# USE OF RADIO-TELEMETRY AND RECAPTURE TO DETERMINE THE SUCCESS OF HEAD-STARTED WOOD TURTLES (GLYPTEMYS **INSCULPTA) IN NEW YORK**

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Abstract.—We radio-tracked three cohorts of head-started Wood Turtles (Glyptemys insculpta) hatched in 1994, 1998 and 1999 for two years each. We released six turtles as one-year olds and four as twoyear olds, all with a minimum mass of 130 g. We attached an Advanced Telemetry Systems 357 or R1680 transmitter weighing 3.8–4.7 g to each turtle. To attain this pre-release mass without the shell abnormalities sometimes associated with rapid growth, we developed the "Michell Protocol," which consisted of maintaining the hatchlings on a moist peat moss substrate with incandescent lighting at a temperature of 22–26°C and feeding only softened Reptomin<sup>®</sup> to avoid food preferences. We placed juveniles in a predator-proof outdoor acclimation enclosure in the spring preceding their release. We used three release locations in the 1.5 km study stream at known Wood Turtle hibernacula. Regardless of release location, all 10 turtles migrated to a portion of the stream adjacent to a meadow dominated by Goldenrod (Solidago spp.), Hay Scented Fern (Dennstaedtia punctilobula), Stinging Nettle (Urtica dioica), Speckled Alder (Alnus incana subsp. rugosa), Multiflora Rose (Rosa multiflora) and Winterberry (Ilex verticillata) prior to the end of their second year in the wild. During the two years we tracked the 10 turtles, survivorship was 100%. We conducted spring emergence surveys in the meadow and we made recapture observations of the head-started turtles.

Key Words.—Glyptemys insculpta; release; survivorship; transmitter; growth; hatchling

### INTRODUCTION

This head-starting study began incidentally through a series of events beginning with the initiation of a mark and recapture study in 1994 by the second author of two stream systems with Wood Turtles (Glyptemys insculpta). A nesting female was encountered laying eggs at an active quarry site near the stream. The clutch of 10 eggs was recovered and incubated following the protocol of John Behler (pers. comm.). Nest predation and hatchling mortality of turtles in the wild are both reported to be high (often in excess of 80%; Fowler 1979; Harding and Bloomer 1979; Brooks et al. 1992). Our initial surveys of the tem we studied is a southeast to northwest flow-

study stream revealed nearly 100% annual nest predation with no observations of juveniles. Because of this, we decided to head-start the hatchlings following a protocol that we developed and used successfully on Eastern Box Turtles (Terrapene carolina). We monitored turtles post release using a combination of radio telemetry and recapture observations to determine whether the head-started turtles were capable of withstanding the challenges of being returned to the wild.

### MATERIALS AND METHODS

Study site and turtles used.—The stream sys-

eastern New York, USA. Besides having an extant Wood Turtle population, the stream is used by White Sucker (Catostomus commersonii) for spawning, further evidence of its high quality water. The stream had a limited number of property owners providing ease of access for monitoring. A former meadow at the southeast end had been dammed into a 1.2 ha pond by American Beaver (Castor Canadensis) 20 y earlier. White Pine (Pinus strobes) bordered most of the shoreline, which is comprised of wetland with large sphagnum beds. The stream had a mixed sand and cobble bed and flows northwest for 1.5 km through mixed deciduous woods with Eastern Hemlock (Tsuga canadensis) and Rhododendron (Rhododendron maximum) along the stream banks. Most of the exposed root systems along the undercut banks used as hibernacula by Wood Turtles are comprised of these dominant conifers in the wooded portions of the stream. Near the southern end of the stream is a meadow of approximately 1 ha, which was determined to be the most heavily used habitat for this population, particularly the juveniles that spent most of their active season there. At the northwest end of this stream is a shallow man made pond of about 2 ha created for ice harvest in the 1800s. Although adult study turtles from this stream used the ponds and habitat beyond them, the headstarted juveniles confined their movements to this 1.5 km corridor.

