



Factors affecting temperature variation and habitat use in free-ranging diamondback terrapins



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ABSTRACT

Measuring the thermal conditions of aquatic reptiles with temperature dataloggers is a cost-effective way to study their behavior and habitat use. Temperature dataloggers are a particularly useful and informative approach to studying organisms such as the estuarine diamondback terrapin (*Malaclemys terrapin*) that inhabits a dynamic environment often inaccessible to researchers. We used carapace-mounted dataloggers to measure hourly carapace temperature (T_c) of free-ranging terrapins in South Carolina from October 2007 to 2008 to examine the effects of month, sex, creek site, and tide on T_c and to determine the effects of month, sex, and time of day on terrapin basking frequency. Simultaneous measurements of environmental temperatures (T_e ; shallow mud, deep mud, water) allowed us to make inferences about terrapin microhabitat use. Terrapin T_c differed significantly among months and creek and between sexes. Terrapin microhabitat use also varied monthly, with shallow mud temperature being the best predictor of T_c November–March and water temperature being the best predictor of T_c April–October. Terrapins basked most frequently in spring and fall and males basked more frequently than females. Our study contributes to a fuller understanding of terrapin thermal biology and provides support for using dataloggers to investigate behavior and habitat use of aquatic ectotherms inhabiting dynamic environments.

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1. Introduction

Changes in temperature have profound effects on the rates of many physiological processes, particularly those of ectotherms whose body temperatures (T_b) are directly influenced by temperatures of their environment (T_e ; Beitinger and Fitzpatrick, 1979; Huey, 1982; Fitzgerald and Nelson, 2011). Ectotherms produce little metabolic heat, and must employ thermoregulatory behaviors such as basking and microhabitat selection to promote optimal physiological performance for locomotion, energy acquisition, reproduction, and other processes (Stevenson, 1985; Rowe and Dalgarn, 2009; Bulte and Blouin-Demers, 2010). Semi-aquatic ectotherms (e.g. many reptiles) rely on a combination of solar radiation and available T_e , such as water and substrate temperature, to regulate T_b . The effectiveness of a particular environment for thermoregulation may change seasonally, daily, or even hourly depending on specific properties of the microhabitats (Heatwole and Taylor, 1987). Thus, examining T_e in conjunction with temperatures of free-ranging, semi-aquatic reptiles is critical to

understanding the nuances of individual thermal variation, and may provide insights into behaviors (e.g. basking, burrowing, swimming) and habitat use (Peterson et al., 1993).

The semi-aquatic diamondback terrapin (*Malaclemys terrapin*) provides a reptilian model for investigating thermal variation and temperature-inferred habitat use because of the dynamic coastal ecosystem in which it lives. Terrapins inhabit salt marsh estuaries along the Eastern and Gulf coasts of the United States and they experience the dramatic variations in environmental factors associated with tidal and seasonal fluctuations (e.g., temperature, water level, salinity and oxygen availability; Ernst and Lovich, 2009; Largier, 2010). Salinity can change from nearly fresh to nearly marine within a single tidal cycle (NOAA, 2005) and tidal amplitude can be up to two meters (Kana et al., 1984). Furthermore, water temperatures within many coastal estuaries can range from near freezing to above 30 °C (Dame et al., 2000), depending on the season and latitude. Terrapins also experience dramatic temperature fluctuations as a result of season or time of day. Williard and Harden (2011) documented terrapins experiencing 7 °C summer temperature variations and 9 °C winter temperature variations (including sub-zero temperatures), both within 24-h time periods.

