating organic sediment dominated by *Spartina pectinata* Bosc ex Link (prairie cordgrass), *Scirpus* spp. (bulrushes), *Typha* spp. (cattails), and *Anaphalis margaritacea* (L.) Benth. (common pearleverlasting). *Pontederia cordata* L. (pickerel weed), *Nymphoides cordata* (Ell.) Fern. (little floating heart), *Nuphar variegata* Dur. (variegated yellow pond-lily), and *Nymphaea odorata* Ait. (American waterlily) were the dominant aquatic species.

Snake sampling

Snakes were first located by systematic visual sweeps from the edge of the forest margin to Grafton creek, just upstream of the breached dam. The water's edge and adjoining flood plain were intensely searched. Snakes were hand-captured, sexed, photographed, and measured. Snout-vent length (SVL) was obtained using a measuring tape while the animal was extended. Body mass (BM) was obtained by placing the animal in a mesh bag and suspending it from a hanging scale. Eastern Ribbon Snakes were marked individually by clipping ventral scales (Brown and Parker 1976). Young-of-the-year (YOY) were marked with a non-toxic permanent marker, instead of scale clipping, due to the small size of their ventral scales. Individuals were placed in one of three categories (adult, juvenile, or YOY) based on SVL and BM. A subset of animals was implanted with radio-transmitters (see below).

A Garmin GPS III Plus handheld global positioning systems unit (Romsey, UK and Taipei, Taiwan) was used to reference initial capture or sighting localities, and also served as a reference when snakes were released following radio-transmitter implantation. GPS locations were also collected for all recaptures and relocations; however, the GPS sensitivity was too low to represent the limited movements of these snakes.

Sampling began on 22 May 2001 and concluded on 10 November 2001, with 52 days of extensive sampling distributed relatively evenly from late May to early September, as follows: May (3 d), June (12 d), July (17 d), August (15 d), and September (5 d). Additional, less extensive sampling occurred from May to November 2001. We typically surveyed for snakes between 0900–1700 h ADT in all habitat types within the study area. Sampling effort was not uniform, since some non-telemetered snakes were coincidentally located while tracking animals with transmitters. Thus, survey procedures were probably biased toward microhabitats favoured by snakes.

All feeding events were directly observed; no snakes were captured and forced to regurgitate food items. Dietary determination was also done by observation of natural feeding events. During these feeding events, the observer was never closer than 2 m from the subject, which is why prey were not identified to the species level. Thermal data were also collected throughout the season, but are not reported here except in relation to hibernacula use.

Radio-telemetry

Temperature-sensitive radio-transmitters (model BD-2G; Holohil Systems Limited, ON, Canada) were surgically implanted in eleven females and two males. Transmitter mass was < 5% of a snake's BM and had a diameter significantly smaller than that of the individual, following the guidelines for transmitter use outlined in Reinert and Cundall (1982). The whip antennas were shortened to 14 cm and sealed with 100% silicone rubber aquarium sealant 2–3 days prior to surgery. Surgeries were performed under lidocaine anesthesia.

The telemetry study included two stages: summer—assessment of summer activity and movement; and fall—location of hibernacula. For summer, transmitters were implanted in six gravid adult females between 7 June and 28 June 2001, and snakes were tracked from June to the end of August 2001. The transmitters for this stage weighed 1.95 g, with a battery life of 16 weeks at 30 °C. Snakes were recaptured 10–14 days after surgery in order to remove the non-dissolvable nylon sutures. For fall, transmitters were implanted in five adult females and two adult males between 5 September and 14 September 2001, and snakes were tracked from September to mid-November 2001. These transmitters weighed 1.06 g, with a battery life of 7 weeks at 35 °C. Dissolvable sutures were used

with these snakes to ensure rapid and efficient postoperative healing in preparation for hibernation.

Following surgery, snakes were monitored in the lab for 3–5 days to allow for postoperative healing. During this period, snakes were provided water *ad libitum* and fed 4–5 *Rana pipiens* Schreber (Northern Leopard Frog) tadpoles to ensure that they had normal feeding behaviour. Subsequently, the snakes were released at their original capture localities. No evidence was found in captivity, nor in the field, to suggest that the transmitters hampered the snakes' movement in any way.

All radio-transmitters were in the 172-MHz frequency band with an anticipated range of 1.0 km. Tracking was done manually using a Wildlife Materials International Inc. (Carbondale, IL) model TRX 1000S receiver with a handheld, 3-element Yagi antenna.

Results

Capture patterns and abundance

The first sighting of a snake occurred on 30 May 2001, and the last transmitter signal was obtained on 8 November 2001. A total of 105 snakes (53 males, 52 females; 13 telemetered, 92 non-telemetered), including nine YOY, were individually marked at the study site. Snakes were active from late May through late September.

From extensive sampling on 52 of 110 days between 22 May and 9 September, 40 of the 96 (42%) individually marked snakes (non-YOY) were recaptured at least once. Recapture frequencies, excluding those from radio tracking, ranged from 0–6 per individual. Capture frequency was unrelated to body size (SVL; $r^2 = 0.027$, $F = 2.598$, $P > 0.11$), but males were recaptured more frequently than females (male: mean = 2.42, median = 2; female: mean = 1.36, median = 1 total captures/individual; Mann-Whitney $U = 686.5$, $P < 0.002$). Monthly sex ratios (May–September) did not vary from unity (χ^2: df = 4, P = 0.903).

Intervals between consecutive captures of non-telemetered, marked snakes during that period, with all recaptured individuals pooled, ranged from 1–56 d (mean = 10.3, median = 6). When mean capture intervals were calculated per individual and a frequency distribution among individuals was generated, the pattern was similar to the pooled sample (mean = 11.0, median = 7.6). Among recaptured individuals, the time between the first and last sighting ranged from 2–103 d (mean = 30, median = 20).

Capture frequencies (non-YOY, male and female combined) during this sampling period fit a theoretical geometric distribution (*G*-test goodness of fit: $G_{adj} = 8.29$, $P \approx 0.217$). Based on this distribution, the population within the sampling area was estimated from frequency of capture (Caughley 1977) to be ≈ 197. Chao's Method (Chao 1988) yielded a similar estimate, i.e., 188 (95% CI = 141–284). Converting to population density, this translates to 5.6–5.9 snakes/ha.