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Growth Rates and Climate Influences on Neonatal Eastern Box Turtles after Egress Following Their First Overwintering

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Abstract

Eastern box turtles *Terrapene carolina carolina* (EBT) are uncommon in the Great Lakes region and are protected in Michigan as a species of special concern. Like many reptiles, little is known about hatchling EBTs, particularly growth and survival of neonates following egress from overwintering. We monitored growth in neonatal EBTs in Manistee National Forest using radio telemetry to locate turtles. During the neonates first overwintering they lost approximately 10% of their body weight. Each neonate had overwintering refugia of varying depths; these depths did not correlate with how much mass was lost. The mean weight for turtles alive four weeks after egress was 7.9936 g with a 0.142 standard error. The absence of a significant weight gain may be the result of adverse weather conditions during the study. This may have led to a lack of readily available food and difficulty in foraging. It is critical to understand those factors that affect growth rates to promote longevity in EBTs to ensure they reach maturity.

Introduction

Eastern box turtles (EBTs, *Terrepene carolina carolina*) are listed by the Department of Natural Resources (DNR) as a species of special concern in Michigan. They are Michigan's only terrestrial turtle and are easily identified by their bright yellow or yellow-orange markings, high domed carapace and hinged plastron. The primary causes of decline in EBT populations are habitat destruction, road mortality, and illegal collection for the pet trade. These turtles are found in upland forests and mixed swamps for the greater part of the year. For one to three weeks each year in June female EBTs migrate to open grasslands to lay their eggs. When the eggs hatch the neonates begin to disperse away from their nest in search of food and a suitable location in which to overwinter. Little is known about the ecology and physiology of neonates after emergence from their nests and following their first overwintering.

Individual growth rates are a critical variable for understanding neonatal EBTs. Ectotherms rely on external heat sources to maintain normal metabolic activity. Therefore, growth rates in reptiles, such as EBTs, depend strongly on ambient temperatures. Ambient temperature affects body temperature and therefore metabolic rate (O'Steeen, 1998).

During neonates first overwintering, a significant amount of weight is lost. The depth of the overwintering burrow, the type of habitat into which the burrow was dug, and the environmental conditions experienced during overwintering may affect the rate of mass loss for each turtle. Understanding characteristics of neonatal EBTs will help promote longevity and long-term population viability.

The primary aim of this research is to evaluate growth rates and climate influences on neonatal EBTs after egress following their first overwintering. Results of this study will provide new information for land management decisions regarding these rare turtles. Understanding basic biotic characteristics like growth rates and overwintering behaviors provides fundamental new knowledge for the broader scientific and conservation community.

Study Site

Data were collected in Manistee National Forest (MNF), which stretches across the northern lower peninsula of Michigan. The study areas are located within the nearly 1,000,000-acre forest. We refrain from providing the exact location of the populations to protect the turtles from poachers. Data were collected at two different open grasslands, the “Turtle Bowl” and the “Savanna.” Both of these openings had short grassy vegetation (less than 18 in) with trees and shrubs scattered throughout providing ideal nesting habitat for box turtles.

Methods

Field

Nests were located and protected in the Summer of 2013. Each hatchling was measured and fitted with a radio transmitter to document movement patterns (by GVSU graduate student Pat Laarman).The sample size decreased over time due to natural predation from predators and also due to unexpected radio transmitter problems. Neonate mass and carapace morphology was measured in the Fall of 2013 following nest emergence. To avoid stress and exposure to cold temperatures, mass and morphological measurements were not recorded when the turtles entered overwintering refugia in the

Fall of 2013 (person. comm. Laarman 2014). Once the weather started getting colder and the turtles stopped moving and they began to prepare to overwinter, a 3'L x 3'W x 1'H wood enclosure with metal screens was placed over the neonates to protect them from predators. The neonates were weighed and measured after emerging from overwintering in the spring of 2014. Depth of overwintering refugia was recorded (mm). Radio telemetry was used to track each neonate every other week throughout the Summer of 2014. For each turtle, a location was recorded as UTMs using a handheld GPS. A digital scale was taken into the field in order to record bi-weekly weight (g). Calipers were used to take measurements including, carapace length (CL), carapace width (CW), carapace height (CH), plastron length (PL), and plastron width (PW). Each measurement was taken at the widest or longest part of the turtle (mm). After all data were collected the neonate was placed back in its exact capture location and position. Temperature data including daily high and low temperature was monitored for the duration of the study.