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Environmental fluctuations within estuaries likely have strong effects on terrapin T_b and various physiological processes, and may result in subsequent changes in habitat use. Previous studies have investigated thermal biology and habitat use of other semi-aquatic turtles by recording T_b or T_c (carapace temperature) and T_e with microdataloggers (Grayson and Dorcas, 2004; Harden et al., 2007; Dubois et al., 2009; Pittman and Dorcas, 2009; Rowe and Dalgarn, 2009; Bulte and Blouin-Demers, 2010), however, few studies have used this affordable and remote monitoring technique to measure thermal variation and assess temperature-inferred habitat use of diamondback terrapins in their uniquely dynamic environment (but see Harden et al. (2007) and Williard and Harden (2011)). We used temperature microdataloggers to measure environmental temperatures (T_e ; water, deep mud, shallow mud) and terrapin carapace temperatures (T_c , used as a proxy for T_b , see Section 2.4 for more detail) for 1 year in two salt marsh tidal creeks to address the following study objectives: 1) investigate the effects of month, sex, creek site, and tide level on terrapin T_c , 2) evaluate the relationships between T_e and T_c to infer seasonal variation in habitat use, and 3) examine the effects of month, sex, and time of day on basking behavior.

2. Materials and methods

2.1. Study area

This study was conducted in conjunction with long-term mark-recapture sampling of terrapins, initiated in 1983 (Lovich and Gibbons, 1990). We executed this study in two tidal creek tributaries, known as Fiddler creek and Oyster creek, of the Kiawah River adjacent to Kiawah Island, Charleston County, South Carolina, USA. Both tidal creeks were bordered by salt marsh dominated by *Spartina alterniflora* (for more information on the study site see Materials and Methods of Dorcas et al. (2007) and citations within).

2.2. Turtle capture and datalogger attachment

During 2007 and 2008, we captured terrapins using trammel nets and seines, primarily during low tides (Lovich and Gibbons, 1990) within the two aforementioned tributaries. Upon capture, any unmarked terrapins were uniquely marked by filing notches into their marginal scutes (Sexton, 1959). Measurements taken on each turtle included straight-line carapace length (SCL), plastron length, width, depth and mass (Tucker et al., 2001). Body mass was measured to the nearest gram using a digital scale. We determined sex via tail length and other secondary sex characteristics (Dorcas et al., 2007). All terrapins were returned to their location of capture within three days.

Prior to release, we attached temperature microdataloggers (iButton Thermochrons, Dallas Semiconductor, Dallas, TX; accuracy ± 0.5 °C; Grayson and Dorcas, 2004; Pittman and Dorcas, 2009) to the posterior carapace of each terrapin using marine-grade epoxy (Loctite Five Minute Marine Grade Epoxy, Avon, OH). We selected individuals for datalogger attachment based on previous capture frequency, which we believed would increase the probability of retrieving the dataloggers at the next sampling period. Before attachment, dataloggers were programmed following the protocols of Grayson and Dorcas (2004) to record T_c at 60-min intervals and were then covered in plastic tool dip (Plasti-Dip International, Circle Pines, MN) to prevent water damage. The amount of epoxy used for attachment was limited to reduce the weight carried by the turtle ($\leq 6\%$ of the smallest turtle's mass). Previous investigations have shown that carapace temperature is strongly correlated with body temperature (Grayson and Dorcas,

2004; Chen and Lue, 2008). However, we did not directly compare body temperature and carapace temperature of terrapins in this study. Consequently, carapace temperatures may differ slightly from actual body temperature, especially during basking. Dataloggers recorded temperatures hourly from 16 October 2007 through 12 October 2008 with the exception of 17–23 May 2008 while they were being replaced. Overall, we recovered dataloggers and were able to evaluate T_c from 17 individual terrapins (males=12, females=5) during 2007 and 2008, although the duration of data collection varied among individual terrapins: 16 Oct. 2007–17 May 2008 ($n=4$), 16 Oct. 2007–29 May 2008 ($n=5$), 16 Oct. 2007–15 Sept. 2008 ($n=2$), 12 May 2008–10 Oct. 2008 ($n=4$), and 28 June 2008–12 Oct. 2008 ($n=2$).

2.3. Environmental data collection

We measured environmental temperatures (T_e) by placing the same model of microdataloggers used to measure T_c in each of three possible microhabitats used by terrapins: water (15 cm below the water surface; $n=2$), shallow mud (10 cm mud depth; $n=2$) and deep mud (45 cm mud depth; $n=2$). The water habitat microdatalogger was secured 15 cm below a buoy tied to a rope and weighted by a small anchor. The two mud habitat microdataloggers were secured to a wooden stake using duct tape at the two designated mud depths (10 and 45 cm) and placed in the intertidal creekbank marsh of their respective creek site. One water datalogger and one wooden stake with two mud dataloggers were deployed at each field site, Fiddler and Oyster creek. Because tide level may influence both T_e and T_c , we obtained 2007–2008 tide information from a National Oceanic and Atmospheric Administration tidal station ~ 45 km from Kiawah Island in Charleston, SC (NOAA National Data Buoy Center, Station CHTS1-8665530).

