Eastern Box Turtle (*Terrapene carolina carolina)* Population Structure in Franklin County, Virginia

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Abstract: A study of eastern box turtle (*Terrapene carolina carolina)* population characteristics was carried out from 2006-2018 using opportunistic captures in and near Ferrum in Franklin County, Virginia. Of 224 new captures, there was a 2.8:1 male to female ratio and an adult to juvenile ratio of 12.2:1. There were 87 recaptures. The population structure was skewed towards older turtles with peak age class between 21-25 years. Male box turtles had a larger average carapace length and weight than females, but carapace width and plastron width were similar. Box turtles were most active from May to September, although activity of males peaked later in the season (July-August) than females (June). Most turtles were found in forests (45%), with 28.5% found in open areas (lawns, gardens) or crossing roads (24.5%). Only fifteen turtles showed signs of injury or disease. It was observed, anecdotally, that box turtles were often active immediately following rain events.

Key Words: Eastern Box Turtle, *Terrapene carolina*, Population Structure, Franklin County.

INTRODUCTION

The eastern box turtle (*Terrapene carolina carolina*) is a common terrestrial reptile found throughout eastern North America, but it is listed as a Tier III species in the Virginia Wildlife Action Plan (VDGIF, 2015) indicating some conservation concern. Although box turtles are still considered to be relatively common, their populations are threatened by high rates of adult and juvenile mortality, especially in urbanized areas, as well as a low reproductive output due to a long time to reproductive age (5-10 years) and small clutch sizes (Budischak et al., 2006; Dodd, 2001; Hall et al., 1999; Stickel, 1978).

Long-term monitoring studies of box turtles provide information on sex, size, and age distribution which allows for an understanding of population structure and conservation status (Hall et al. 1999; Budischak et al., 2006). For example, Gibbs and Steen (2005) found a trend for male-biased populations of many turtle species in the United States possibly due to higher female road mortality during their nesting movements. Female box turtles often move to open non-forested areas for nesting (Congello, 1978; Hall et al. 1999; Fredericksen, 2014), perhaps because of higher insolation at these sites that facilitates incubation. Such movements may make female box turtles more vulnerable due to mortality from vehicle collisions or mowing. Higher female mortality may reduce population recruitment. In addition, juvenile turtles are also more susceptible to predation because of their small size and a shell that is less protective compared to that of adults (Dodd, 2001). Monitoring seasonal activity and the incidence of disease and injury is also important for this species under the ongoing threat of human impacts on box turtle habitat.

In this study, I report on the results of a monitoring study of eastern box turtles from 2006-2018 at sites near Ferrum in Franklin

County, Virginia. Box turtles that were encountered at two major study sites were captured, marked, measured and released. The objective was to determine the population structure of turtles at these sites including information on size, age, sex ratio, and juvenile to adult ratio. I also recorded observations regarding turtle activity (e.g., mating, seasonal activity, habitat characteristics at capture sites, activity related to weather at the time of capture) and health status (injuries, diseases).

MATERIALS AND METHODS

Data were collected from 2006-2018 at two study sites in southwestern Virginia: the campus of Ferrum College in Franklin County and a private property approximately 2 km from the college. The elevation of the study area averages 350m and has a rolling topography characteristic of the Blue Ridge and Upper Piedmont physiographic provinces. The Ferrum College site encompasses 280 ha. Approximately 60% of this site is occupied by forests and where most box turtles were encountered. The Rambling Rose site includes 12 ha, most of which is forest that surrounds a house (dwelling of the author) with adjacent lawn and shrublands. The forests of both sites are composed predominantly of mixed hardwoods and pine species dominated by oaks (*Quercus spp*.) tulip poplar (*Liriodendron tulipifera*), red maple (*Acer rubrum*), and white pine (*Pinus strobus*). Forests at Ferrum College also include a few small plantations of loblolly pine (*Pinus taeda*) and white pine and there is a 2-ha white pine plantation at the Rambling Rose site.

During the study period, all box turtles that were encountered at the two sites were marked and data were collected as detailed below. Research projects conducted at both study sites ensured a fairly consistent opportunity for encountering box turtles during the study period. Although smaller in size, more opportunity to encounter box turtles occurred at the Rambling Rose site because it is a residential property of the author.