Data Analysis

A two-sample t-test was conducted on neonates who overwintered in open grasslands and neonates that overwintered in upland forests to see if there was any relationship between percent body mass lost and the overwintering site. A Pearson's Correlation test was conducted to examine the relationship between the depth of the overwintering burrow and the percent body mass lost. Average weights and lengths were recorded for neonates that survived four weeks after overwintering. A Pearson's Correlation test was run to determine if there a correlation between the depth of the overwintering hole and the percent body mass lost.

Results

Growth Rates

Neonatal growth was slow the first year following egress. Growth rates varied for each turtle but the trends were all similar. Average carapace length increased from 32.02 mm at hatch to 34.42 mm at six week after egress from overwintering (Figure 1). The weekly growth rate (mean CL = 0.22 ± 0.2 SD mm per week) increased from 0.034 mm/week following egress from overwintering to 0.42 mm/week at six weeks post egress (Figure 2).

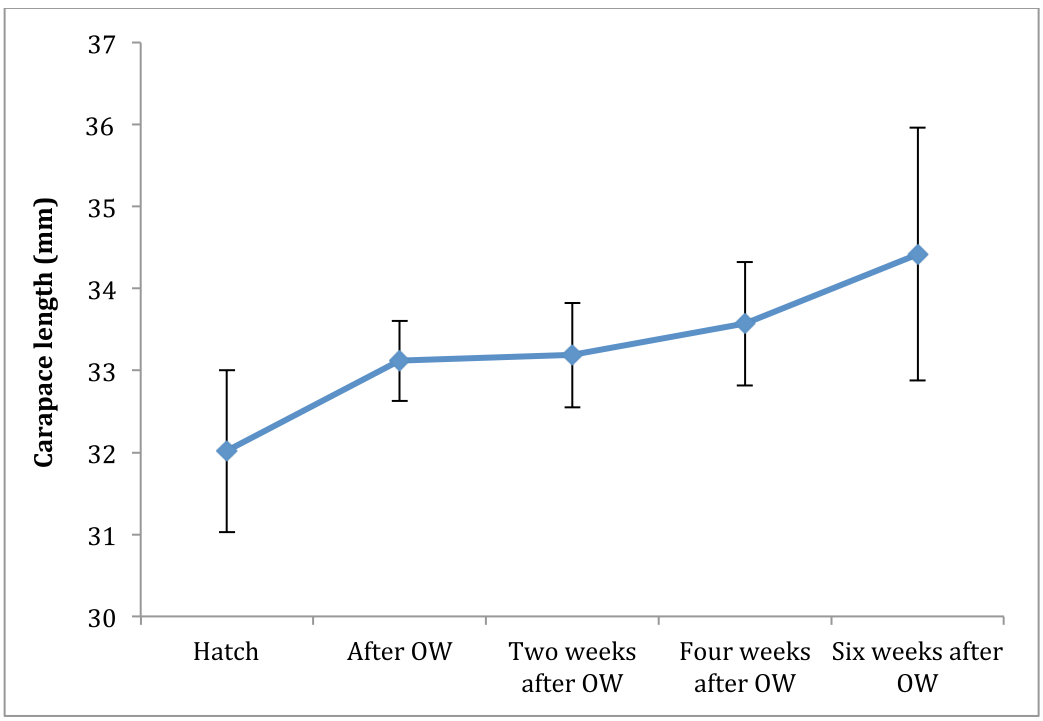

Figure 1. Average carapace length for EBT hatchlings following hatching and at two-week intervals following overwintering (OW), mean ± 1SD.