2.4. Data analysis

To evaluate the effects of month ($n=12$), sex ($n=2$), and creek ($n=2$) on terrapin T_c , we performed a generalized linear model (GLM; SAS v. 9.2). To avoid auto-correlation among our T_c data, we randomly selected 30 daytime time-stamped T_c (decided by examining the average time of sunrise and set within each month) from both tidal creeks for each week, resulting in a total of 1560 data points over the course of the year-long study. To evaluate the effects of tide level (low, high; $n=2$) on male and female terrapin T_c , we matched the available tide data to our time-stamped T_c data in order to identify the time points closest to both high and low tides for each day. Because each high or low tide time point was roughly 12 h removed from the previous tide time point, auto-correlation within this dataset was not an issue. Prior to analysis, all T_c data were separated by sex and log transformed to conform to the assumptions of parametric statistical analysis and then analyzed using a GLM to examine month, sex, creek, and tide as predictors of terrapin T_c . Significance of these independent variables was assessed using an $\alpha=0.05$. Finally, we used a Duncan's multiple-range test to investigate significant differences in mean terrapin T_c among our independent variables, which allowed us to determine if monthly differences in mean T_c differed, and whether mean T_c was different between sites, between sexes, and between high and low tide.

To evaluate the relationships between T_e and T_c and infer monthly habitat use, we used a corresponding subset of 30 weekly, daytime, time-stamped T_c from both tidal creeks and corresponding T_e (water, shallow mud, deep mud). All T_c and T_e data were log transformed to conform to the assumptions of parametric statistical analysis. We used linear regression to assess the effectiveness of each environmental predictor on terrapin T_c . We used an

information-theoretic approach to compare three models (water, shallow mud, deep mud) for each month and distinguished among competing models with Akaike's Information Criterion, corrected for small sample size (AIC_c), and corresponding AIC_c weights (Burnham and Anderson, 2002).

To examine the effects of month and sex on basking frequency we used our full dataset and compared each terrapin's T_c at each recorded daytime time point to the warmest available T_e for that point. We inferred basking if T_c was recorded at 5 °C above T_e (Grayson and Dorcas, 2004). This basking criterion was established by Grayson and Dorcas (2004) because it was the smallest value that accounted for variation within T_e at a given time, where recorded T_c could not have been obtained by the turtle changing its habitat. Although this criterion likely results in an underestimation of basking events, the estimation will be uniform over time among terrapins and allowed us to infer and compare basking behavioral trends spatially and temporally. We used logistic regression and an information-theoretic approach to determine the probability of basking, with potential predictors being month, sex, time of day, month*sex, month*time of day, sex*time of day, and month*sex*time of day.

3. Results

Mass for female terrapins used in our analysis ranged from 1073 to 1236 g (mean = 1163 ± 65 g, $n=5$) and SCL ranged from 186 to 202 mm (mean = 191 ± 6.3 mm). Mass for male terrapins used in our analysis ranged from 228 to 334 g (mean = 285 ± 37 g, $n=12$) and SCL ranged from 111 to 133 mm (mean = 123 ± 6.0 mm). Water temperature ranged from 3.7 to 34.1 °C (SD = 6.92, $n=8538$), shallow mud temperature ranged from 3.3 to 32.3 °C (SD = 6.71, $n=8538$), and deep mud temperature ranged from 12.4 to 31.1 °C (SD = 4.88, $n=8538$). All three microhabitats followed similar temperature profiles, with deep mud fluctuating to a lesser degree.