We hatched from eggs three cohorts of Wood Turtles used in this study. We collected these eggs from nests that would otherwise have likely failed. We salvaged a clutch of 10 eggs from an active quarry in 1994. The second clutch consisted of three eggs left on the surface by a female digging out the nest of another female in 1998. We collected the third clutch of five eggs in 1999 from a monitored nest located on a road shoulder in a red shale substrate containing no soil, which resulted in the eggs beginning to collapse from the heat and lack of moisture. We placed all eggs in depressions in a substrate

ing stream located at 41°N, 74°West in southeastern New York, USA. Besides having an extant Wood Turtle population, the stream is used by White Sucker (*Catostomus commersonii*) for spawning, further evidence of its high quality water. The stream had a limited number of property owners providing ease of access for monitoring. A former meadow at the southeast end

> Head-start protocol.—After the turtles hatched, we placed them in a 30 Quart Sterilite<sup>®</sup> (Sterilite Corporation, Townsend, Massachusetts, USA) opaque plastic container (55 x 40 x 33 cm). The substrate consisted of 6–8 cm of thoroughly moistened peat moss with small clusters of fresh sphagnum in several locations for additional cover. We saturated the peat moss initially and then wrung it out by hand to create a suitable moisture content. We sprinkled the surface of the substrate regularly to prevent any drying and/or dusty conditions. We recessed two appropriate sized durable plastic plant saucers into the peat moss to provide water and to facilitate cleaning. We then lifted the saucers out and cleaned as needed, often more than once daily. For hatchlings, a saucer 2 cm deep by 14 cm in diameter was suitable. As the turtles grew, we increased the saucer size accordingly. To maintain a humidity of 75-85%, we used the lid of the container as a cover with a slot cut into the center of the lid approximately 10 cm wide by 50 cm long. We placed an aquarium hood light, without a glass cover, containing two 15 Watt incandescent aquarium bulbs loosely over the slot. To maintain a temperature gradient within the container of 22-26 °C in a room with an ambient winter temperature of 21–22 °C we kept the lights on 24 hours. We fed the turtles once daily as much as they would eat of  $\operatorname{Reptomin}^{\mathbb{R}}$ (Tetra GmbH, Melle, Germany), which was soaked in warm water until thoroughly softened, drained, and then placed in a pile on a flat plastic lid on the substrate. No reptile vitamins or dietary supplements were added to the food. To help prevent aggressive behavior such as

leg and tail biting, we maintained no more than five turtles in each set up. We weighed the turtles periodically. In addition to the study turtles, we used this head-start protocol for six donated hatchlings (from the Cold Spring Harbor Aquarium) reared for a repatriation study by the New York State Department of Environmental Conservation.

Prior to release into the study stream, we placed the juvenile Wood Turtles in predatorproof outdoor enclosures constructed of plywood and hardware cloth, measuring  $122 \times 183$  cm or 122 cm square. A partial roof allowed for both sun and shade. We moved the turtles into the outside enclosures sometime during June, depending upon weather conditions. Acclimation ranged from four to six weeks. During this time we introduced natural foods such as earthworms, slugs, and insects, which were taken readily. We did not provide the 1999 cohort with natural food prior to release.

Release, telemetry, recapture.—We released five of the eight head-starts from the 1994 cohort as one-year olds back into their natal stream with no follow-up study due to limited resources for this study. We radio tracked 10 head-started juveniles from the three cohorts with an objective to follow their movement for two years to determine their survivorship post-release. Six were released as one-year olds and four were released as two-year olds to determine whether there was any significant difference in survival. Three different release locations were used in this study, all known to be Wood Turtle hibernacula. Prior to release the turtles were fitted with Model 357 ATS (Advanced Telemetry Systems Inc., Isanti, Minnesota, USA) transmitters weighing 3.8-4.7 g. This model transmitter was later changed to R1680 with the same configuration but at the lighter end of the weight range. Transmitters weighed  $\leq 3\%$  of the weight of the turtle and were attached with Devcon<sup>®</sup> 2-Ton Waterproof Epoxy (Illinois Tool Works Inc., Riviera Beach, Florida, USA). The location of the transmitter



**FIGURE 1.** One year-old head-started Wood Turtle (*Glyptemys insculpta*) fitted with 4 g transmitter.

was in the "shadow" of the posteriolateral carapace so that the turtle was no higher or wider with the transmitter in place (Fig. 1). This was to avoid any potential for entrapment under root systems, brush piles, rock crevices or tunnels; all habitats that were frequented by the study turtles. The transmitters were equipped with a semi-rigid trailing antenna 10 cm in length and positioned with the antenna angled 30° from the ground. Model TRX1000S<sup>®</sup> and TRX2000S<sup>®</sup> (Wildlife Materials Inc., Murphysboro, Illinois, USA) were used with a Yagi three element folding directional antenna to radio track the turtles.

