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Radio Telemetry and Post-emergent Habitat Selection of Neonate Box Turtles (Emydidae: *Terrapene carolina*) in Central illinois

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Although factors influencing turtle offspring prior to nest emergence have received considerable attention by researchers (Gutzke and Crews 1988; Janzen et al. 2000; Packard and Packard 1987), the activity of neonates following their emergence from the nest is poorly understood (but see Burger 1976; Butler and Graham 1995; Keller et al. 1997). Previous field research has produced valuable information on several aspects of neonate ecology for several species (Brewster and Brewster 1991; Butler and Sowell 1996; Janzen 1993). However, a thorough understanding of life history patterns for many species is absent, and some existing information is conflicting (e.g., Congdon et al. 1999; Janzen et al. 2000). The lack of knowledge is primarily due to the cryptic nature of neonates and various logistical problems associated with studying small animals in the field. Recent advances in radio telemetry technology such as decreased transmitter size and increased battery life facilitate tracking small neonate turtles for a longer duration.

We studied nest dispersal and habitat use in neonate box turtles using a relatively new, very small radio transmitter. Few studies have been conducted using telemetry on neonate turtles (e.g., Butler et al. 1995), and none has focused on nest dispersal and habitat use of neonate box turtles.

The study was conducted at Rhodes-France Boy Scout Reservation (RFBSR) located in western Shelby County, Illinois, USA (39°19'N; 89°02'W), from March to April 2002. Two nests were located by radio tracking gravid female turtles during summer 2001 (Flitz 2003). The nests were sited in relatively open areas next to a tree stump in a grassy field and at the edge of a fire trail (see Flitz 2003 for more description). Nest disturbance was prevented by using excluder devices, made of hardware cloth of 0.6 cm^2 mesh and 30 cm diameter with walls buried 15 cm into the ground, around the nest until the end of the 2001 activity season. Upon hatching and emergence, neonate turtles from both nests (clutch sizes were 4 and 5, respectively) were collected, brought to our laboratory and allowed to overwinter in an outdoor enclosure (1.5 x 1.5 m) under ambient conditions. Each turtle was marked with a unique series of notches in the marginal scutes. This facilitated identification and placement back at the proper nest site the following spring.

After overwintering, single-stage radio transmitters (model LTM, Titley Electronics, Australia; 0.95 g) were attached to the carapace of six randomly chosen neonates (three from each clutch) using a non-toxic silicon adhesive (Fig. 1). Each transmitter cost approximately US $170, had an average lifespan of 28 days (pers. obs.; D. Titley, pers. comm.), and did not contain a thermistor. We relocated the subjects using a Telonics TR2 receiver (159.000-160.000 MHz) and a 6-element Yagi antenna. On average, the transmitter represented 13.4% of individual body mass (mean ± 1 S.E. mass of neonates = 7.11 ± 0.10 g). At the time we designed this study, the LTM model was the smallest transmitter of this longevity being manufactured for attachment on turtles. We concede that this mass exceeds normal guidelines for relative mass of transmitters (usually 5–8%, and rarely up to 10%; Cochran 1980; Richards et al. 1994); however, we did not observe differences in the mobility of neonates outfitted with these transmitters (discussed below).

On 30 March 2002, all neonates were returned to their respective nest sites at RFBSR and allowed to disperse. Each neonate was located 15 times between 0900 and 1700 h on an alternate day cycle (study duration = 32 days), and locations were marked with forestry flags. Upon relocation, air temperature at 1 m above ground (±1° C), and distance (±1 cm) and compass bearing from the previous location were recorded. Many movements were of small magnitude and were within the margin of error of most handheld Global Positioning System units, so we did not take GPS

TABLE 1. Mean distances moved between relocations (m ± 1 S.E.) and microhabitat characteristics (of a 1 m^2 plot centered at point of relocation) for telemetered neonate box turtles (*Terrapene carolina*) at Rhodes-France Boy Scout Reservation (RFBSR), Shelby County, Illinois, between 30 March and 27 April 2002. Means are based on values recorded at 15 relocation points per subject and 75 randomly-selected sites at RFBSR.

	Feature of microhabitat							
Subject #	Distance moved (m)	% bare ground	% leaf litter	% herbaceous vegetation	% woody vegetation	% canopy closure	vegetation height (cm)	light intensity (lux)
202	1.14 ± 1.40	11.9	58.4	28.6	1.3	41.6	5.6	504.9
203	1.14 ± 1.39	48.3	34.5	12.2	5.0	61.3	7.7	442.9
204	2.35 ± 1.37	22.0	39.7	33.0	6.0	31.0	7.0	512.1
random	n/a	15.5	26.6	47.2	10.9	71.3	37.4	138.7

readings. If the turtle moved less than 30 cm from the previous location, the exact distance was recorded but we did not mark the new position with another flag to minimize the physical obstructions within the immediate vicinity. We also recorded the following parameters in discrete categories at each relocation: sky condition (full sun, some cloud, most cloud, full cloud), amount of subject exposure (full exposure, partially concealed, fully concealed, buried), and subject activity (stationary, walking, eating, other).