We found considerable variation in terrapin T_c among months ($F=677.43$, $df=11$; $p<0.001$), between sexes ($F=36.82$, $df=1$; $p<0.001$), and creeks (GLM; $F=5.77$; $df=1$; $p=0.02$), though mean T_c between sexes (males = 21.1 °C ± 0.23, females = 21.9 °C ± 0.30) and creeks (Oyster = 21.3 °C ± 0.26, Fiddler = 21.5 °C ± 0.26) were similar. Mean T_c differed among months, with the exception of the summer months (June–August), which did not differ from one another, and November and March, which also did

not differ (Fig. 1). Finally, we found no difference in mean T_c between high and low tides (GLM; $F=0.43$, $df=1$; $p=0.51$).

The best T_e predictor for T_c varied seasonally and among microhabitats. Specifically, from November to March, T_e of shallow mud was the best-supported predictor of terrapin T_c ($AIC w_i \geq 0.97$), whereas from April to October, T_e of the water was the best predictor of T_c ($AIC w_i \geq 0.92$), with the exception of June when T_e of the shallow mud was the best predictor of terrapin T_c ($AIC w_i \geq 0.99$, Table 1). We found no support for terrapin T_c to be predicted by T_e of the deep mud.

To investigate their relationship with relative basking probability, sex, month, time of day, and each combination thereof were examined as predictors of relative basking probability. We detected 650 basking events throughout our study from all 17 terrapins. We found that the model that included sex and month best predicted relative basking probability ($AIC w_i=0.69$), followed by the model that included sex, month, and time of day ($w_i=0.31$, Table 2). Across all months, males had a higher mean basking probability than females. We found that the probability of basking for both sexes was greatest during early spring (March–May), with April exhibiting the highest probability of basking for both males (0.038) and females (0.033). Compared to spring, both male and female terrapins had a relatively lower mean probability of basking (≤ 0.020) during summer (June–August) and fall months (September–November). The winter months (December–February) had the lowest relative basking probability for both sexes (0.001, Fig. 2).

4. Discussion

Our results suggest that, like many ectotherms, terrapins are subject to environmental factors including surface, substrate and water temperatures, and rely on behavioral adaptations to thermoregulate (Helmuth et al., 2006). We observed that terrapin T_c closely followed T_e fluctuations throughout the year. By comparing T_c with available T_e we inferred a shift in microhabitat selection across the year, from shallow mud (November–March) to open water (April–October, with the exception of June). Additionally, in examining basking probabilities we found evidence that terrapins bask most frequently in the spring and fall months, and that adult males may bask more frequently than adult females. Finally, we found no evidence to support the idea that daily tidal fluctuations have an effect on terrapin basking or thermoregulatory behavior.

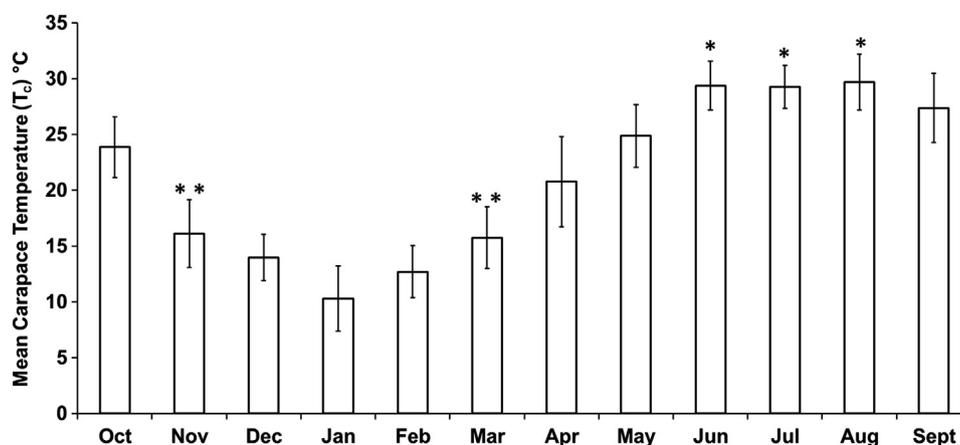


Fig. 1. Average T_c by month through one calendar year ± SD. A warming trend is seen through the spring and summer months, followed by a cool down in late fall and early winter. Columns with matching numbers of asterisks were shown to be similar by a Duncan's Grouping.