Turtles encountered were uniquely numbered with an engraving tool on the upper left portion of their plastron. Although some wear on the numbers was evident for turtles not recaptured recently, engraved numbers were legible enough to determine the identity of the turtle. Numbers on recaptured turtles were re-engraved. Date of capture was recorded. Turtles were also measured with a tape measure or calipers for carapace length, carapace width, and plastron length. The sex of the turtle was determined based on plastron concavity and carapace shape. For juvenile turtles, considered to be $\leq$ 5 years of age, it was difficult to determine sex. Weight was determined with a pesola scale and age was roughly estimated by counting the rings on the carapace scutes up to an approximate age of 30, above which it was difficult to determine the age of the turtles.

Other observations at the time of capture included site characteristics (e.g., forest, lawn, road, shrubland, stream), weather activity (e.g., following rain), behavior (e.g., mating, nesting), and injuries or diseases (e.g., missing or damaged scutes, missing or damaged limbs, eye infection, ear infection, dead).

RESULTS

A total of 224 captures of individual turtles were made, including 87 recaptures of 49 individual turtles. Two turtles, one male and one female, were recaptured 7 times. Of the 224 individual captures, there were 153 males, 54 females, and 17 juveniles which

were too young to determine sex. The male to female ratio was therefore 2.8:1 and the adult to juvenile ratio was 12.2:1

It is difficult to determine the age of older turtles because of wear on the shell that obscures growth rings and there were 28 turtles that were too difficult to accurately determine age from growth rings. The population structure, however, appears to have a skewed distribution to older turtles with a peak in the age class between 21-25 (Figure 1), although this skewness may be the result of fewer box turtles in the youngest age classes. Because smaller turtles are more difficult to find, numbers of turtles in these age classes are likely underestimated.

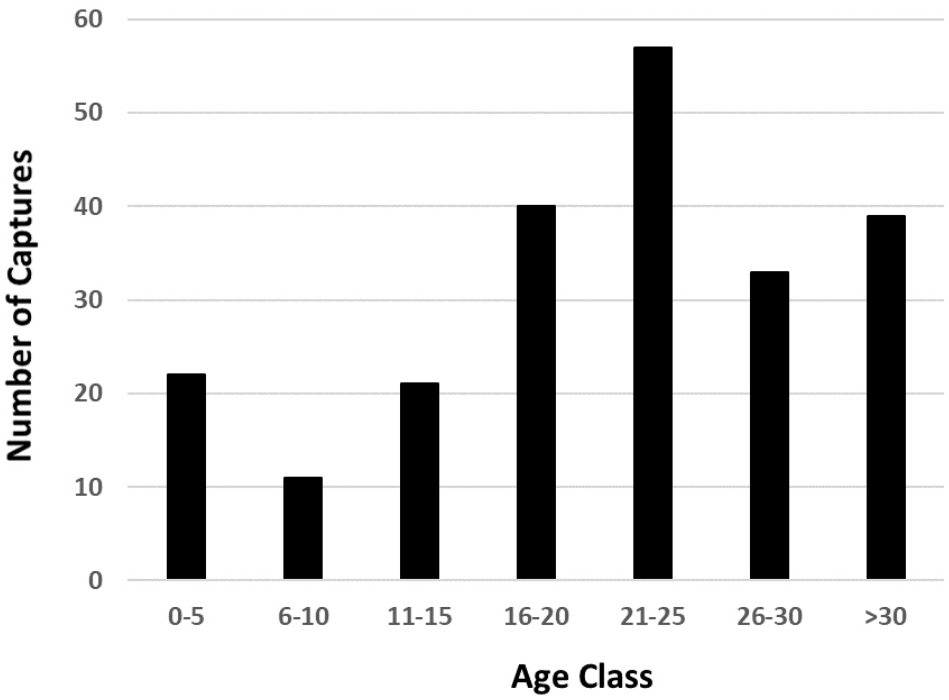

Figure 1. Age structure of box turtles captured from 2006-2018 at two sites in Franklin County, Virginia.

Male box turtles were significantly larger in carapace length ($t = 2.45$, $p = 0.02$) but weight ($p = 0.16$), carapace width ($p = 0.56$), and plastron length (0.60) were not significantly different (Table 1). Male box turtles were more elongated in form than females, which have a more compacted dome-shaped form. Plastron length, carapace length, and carapace width were very similar for juvenile turtles (< 5 years). Turtle weight increased with age until approximately the age of 15 when weight became relatively stable.

Table 1. Box turtle weight and size characteristics for males, females, and juveniles (too small to determine sex). Means are presented with one standard error in parentheses.

