ECOLOGY AND BEHAVIOR OF THE GULF COAST BOX TURTLE (*TERRAPENE CAROLINA MAJOR*) IN THE PANHANDLE OF FLORIDA

LUCILLE F. STICKEL BOX TURTLE RESEARCH AWARD

2019 REPORT

AMERICAN TURTLE OBSERVATORY

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Project Overview

The Gulf Coast box turtle (*Terrapene carolina major*) is a unique lineage of Eastern box turtle (*Terrapene carolina*). *Terrapene. c. major* is noted to have morphological and habitat differentiation from other *T. carolina* lineages, specifically its larger body size and frequent utilization of aquatic environments (Kiester and Willey 2015). This differentiation may be a result of ancestry from the extinct Pleistocene Giant box turtle (*T. c. putnami*). However, regardless of its evolutionary origin, information regarding *T. c. major* movement patterns, habitat selection, reproduction, population viability, and vulnerability to road mortality is lacking.

In 2014, we initiated a mark-recapture effort to generate population estimates and assess the status of the Gulf Coast box turtle in the Apalachicola River watershed in the Florida Panhandle, and to build capacity for a long-term, standardized monitoring and applied conservation research program. In March 2016, we added a radiotelemetry component to evaluate home range size, movement patterns, habitat selection, and vulnerability to road and railway mortality. Early on in the fieldwork, fighting behavior among males was frequently observed and thus investigating possible territoriality in this lineage was subsequently added as a study objective. The radio-telemetry work continued through 2018.

Project Objectives

1) evaluate seasonal home range size and structure differences between males and females,
2) evaluate seasonal habitat use and selection by males and females,
3) evaluate road mortality effects on local populations,
4) evaluate seasonal aquatic use, and
5) investigate the biological purpose of fighting behavior observed among males.

Methods

Study Area – Five long-term radiotelemetry study sites were selected along the Apalachicola River based on surveys conducted in previous years. Sites were chosen based on their accessibility, limited recreation disturbance, and habitat suitability for *T. c. major*. Common habitat types found at the sites included tupelo and cypress swamps, mesic mixed forests, and coniferous forests. Road mortality was assessed on major state roads in close proximity to the five study sites.

Processing Turtles – All box turtles encountered during surveys and radiotelemetry were uniquely marked using a triangular or circular file (following the system proposed by Ernst et al. 1974). All box turtles detected were measured using dial calipers and weighed to the nearest 0.1 gram. In addition, we photographed the carapace and plastron of all individuals. All methods were approved by the University of Massachusetts Amherst's Institutional Animal Care and Use Committee (IACUC).

Radiotelemetry – In March 2016, four adult *T. c. major* were fitted with a radio transmitter (R1860, Advanced Telemetry Systems, Isanti, MN) at each of the five sites, for a total of 20 individuals (11 males, 9 females). Locations were obtained twice a week from mid-May to mid-August in 2016 and 2017 and monthly in March, April, November, and December 2016, March 2017, and March 2018. During every location event, Global Positioning System (GPS) location (Garmin GPS Map 78, Olathe, KS), air temperature (°C), water temperature (°C) (if applicable), weather conditions, categorical turtle activity, distance to water, and a habitat assessment within 5 meters were recorded. The habitat assessment included dominant habitat type (cypress/tupelo swamp, hardwood forest, mixed forest, pine forest, pine plantation, forested wetland, and transition) and percent cover and dominant species of the canopy, shrub, and herbaceous layers within 5 meters of the turtle.

Home range sizes for the 20 radio-tagged individuals were calculated using the package 'adehabitat' in R (Calenge 2006, R Core Team 2016). Minimum convex polygons (95% and 100%) and fixed kernel density estimations were determined. Other calculations included average distance moved per day and home range fidelity.

Habitat Use and Selection – Habitat use and selection were evaluated by comparing location events to random points created in Geographic Information Systems (GIS) using the Florida land cover dataset (Florida Fish and Wildlife 2016) and conducting a logistic regression.

Road Mortality Assessments – Alive individuals encountered on roadways were processed the same as incidental captures during radiotelemetry location events and assisted off the road in the direction of travel. Individuals found dead on the road had GPS location recorded, along with sex, date, time, and weather conditions, and a tissue/toenail sample taken.

Results

Home Range – Females had significantly larger home ranges than males in both 2016 and 2017. Female home ranges averaged eight times larger in 2016 and 11 times larger in 2017 compared to males (Table 1 and 2). Average distance moved per day was also significantly higher for females than males, averaging twice as far. Males had significantly higher home range fidelity than females, averaging 44.3% with females averaging 21.4%.

Habitat Use and Selection – Logistic regression results indicated that females used coniferous plantations and wet coniferous plantations significantly more than forested wetlands whereas males used forested wetlands significantly more than any other habitat type. For both males and females, approximately 25% of total locations were aquatic (i.e., the individual was soaking, swimming, or submerged in water).

Behavior – A total of eight fights were observed during the 2016 and 2017 field seasons with four different male radio-tagged individuals (M95, M97, M109, and M151) (Table 3). An additional 14 fights were observed from 2014 to 2017 with incidental non-radio tagged individuals. No females were observed fighting between 2014 and 2017, but were occasionally

found near (<5 m) fighting males. Two pairs of males were observed fighting both years, M97 with M98 and M109 with M129.