Table 1

Monthly microhabitat use inferred by using environmental temperatures (T_e) as predictors of terrapin carapace temperature (T_c). A generalized linear model and AIC_c inference was used to determine candidate microhabitat models that best predicted T_c , and thus, terrapin habitat use. The best supported predictor microhabitat model for each month is in bold. Number of parameters (K)=2 for every model.

Month	Microhabitat model (T_e)	AIC_c	ΔAIC_c	Akaike weight (w_i)
October	Water	-696.92	0.000	1.00
	Deep mud	-539.72	157.207	0.00
	Shallow mud	-615.39	81.537	0.00
November	Water	-568.80	51.753	0.00
	Deep mud	-481.17	139.385	0.00
	Shallow mud	-620.55	0.000	1.00
December	Water	-611.90	70.112	0.00
	Deep mud	-477.19	204.819	0.00
	Shallow mud	-682.01	0.000	1.00
January	Water	-434.54	52.184	0.00
	Deep mud	-291.75	194.979	0.00
	Shallow mud	-486.73	0.000	1.00
February	Water	-596.97	6.678	0.03
	Deep mud	-436.84	166.808	0.00
	Shallow mud	-603.65	0.000	0.97
March	Water	-521.37	21.208	0.00
	Deep mud	-440.10	102.490	0.00
	Shallow mud	-542.57	0.000	1.00
April	Water	-564.38	0.000	0.92
	Deep mud	-535.16	129.218	0.00
	Shallow mud	-559.61	4.770	0.08
May	Water	-742.99	0.000	0.99
	Deep mud	-625.10	117.893	0.00
	Shallow mud	-734.01	8.983	0.01
June	Water	-733.52	9.509	0.01
	Deep mud	-661.35	81.676	0.00
	Shallow mud	-743.02	0.000	0.99
July	Water	-811.55	0.000	1.00
	Deep mud	-740.23	71.316	0.00
	Shallow mud	-778.86	32.686	0.00
August	Water	-723.47	0.000	1.00
	Deep mud	-646.83	76.641	0.00
	Shallow mud	-682.69	40.772	0.00
September	Water	-719.82	0.000	1.00
	Deep mud	-582.50	137.316	0.00
	Shallow mud	-687.58	32.238	0.00

Table 2

Predictive power of month, sex, time of day, and combinations thereof on relative basking probability. AIC_c inference was used to determine which models best predicted relative basking probability. The best supported predictor models are in bold.

Model	K (# of parameters)	AIC_c	ΔAIC_c	Akaike weight (w_i)
Sex and month	3	6337.02	0.00	0.69
Sex, month, and time of day	4	6338.59	1.56	0.31
Sex and time of day	3	6845.89	508.86	0.00
Month and time of day	3	6384.92	47.89	0.00
Sex	2	6843.43	506.40	0.00
Month	2	6383.65	46.62	0.00
Time of day	2	6891.73	554.69	0.00

Previous studies of thermal biology of freshwater turtles have also shown a strong correlation between turtle temperature and T_e . For example, Grayson and Dorcas (2004) noted that T_b (measured as T_c) of eastern painted turtles (*Chrysemys picta*) was correlated with T_e and Rowe and Dalgarn (2009) showed that *C. picta* behaviors correspond with daily fluctuations in ambient

temperatures. Although T_c is likely not identical to internal T_b , particularly with larger aquatic turtles (e.g. *Chelydra serpentina*; Brown et al., 1990), previous studies have found T_c to be strong indicators of T_b of small to medium-sized turtles (*C. picta*: Grayson and Dorcas, 2004; *Cuora flavomarginata*: Chen and Lue, 2008; *Platysternon megacephalum*: Shen et al., 2013). Moreover, due to the relatively small body size of terrapins (mass range=228–1236 g, this study), thermal inertia between T_e and T_b is likely negligible (Lutterschmidt and Reinert, 2012), particularly on the hourly time interval we used.