Sex	Weight (g)	Carapace Length (mm)	Carapace Width (mm)	Plastron Length (mm)
Male	371.5 (77.03)	125.6 (12.56)	98.7 (16.25)	111.5 (14.59)
Female	354.1 (101.50)	120.4 (15.45)	100.1 (14.94)	112.5 (17.47)
Juvenile	66.7 (32.44)	69.5 (12.96)	64.5 (10.76)	64.7 (15.05)

Most captures of box turtles occurred from May-September with a peak in June (Figure 3), but the peak for females occurred earlier in the year (June) and later for males (July) (Figure 4). A few turtles emerged in March. One turtle was found near the foundation of my house on an unusually warm day on December 9, 2012. This turtle had an ear infection and was very lethargic. No captures were made in November, January or February. Although no rainfall data were recorded for dates of captures, it was noted that turtles were often found immediately following rain events (Table 2). There were 7 pairs of turtles in copulation and 15 newly captured turtles showed some sign of injury or disease. Dates of copulation ranged from June 8 to September 27. Only one female turtle was encountered during nesting (July 9). Three turtles that had been marked were later found dead (Table 2). Turtles were found mainly in three different habitat conditions based on 298 observations: mature forest (45%), open areas (e.g., lawns, gardens) (28.5%) and crossing roads (24.5%). Three turtles were found in brushy areas, two in streams, and one in a wetland.

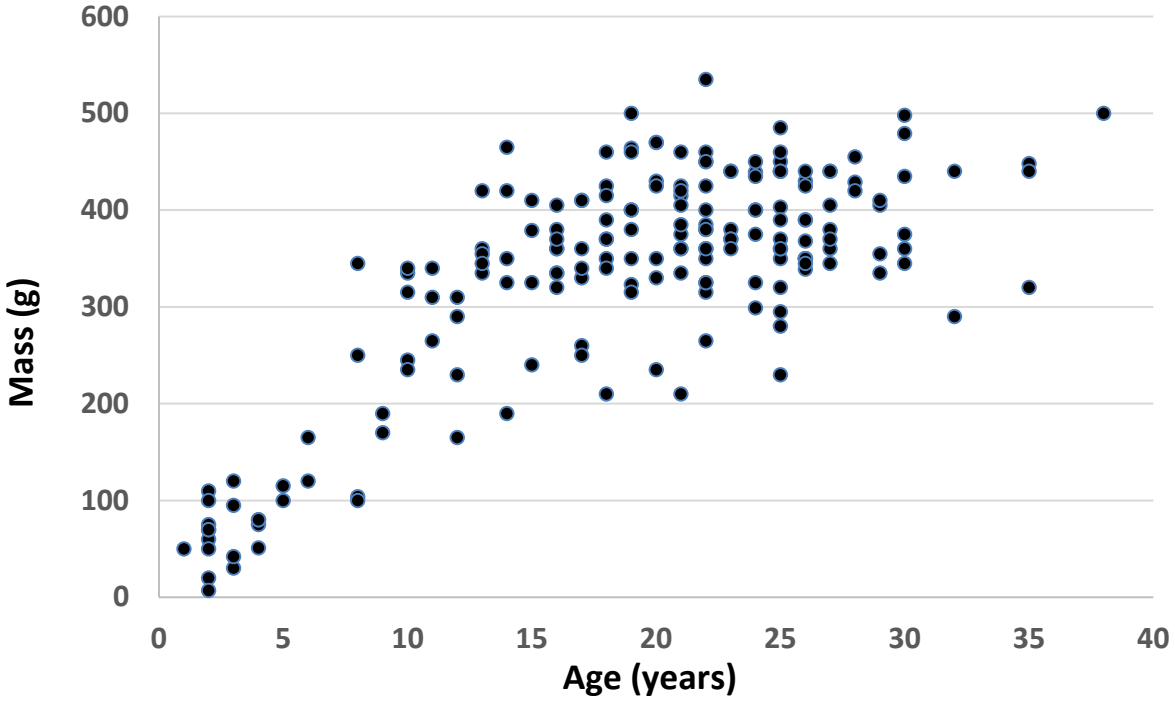

Figure 2: Relationship between turtle age and mass of all initial captures (excludes recaptures) recorded during the study period at both sites.