Road Mortality Assessments – A total of 116 individuals from six species (*Terrapene carolina major, Chelydra serpentina, Kinosternon subrubrum, Deirochelys reticularia, Pseudemys concinna,* and *Trachemys scripta scripta*) were encountered on three state roadways during the 2016 and 2017 field seasons. Out of the 116 individuals, 77 were found alive on the road (AOR) and 39 were found deceased (DOR). A total of 104 *T. c. major* were encountered with 71 individuals AOR and 33 individuals DOR.

Table 1. A summary of the home range and movement estimates for *T. c. major* during the 2016 field season. Home range (MCPs and kernels) is reported in hectares and movement (distance per day (DPD) and straight linear distance (SLD)) are reported in meters. The minimum, maximum, and standard deviation is representative of all 20 individuals of both sexes.

	MCP (95%)	MCP (100%)	Kernel. 95	Kernel. 75	Kernel. 50	DPD	SLD
Female	5.9	7.9	21.5	9.5	4.3	23.0	528.1
Male	0.7	0.9	2.7	1.3	0.7	12.0	180.6
Minimum	0.2	0.2	0.6	0.3	0.2	5.7	84.3
Maximum	10.7	17.0	53.5	20.8	9.1	39.7	1020.8
St. Dev.	3.7	4.8	14.4	6.1	2.8	8.7	234.6

Table 2. A summary of the home range and movement estimates for *T. c. major* during the 2017 field season. Home range (MCPs and kernels) is reported in hectares and movement (distance per day (DPD) and straight linear distance (SLD)) are reported in meters. The minimum, maximum, and standard deviation is representative of all 20 individuals of both sexes.

	MCP (95%)	MCP (100%)	Kernel. 95	Kernel. 75	Kernel. 50	DPD	SLD
Female	8.8	10.9	34.1	15.6	6.5	13.3	614.6
Male	0.7	0.9	2.8	1.4	0.7	5.8	169.9
Minimum	0.1	0.2	0.4	0.2	0.1	3.0	65.8
Maximum	42.5	45.4	148.0	70.6	28.7	29.6	1258.6
St. Dev.	9.5	10.1	33.3	15.8	6.4	6.3	313.1

Table 3. Summary of the eight fighting occurrences involving the radio-tagged individuals during the 2016 and 2017 field seasons. Body size is summarized using straight carapace length (SCL) (mm) and mass (g).

Fight	Date	Turtle ID	Outcome	SCL	Mass	Notes
1	3/14/2016	M109	Winner	204.6	1415	M109 chasing
		M129	Loser	197	1211	M129
2*	3/14/2016	M95	Winner	166	834	M134 flipped,
		M134	Loser	171	768	M95 upright
3	3/17/2016	M151	Loser	189	1220	M44 biting
		M44	Winner	176	851	M151's leg
4	5/24/2016	M97	Winner	175.9	917	M98 inside
		M98	Loser	184	971	shell, M97 alert
5	6/9/2017	M95	Winner	166	834	M371 on his
		M371	Loser	169	739	side, M95 alert
6	6/13/2017	M97	Loser	175.9	917	M97 mounted
		M134	Winner	171	768	by M134
7	6/13/2017	M109	Winner	204.6	1415	M129 on his
		M129	Loser	197	1211	back, M109 alert
8	8/8/2017	M97	Unknown	175.9	917	Facing each
		M98	Unknown	184	971	other, alert

*M95 was not radio-tagged in 2016 but was tagged in 2017 to replace M104.

Discussion

The results from our study indicated males and females utilize the landscape in significantly different ways. While the vast majority of our study occurred during the summer season when females are nesting, nesting movements do not solely explain the significant differences. We suggest that male *T. c. major* may establish dominance hierarchies or territories based on the fighting behavior observed and the home range traits of males. Females do not establish hierarchies or territories, but may disperse further to ensure genetic diversity and are likely more adaptive to landscape changes. The road mortality assessments indicated that populations in proximity to the state highways are likely to be at risk of population decline due to skewing the sex ratio in favor of males (Langen et al. 2007, Shepard et al. 2008, Steen and Gibbs 2004).

While the genetics and phylogeny remain unclear on the evolution of *T. c. major*, this lineage has demonstrated highly unique spatial and behavioral characteristics compared to its conspecifics and should be considered a unique lineage. Additionally, a longer-term assessment during multiple seasons would provide a deeper understanding to their ecology and provide a better perspective for their conservation and management. The possibility of males establishing

dominance hierarchies or territories also needs further exploration to understand its ultimate effect on movement, home range size, and habitat selection. Careful documentation of *T. c. major* ecological parameters and population genetic analyses will shed light onto this unique lineage and aid in conservation efforts if *T. carolina* populations continue to decline.

Award Contributions

The money awarded to American Turtle Observatory by the Box Turtle Conservation Committee aided in all aspects of this project's completion, including data collection (i.e. equipment), data management and data analysis. The majority of the award supported equipment costs including radio transmitters, BNC cables, and batteries. We will acknowledge your contribution in all upcoming reports, presentations, and manuscripts.

Other Information

The spatial ecology and behavior information we obtained from our study has been presented in this report, permit reports and will be submitted to a peer reviewed scientific journal (e.g., Journal of Herpetology, Herpetological Conservation and Biology) in 2019. We are also presenting this information in more detail at the upcoming Box Turtle Conservation Workshop in May and at the Turtle Survival Alliance conference in August.

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