The two one-year olds from the 1994 cohort were initially tracked twice daily the first week until we had a general idea of what kind of behavior to expect so as not to lose signals. After one week, we tracked turtles once a day for an additional week and then approximately twice per week for two field seasons. The two-year old from that cohort was tracked for one field season. We checked the signals several times during hibernation to confirm transmitter function and document any movement. The 1998 cohort of three one-year olds were tracked approximately every three days for two active seasons. The one-year old and three two-year olds from the 1999 cohort were tracked less regularly for three years. Location data, time, weather conditions, turtle activity, approximate distance from the study stream, level of crypsis and habitat used were recorded. Once

a turtle was located, we retreated a few meters to minimize any possibility of altering the behavior or movements of the turtle. We conducted this study as non-invasively as possible; in general the only handling and/or measurements were performed while changing transmitters. Following the initial telemetry studies, we conducted annual spring surveys along the stream corridor to identify head-started turtles by their unique notch codes. When available, transmitters were attached to obtain additional data on the behavior of the head starts as they became sub-adult and adult.

#### RESULTS

All hatchling Wood Turtles in the three cohorts weighed between 9.0-9.5 g. The turtles grew rapidly and uniformly to a size capable of carrying the 3.8–4.7 g transmitters after 10 mo without exceeding a load of 3% of their body weight. None of the abnormal shell growth or malformation often anecdotally attributed to rapid growth in chelonians was observed. The juveniles fed voraciously on the softened Reptomin<sup>®</sup>. When not feeding or immersed in their water dishes, the juveniles spent most of their time buried in the substrate, totally hidden from view. Although the incandescent lights were on for 24 hours/day, the turtles cycled their periods of activity and dormancy within that period based on the time of the day when they were regularly fed. Their outward appearance and body proportions matched those of wild juvenile Wood Turtles of the same size, not age.

When the turtles were introduced to the outdoor pre-release acclimation enclosure, they used the natural furnishings such as logs, leaves and vegetation for cover. After only a few days in the enclosure, the turtles became cryptic and would not feed under direct observation. Feeding slowed initially after being moved outside as the turtles spent more time exploring and hiding. Within a week or two they resumed feeding on the Reptomin<sup>®</sup>. When the turtles were visible, they

scurried for cover when the cage was approached. When offered slugs or earthworms, the turtles immediately responded to the movement.

Survivorship while the turtles were tracked was 100%. All three of the 1994 cohort have been observed as adult or sub adult recaptures. Two of three of the 1998 cohort have been observed as adult recaptures. Two of the 1999 cohort of four have been observed as sub adults, one as an adult and one last observed as a three year old.

The 1995 and 1996 movements of the two one year olds are shown on discreetly drawn maps to protect the location of the study stream (Fig. 2 and 3). The juvenile turtles ultimately led us to the meadow location at the south end of the stream that appeared to be the preferred habitat for juvenile Wood Turtles. The release location was close to the north end of the stream. Turtle 94-2 hibernated a short distance upstream from the release site, but was dislodged during a major flood event in January of 1996. After the flood waters receded, the signal was coming from a large (15 m long by 3 m high) debris pile. Turtle 94-2 emerged unscathed in April and commenced an active foraging season while traveling south to the meadow, the apparent preferred foraging and overwintering habitat for this stream system. It was there that Turtle 94-2 hibernated in the fall of 1996 in a communal juvenile Wood Turtle hibernaculum. Turtle 94-1 also hibernated in 1995 upstream of her (recapture has shown this turtle to be female) release site. In 1996 she moved to the meadow area while foraging but traveled downstream to enter hibernation on October 4, 1996. However, on April 4, 1997 she was located in a hibernaculum upstream at the meadow, apparently having moved much later than the other juveniles were active in the fall. We found that the head-started one and two year olds were generally in hibernation or making only very small movements by the end of September and early October, whereas our adult telemetered turtles were active, including mating, through the end of November. The two year old from the 1994 cohort was released at the same site as the one