On 30 April 2002, we revisited all relocation points and completed an analysis of the habitat within a 1-m area centered around each point (methodology follows Flitz 2003; Wilson 1998). The following measurements were recorded: % bare ground, % leaf litter, % herbaceous cover, % woody vegetation, % canopy cover (recorded using a densiometer), maximum vegetation height (± 1 cm), and light intensity at the ground surface (in lux; Extech Instruments light meter). Values for these parameters were compared to those measured at 75 randomly chosen sites within RFBSR recorded in April 2001 (Flitz 2003). Between 2001 and 2002, we did not observe drastic changes in vegetation characteristics and the pattern of human use of RFBSR remained the same.

FIG. 1. Neonate (36 days post-emergence) box turtle, *Terrapene c. carolina*, with 0.95 g transmitter. Glossy area on turtle's left dorsolateral surface is area where transmitter had been attached with silicone adhesive.

Three turtles from the same clutch had moved less than 0.5 m in the first five days following their release. On the sixth day, the transmitters were discovered without the turtles within 0.5 m of their last locations. The presence of marks resembling tooth impressions on the resin casing of the transmitters suggests that a mammalian predator had eaten these subjects. Because of this, we discarded all data from the predated subjects and base the remainder of our results on the remaining three neonates. The remaining telemetered turtles survived the duration of the study, and one of the non-telemetered turtles was observed 18 days into the telemetry period within 10 m of its nest location.

The total distance moved by our subjects during the study averaged 21.94 ± 5.46 m. Distances moved between relocations ranged from 0 to nearly 7.5 m, although the mean distance moved was on the lower end of that scale (Table 1). Minimum convex polygon estimates of home ranges averaged 39.96 ± 27.00 m^2 (Jennrich and Turner 1969). These home range areas are based on a limited sample (15 relocations per individual) and thus should be interpreted with caution. Subjects moved within the area around the nest site and were most often encountered motionless underneath a layer of leaf litter (36 of 43 observations). Air temperature at the time of relocation ranged from 9 to 27°C. The relationship between temperature and distance moved were not determined because subjects could have moved at any time between two relocations.

Sites where we relocated our subjects had less canopy closure ($c^2 = 44.8$, $p < 0.001$) and higher light intensity ($c^2 = 41.6$, $p < 0.001$) than randomly-chosen locations within RFBSR (Kolmogorov-Smirnov tests; Table 1). Light intensity was inversely correlated with canopy closure ($r^2 = 0.22$, $p = 0.001$) and we recorded higher air temperatures at the time of relocation at sites with higher light intensity ($r^2 = 0.11$, $p = 0.03$). Of the measured microhabitat characteristics, subjects were found in sites that had more leaf litter ($c^2 = 11.2$, $p = 0.007$), less herbaceous cover ($c^2 = 16.7$, $p < 0.001$), and shorter vegetation height ($c^2 = 28.1$, $p < 0.001$) than random sites. Relocation sites did not differ from random locations in the percent bare ground or percent woody vegetation available.

Following their emergence from the nest, neonate box turtles at RFBSR used habitats having characteristics that differed from randomly-selected areas. In the days immediately following emergence from the nest, this pattern of use was likely influenced by the nest site itself. As elsewhere (Congello 1978; Messinger and Patton 1995), female box turtles at RFBSR tend to excavate their nests in relatively open habitat (see Flitz 2003 for quantified habitat parameters). Regardless of the structure of emergent vegetation, we relocated the neonates most often within the leaf litter layer. We observed one neonate in the entrance of a mole burrow, and found another occupying a shallow depression under the leaves. Similar postures, occasionally termed "forms," have been recorded in neonate semi-aquatic turtles (Butler and Graham 1995) and adult *T. carolina* (Flitz 2003; Stickel 1950). In the early part of the activity season (e.g., April), leaf litter might provide some insulation from cool air currents above the leaves or concealment from predators.

Radio telemetry of amphibians and reptiles historically has been constrained by the size and mass of the transmitter. Whether implanted or affixed to the animal's surface, the concern has been that the subject mobility would be impaired by the transmitter's bulk (Fitch 1987; Richards et al. 1994). In spite of losing half of our test animals, we do not think that the LTM transmitters impaired the movements of neonate box turtles. We observed each of the neonates moving within the leaf litter layer without hindrance from the transmitter or its antenna. Transmitters of this size and style would probably be suitable for other small turtle species. Construction of a similar transmitter with a longer battery life would be most useful to better assess microhabitat selection and activity of neonate turtles without undue disturbance.

Our data represent only three individuals of a single *T. carolina* clutch. Nevertheless, they provide information on the activity of a poorly-studied life history stage of a turtle species that is encountered across much of the eastern United States. As the survival of pre-adolescent individuals is essential to ensure the persistence of any species, we hope to encourage further study of early life history stages with the technology that has recently become available and affordable. Furthermore, as neonate turtles might utilize habitat that differs from juvenile and adult areas of activity (Butler and Graham 1995; Dodd 2001), conservation efforts for some turtle populations may be overlooking habitat types that are critical to the species' survival.

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