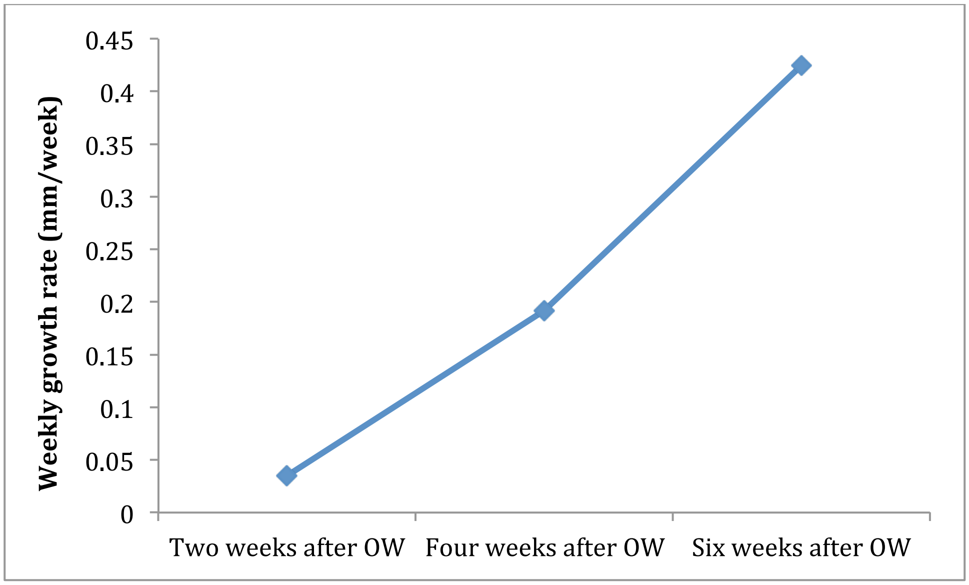

Figure 2. Increase in average weekly growth rate for neonate EBTs based on bi-weekly measurements of carapace length at overwintering (OW) emergence to six-weeks post emergence.

Overwintering

Neonatal EBT mass decreased for every turtle from hatching to after overwintering. In the 17 EBTs that survived their first overwintering the percent body mass loss ranged from 9.21 to 11.57. Following overwintering the turtles began to gain weight at a steady pace. The weight gain increased the most from eight to twelve weeks (Figure 3). The t-test showed no significant difference between the percent body mass lost and the location of the overwintering site ($t = 0.17$, $p = 0.871$). There was also no significant correlation between the depth of the overwintering burrow and the percent body mass lost during overwintering ($p = 0.82$).

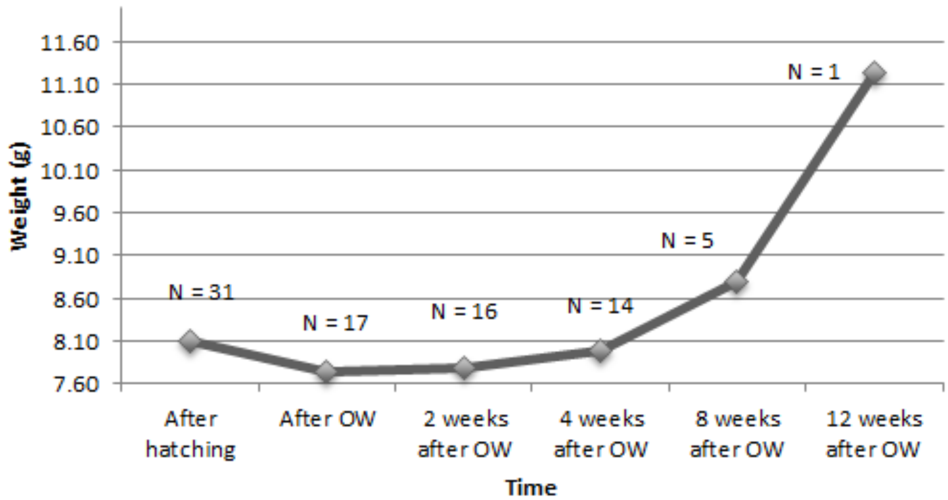

Figure 3. Average mass of neonatal EBTs following hatching and their first overwintering (OW).

Temperature

Environmental conditions may affect neonatal EBT growth rates. The weather in Manistee was considerably colder than in years past. The daily high temperatures during the month of July were lower than the historical average for 30 of 31 days. The daily low temperatures were lower than the historical average for 25 of 31 days during the month of July (Figure 4). July in Michigan is typically one of the warmest months, and this should be a time when the turtles are most active.