**FIGURE 2.** Movements in 1995 and 1996 of a head-started Wood Turtle (*Glyptemys insculpta*), #94-1, translocated to a stream site in southeastern New York, USA.



**FIGURE 3.** Movements in 1995 and 1996 of a head-started Wood Turtle (*Glyptemys insculpta*), #94-2, translocated to a stream site in southeastern New York, USA.



**FIGURE 4.** Adult female Wood Turtle (*Glyptemys insculpta*) #98-1, located 18 April 2009 with an old transmitter in place for approximately 8 yr. Note slight deformity of some scutes.

year olds and traveled to the meadow in his first year.

The three one year old head-starts from the 1998 cohort were released at an open area approximately midway along the stream. One reached the meadow in less than a month. The other two hibernated near their release site for the first year and arrived at the meadow in May and June respectively the following spring. We discovered an interesting observation on Turtle 98-1 who was initially tracked for two years. Her third transmitter attached on 19 July 2001 then failed. She was relocated on 18 April 2009 with the old transmitter still in place, resulting in a slight deformity of several scutes (Fig. 4).

The one year old and three two year olds from the 1999 cohort were released at the northern end of the meadow and remained in the general vicinity during the time they were radio tracked. The sub adult and adult recaptures of the head-started turtles have been primarily in the vicinity of this meadow. The predominant plant species in this meadow include: American Red Raspberry (*Rubus idaeus*), European Red Raspberry (*Rubus strigosus*), Black Raspberry (*Rubus occidentalis*), Highbush Blackberry (*Rubus allegheniensis*), Northern Dewberry (*Rubus flagellaris*), Japanese Barberry (*Berberis thunbergii*), Virgin's Bower (*Clematis virginiana*), Multiflora Rose (*Rosa multiflora*), Hay Scented Fern (*Dennstaedtia punctilobula*), Stinging Nettle (*Urtica dioica*), and Goldenrod (*Solidago* spp.). Winterberry or Black Alder (*Ilex verticillata*) and Speckled Alder (*Alnus incana subsp. Rugosa*) line the stream bank of the meadow and provide the root systems in which many of the juveniles hibernated.

#### DISCUSSION

It was of the utmost importance in our attempt to head-start hatchling Wood Turtles to provide them with suitable growth conditions and diet to prevent any of the deformities and malformed shells seen in some captive reared turtles (Frye 1991). MacArthur and Barrows (2004) discuss accelerated growth and/or an excessively high protein diet as potential causes for abnormal growth and pyramiding of scutes of the carapace. Donoghue (in Mader 2006) states that pyramiding is multifactorial and may include factors such as temperature, lighting, vitamin deficiencies and low humidity. Although anecdotes abound, there is only one study that shows a cause and effect relationship between nutrients, humidity, and scute pyramiding (Wiesner and Iben 2003). We think that humidity plays a major role in normal shell growth. Juvenile Wood Turtles, as do other species, such as box turtles, spend most of their terrestrial time under the cover of thick vegetation where the humidity is high enough to support the presence of slugs and various worm species even during dry weather (pers. obs.). The moist peat moss substrate used in our protocol provided 75-85% humidity levels for the head-started turtles in this study.

There are numerous commercial turtle diets on the market. The internet is also replete with contradictory turtle care websites. Frye (1991) states that Reptomin<sup>®</sup> is an excellent artificial food and MacArthur (2004) recommends Reptomin<sup>®</sup> if a commercial diet is used. Because natural food items for juvenile Wood Turtles are seasonal, there are no definitive nutritional standards established for any turtle species, and turtles are known to develop food preferences, we decided to use the thoroughly soaked Reptomin<sup>®</sup> as an exclusive diet to provide consistent nutrition. We had previously used it successfully on Eastern Box Turtles (*Terrapene carolina*). Belzer and Seibert (2007) have used our protocol successfully since we first presented it in 1999 at a Wood Turtle Symposium at Penn State University.