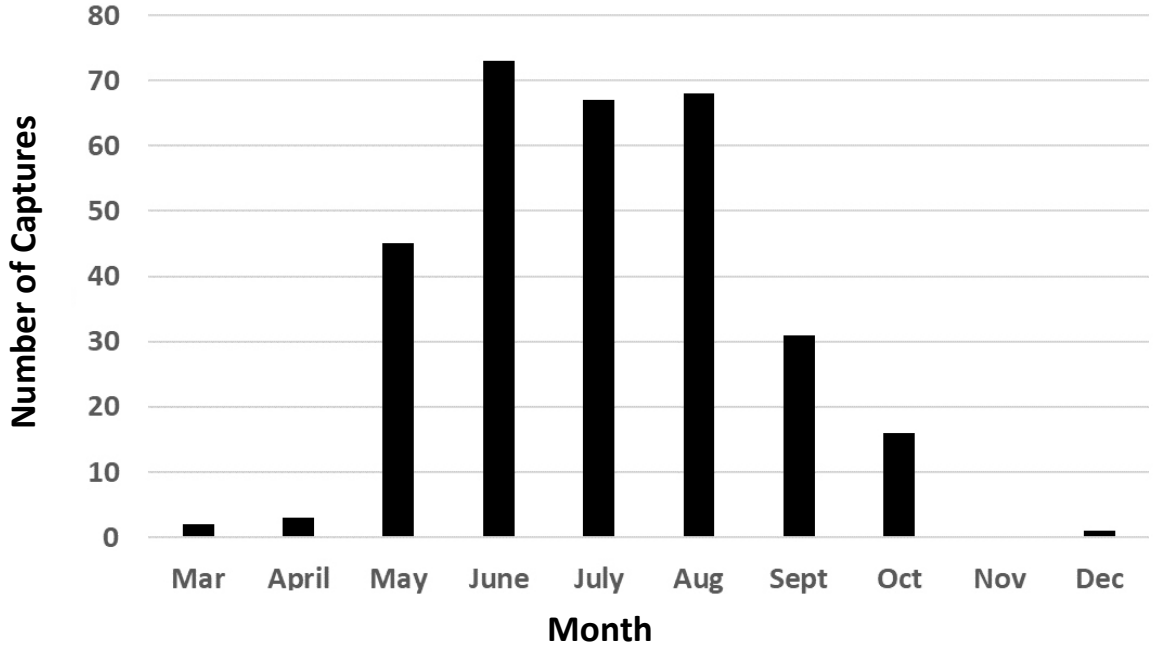

Figure 3: Total captures and recaptures of box turtles by month in which the capture was made.