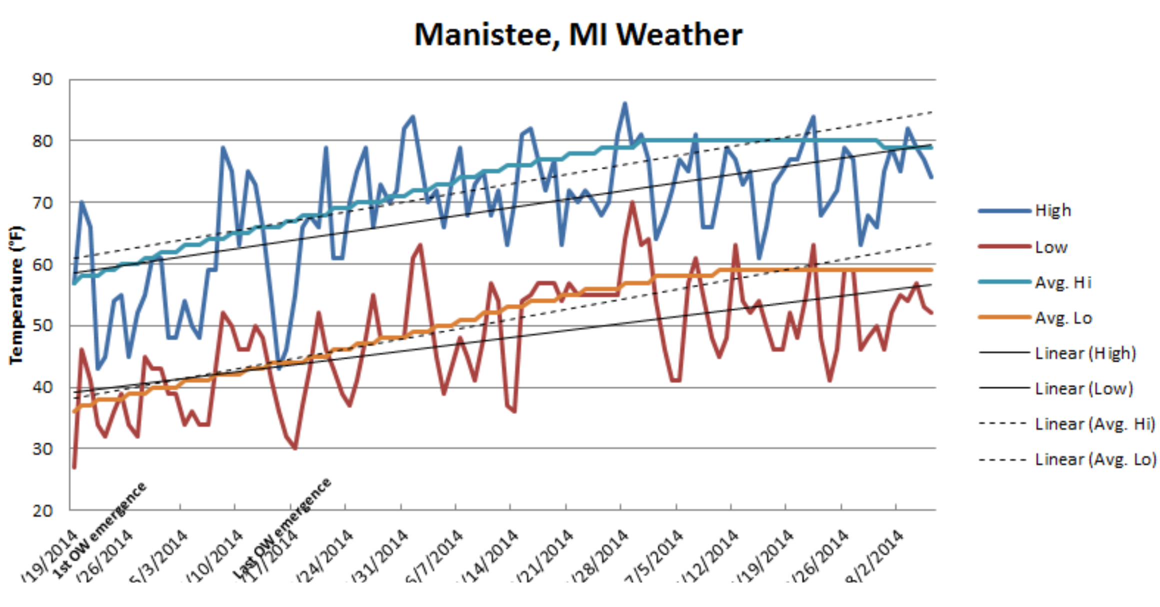

Figure 4. Average daily temperatures for Manistee, MI during spring and summer 2014 compared to the historical average high and low temperatures for July.

Discussion

The individual growth rates of neonate EBTs were highly variable, which may be linked back to energetics and how much each individual turtle moved. The neonates in this study experienced temperatures that saw the average high temperature consistently below what is normally recorded as well as having average low temperatures lower than usual for the area. All neonates lost considerable mass during overwintering. Costanzo et al. (2008) summarized the literature on the ecology and physiology of overwintering in hatchling turtles and found that overwintering body mass loss ranges from 14-25% depending upon the species (Costanzo, Lee, and Ultsch, 2008). Our estimate of approximately 9-12% body mass loss during overwintering is on the lower end of this range.

Weather, from severe to mild, is one factor that can cause disturbances in a species habitat. Disturbances may have a profound impact on an ecological environment, such as a hurricane, or mild in the case of a particularly bad winter or rain season. In a study by Dodd and Dreslik (2008) on long-lived turtles, the researchers found that habitat disturbances affected the individual growth rates and the timing of maturation (Dodd and Dreslik, 2008). During this study, a particularly cold and rainy spring in the Manistee National Forest changed the environment into which the hatchlings would normally emerge. The environmental changes may have altered the availability of resources such as food and shelter; which may also have contributed to an increased mortality. The scarcity of food may result in the normal use of food energy for growth being used instead to maintain life. The ambient temperatures may also have had an effect on neonatal EBT growth rates. The way a reptile controls its body temperature and energy expenditure is critical to its long-term survival and reproductive success (Nagy 2008, Penick et al. 2002).

Box turtles have the lowest known field metabolic rate (metabolic rate of an animal in the wild) of reptiles currently measured, including the desert tortoise (Penik *et al.* 2002). This low metabolic rate would normally help a more mature box turtle withstand environmental stresses and is probably characteristic of an ectothermic lifestyle. A neonate may not have had time to develop the energy resources that would allow them to withstand these stresses potentially leading to a greater loss in energy (mass) during times of habitat stress. Due to a particularly cold, harsh winter the EBTs were exposed to significantly colder temperatures than average for a Michigan spring. Suggestions for additional research could include the monitoring of neonatal EBT populations in conjunction with the temperature and climate over several years which may provide a greater understanding of their habitat needs and survival rates which can aid conservation management.

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