We used incandescent lighting to provide adequate temperatures to support active feeding and promote digestion. We determined that it was not necessary to provide additional UVB lighting for Vitamin D synthesis. The commercially prepared Reptomin<sup>®</sup> contained adequate calcium and Vitamin D as well as other nutrients to support solid, uniform shell growth (McArthur 2004). The value of UVB lighting is also limited by the exposure which a turtle receives. Our turtles would have received minimal benefit from such lighting because the head-started turtles remained hidden in the substrate most of the time.

The relatively small size of the container, 28.4 liter (30 quart), used to raise the head-starts allows the turtles to be in close proximity to their food and water to encourage feeding and soaking. If feeding aggression occurs, the turtles can be separated into several containers. In our experience, keeping several turtles together encourages feeding, as the movement of a feeding turtle stimulates the others to feed. The head-starting protocol that we developed accomplished the objective of producing healthy juvenile Wood Turtles that reached a CL (carapace length) of 105-110 mm in the first year, a CL of 118-138 mm in the second year and CL of 135-156 mm in the fourth year exceeding the size of a seven year old turtle (126 mm) kept in semi natural, optimal conditions as reported by Harding and Bloomer (1979). Yahner (1974) and Murphy (1976) reported that once juvenile box turtles attain a body weight of 250–300 g, they suffer no greater mortality from predation than adults. The 100% survival of the head-started Wood Turtles in this study

with release weights in the range of 169–363 g supports the concept that a larger size reduces vulnerability to predation. We did not, however, conduct a comparison study of older non-headstarted juveniles of equal size, in part due to the scarcity of such juveniles in the study stream.

When we began this study in 1994 we sought to develop a successful technique to raise healthy head-started Wood Turtles, normal in appearance, to a size which would reduce their risk of predation without compromising their ability to adapt to their natural environment and exhibit normal juvenile Wood Turtle behavior. The "Michell Method" proved to be a successful formula for rearing the head-starts. Through telemetry we confirmed that all 10 of the study turtles survived and thrived their first two years in the wild and subsequent recaptures of nine as sub adults or adults confirmed their long term survival. Although the sample was small with six one-year old turtles and four two-year old turtles, we observed no differences in their behavior. The movement of all 10 turtles within the first two years to the meadow at the southeastern border of the 1.5 km study stream and the fact that they remained in that vicinity supports the premise that the head-starting process did not affect their ability to select appropriate natural hibernacula and foraging areas. The minimally invasive approach to the study prevented disruption to their natural activities and may have contributed to the success of the project. Our results support the concept that carefully planned head-start programs could be a useful conservation tool.

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KATHY MICHELL received her Bachelor of Science degree in Biology from Lebanon Valley College, Annville, Pennsylvania, USA. Her wildlife biology career began over 20 y ago while conducting reptile and amphibian survey work for the New York State Department of Environmental Conservation (NYSDEC) Herp. Atlas and Natural Heritage Program. She and co-author Robert Michell began their North American Wood Turtle research in 1993 evaluating the success of head-starting, translocation, and rehabilitation through long-term mark and recapture and telemetry studies. During winter months, Kathy worked with the NYSDEC monitoring overwintering populations of Bald Eagles (Haliaeetus leucocephalus in the Mongaup Reservoir system and the Delaware River valley for 10 yr. In addition to working with turtles, her career has expanded to research involving the study and protection of the Timber Rattlesnake (Crotalus horridus) including time-lapse camera studies of emergence, movement patterns of metapopulations divided by highways, and colonization of infrastructure. Kathy is also a licensed New York and New Jersey wildlife rehabilitator specializing in reptiles, and has presented at numerous conferences throughout the northeast. In 2004 she founded the non-profit New York Center for Turtle Rehabilitation and Conservation, Inc. She is currently works as a wildlife biologist through her company, KT Wildlife, LLC. (Photographed by Tom Michell).



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