The simultaneous measurements of T_c and T_e of estuarine microhabitats allowed us to document clear shifts in terrapin microhabitat use throughout the year. Our data suggest that terrapins at Kiawah Island use shallow mud from November to March and open water during most other months of the year, with the exception of June. During June, terrapins may have been in a transition zone between microhabitats, nesting, or visiting a habitat that we did not monitor with a similar temperature profile as the shallow mud. We found no support of deep mud as a predictor of terrapin T_c and thus conclude that terrapins rarely, if ever, bury themselves in deep mud (45 cm). Our results suggest that terrapins in South Carolina overwinter in the shallow intertidal mud of the salt marsh, and emerge from dormancy and enter the water column in/around April. Habitat predictions in this study are consistent with studies in southeastern North Carolina where terrapins were observed to hibernate in shallow intertidal mud (4–5 cm) from October to April (Williard and Harden, 2011; Harden and Williard, 2012). Although we found strong support for the use of two microhabitats, terrapins may occasionally use additional microhabitats, including dunes near estuarine areas, sandy mounds within marshes, natural sand levees, diked areas, and other coastal elevations above normal high tides (Palmer and Cordes, 1988). However, the focus of this particular study was to document monthly temporal shifts in frequented microhabitat used and activity (basking, swimming, burrowing) throughout a year and thus, we did not measure temperatures of all microhabitats available to terrapins within the marsh ecosystem.

Terrapins exhibited the highest probability of basking during the spring months and exhibited a second, smaller peak in the fall. Spring and fall are transitional periods during which the energy gained through solar radiation offsets the loss of energy through conduction while exposed to cooler environments (Heatwole and Taylor, 1987). During the summer months, we observed a decline in basking behavior, likely because in warmer months basking is not required to achieve an optimal body temperature (Harden et al., 2007). Grayson and Dorcas (2004) documented similar patterns of basking in *C. picta*, in which basking was used to obtain higher T_c predominately during the late winter, spring and fall months, and less often during summer months.

Throughout our study, adult males consistently had higher mean basking probabilities than adult females, which is corroborated with results from Grayson and Dorcas (2004) who recorded more basking events for males, particularly during the winter months of January and February. These findings may be explained by the dramatic sexual dimorphism of terrapins in which males have a higher surface area to volume (SA/V) ratio, potentially causing males to lose heat to their environment more rapidly than females. As a result, males may exhibit higher basking rates in order to maintain T_b above that of T_e . However, other studies have shown that female turtles bask more frequently than males, particularly when they are ovigerous and have elevated energy requirements for egg production (Carriere et al., 2008; Rowe and Dalgarn, 2009).

Adult male terrapins may also exhibit higher basking frequencies than adult females in order to maintain osmotic balance of body fluids, which likely poses more of a challenge for males due

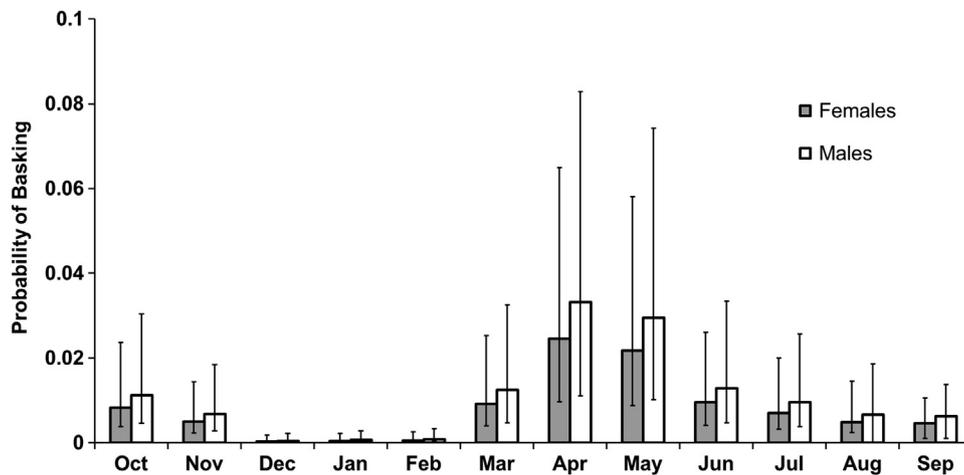


Fig. 2. Relative basking probabilities of males and females each month \pm SE. The probability of recording a basking event in a given month by a given sex was calculated by dividing the total basking events recorded for a given sex in a month by the total daytime data points for individuals of that sex in that month.