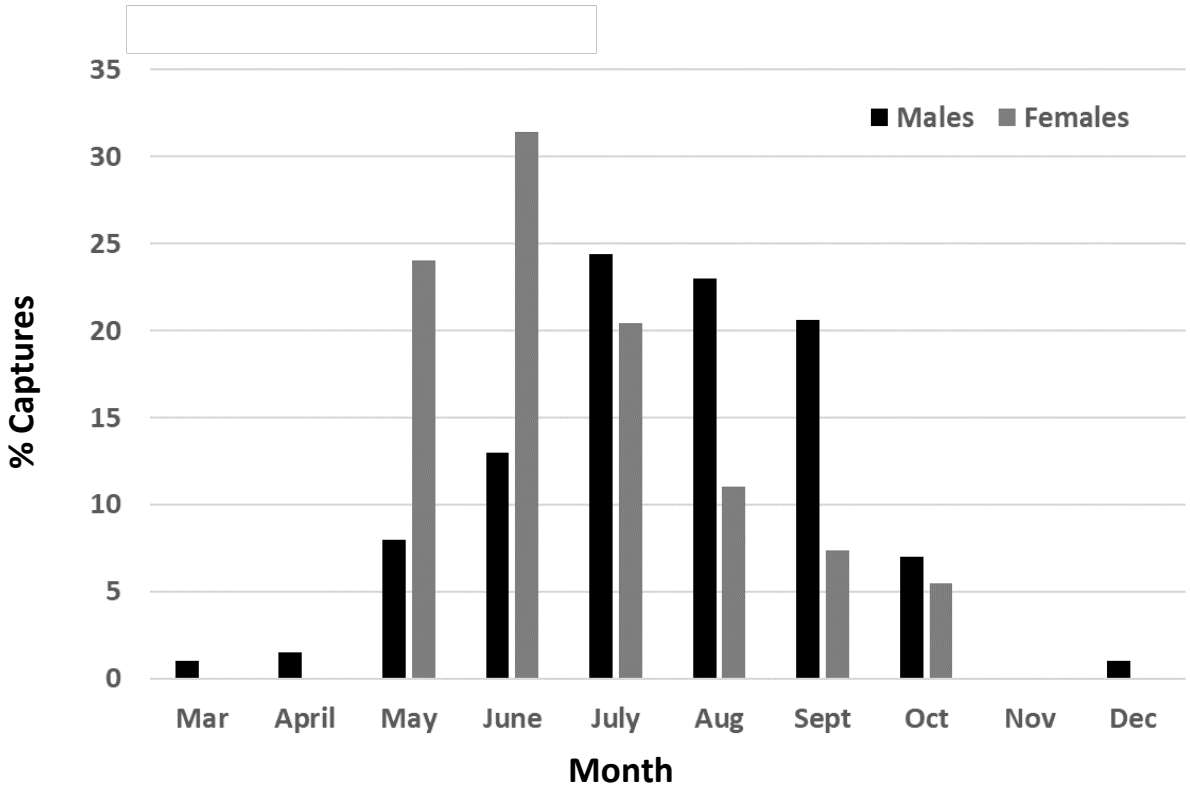

Figure 4. Percent captures for male and female box turtles.

Table 2: Observations during capture of box turtles including weather, behavior, and injury.

Found during/ after rain	Nesting	Copulation	Male conflict	Ear infection	Eye infection	Shell damage	Leg injury	Dead
24	2	7	1	4	2	7	2	3

DISCUSSION

The most notable observation in this study is the highly skewed male:female ratio (2.8:1). Many other studies have found male-skewed sex ratios (Dolbeer1969, Hall et al. 1999, Stickel 1989, West and Klukowski 2016). The male:female ratio is this study however is larger than these studies (1:2 – 2.0). Budischak et al. (2006) found a ratio skewed towards females (male:female of 0.66:1) in North Carolina. In a study in Delaware, Nazdrowicz et al. (2008) found male-skewed sex ratios at two study sites (one site with a 3:1 male:female ratio), but balanced age distributions at two other sites.

At a site in Central Virginia, Wilson and Ernst (2005) found a 1:1 sex ratio of box turtles. It is not certain why the sex ratio is so highly skewed towards male in this study. In

a radiotelemetry study (Fredericksen 2014) using a subset of the turtles in this study, I found that female turtles moved long (> 1 km) distances to nesting locations in the early summer to habitats with more sunlight (recent clearcut surrounded by lawns and hayfields). Such movements may make turtles more vulnerable to road and mowing mortality as proposed for turtles in general by Gibbs and Steen (2005), particularly in fragmented landscape. Iglay et al. (2007), however, found that box turtles in isolated areas within fragmented landscapes moved less than those in more continuous habitat. Dodd (1997) proposed that females that nest in forests are more likely to produce more males than females because of cooler temperatures of forests tend to produce more males. In this study, more turtles were found in forest habitats than open areas.

Juvenile turtles (< 5 years) represented a small number (17) of the captures of this study. Observation bias may certainly be a potential explanation for the low number of juvenile captures because they are difficult to find

(Stickel 1950, Wilson and Ernst 2005) and do not appear to have a large home range (Fredericksen 2014). Juvenile turtles may confine themselves to areas with dense cover because they are vulnerable to predation because of their small size and softer shell (Dodd 2001, Jennings 2007).

A clear correlation between age and mass was observed until box turtles reached an age of approximately 20 years. Budischak et al. (2006) found similar uncoupling between age and mass in older turtles as well as more variability in this relationship for older turtles. Male turtles weighed more than females and had longer carapaces, but females had slightly longer carapace widths and plastron lengths. Differences between male and female carapace dimensions in this study are similar to those reported in other studies (Stickel and Bunck 1989; Budischak et al. 2006; West and Kluckowski 2016). The majority of box turtles found in this study were between 16-30 years, which differed from a study by West and Kluckowski (2016) in Tennessee who found most turtles to be between 14-20 years old, with few individuals older than 20 years old. Box turtle activity dramatically increased in May and then declined sharply in September, corresponding to other studies of the seasonal activity and overwintering behavior of turtles at these same study sites (Ellington et al. 2007, Fredericksen 2014).

Monitoring of these populations will continue including an assessment of population changes due to potential impacts of climate change and human development. Currently, the two study sites have relatively low risk of mortality because there are few roads and limited logging and deforestation, but this may change over time.

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ACKNOWLEDGMENTS

Thanks to many students at Ferrum College who worked with me on this project, particularly Ken Graves, Hannah Shively and J.D. Fiore and Taryn Hayden who helped to summarize the data. I also thank my family, Nell, Neil and Lily Fredericksen, who helped find turtles. This project was conducted under the Virginia Department of Game and Inland Fisheries Scientific Collection Permit #061583.