to their larger SA/V ratio. Integument (skin and shell) permeability is generally low in reptiles, minimizing the passive exchange of water and salts between reptiles and their environment (Lillywhite, 2006). Documented rates of water efflux and salt influx across terrapin integument is also low, however, prolonged exposure to salt water results in a gradual, yet substantial, increase in plasma Na^+ and Cl^- concentration and weight loss suggestive of dehydration (i.e. osmotic stress; Robinson and Dunson, 1976). Therefore, by leaving the water, terrapins are able to minimize salt and water exchange between their body fluids and their estuarine environment and thus reduce hyperosmotic stress, particularly during times when fresh water is not available. A study conducted on captive terrapins in seawater found that terrapins engage in emersion more often when deprived of freshwater, even when doing so results in a non-optimal T_b (when air temperature is markedly lower than water temperature and light source is absent; Davenport and Magill, 1996). Davenport and Magill (1996) also postulated that larger terrapins lose less water when immersed in seawater than smaller terrapins under similar conditions (due to differences in SA/V ratio for water and salt exchange), suggesting that larger terrapins can immerse for a shorter period to achieve osmotic balance of body fluids. Although evaporative water loss may be enhanced via basking, it is possible that the reduced salt intake from seawater and the elevated excretion of salt via the cloaca and salt glands that occurs while basking on land may provide a more efficient means of osmoregulation than might be possible in seawater (Davenport and Magill, 1996).

Shifts between aquatic and terrestrial habitats may play an important role in water and salt balance for this species (Coker, 1906; Yearicks et al., 1981; Spivey, 1998; Butler, 2002; Harden et al., 2007; Haramis et al., 2011; Williard and Harden, 2011; Harden and Williard, 2012). Thus, in addition to osmoregulation via increased basking frequency, terrapins may also be exploiting shallow mud habitats with high humidity levels and lower salinity of interstitial water in estuarine sediments to decrease rates of water exchange and further enhance the terrapin's ability to conserve water stores during periods of osmotic stress (Nestler, 1977; Davenport and Magill, 1996).

Inhabiting an estuarine environment means that terrapins must experience continuous fluctuations in tide. The daily tidal magnitude varies to a degree that it results in substantial habitat changes which may influence feeding ecology, predator interactions and basking opportunities (Ernst and Lovich, 2009). However, we found no correlation between T_c and tidal cycle. Even

during low tide, when we would expect to see elevated water temperatures correlated with a decrease in volume without a comparable decrease in surface area, there seems to be little to no effect on water temperatures. Harden et al. (2007) reported elevated T_c as a result of basking events rather than the daily tidal fluctuations. In a study on Florida terrapins, tide was not found to affect counts of terrapins (Butler, 2002), but Harden et al. (2009) found more terrapins in the water during head counts surveys at low tide than at high tide. Our data suggests that thermoregulation, and potentially behavior, are unaffected by tidal variations, but more study on the topic is needed to clarify the potential effects of tidal fluctuation on terrapin behavior.

Future studies to clarify our findings and support our explanations are required. Radio-telemetry in conjunction with temperature dataloggers could be especially effective in investigating microhabitat usage by allowing for comparisons between visual observations and thermal recordings. Additionally, understanding more about the seasonal osmotic and metabolic status of terrapins could help to elucidate the patterns in habitat use shifts and behavioral thermoregulation we documented in our study, particularly between sexes and months. Currently, terrapins face a suite of mainly anthropogenically-induced threats that suggest an uncertain future for their populations throughout much of their range, including Kiawah Island, SC. Knowledge of habitat use, behaviors, and thermal biology of terrapins can be used to establish and improve conservation and management measures. For example, knowledge of seasonal shifts in habitat use, as provided by our thermal profiles, can be important information for blue crab fishermen when they are deciding when and where to deploy crab pots that will minimize terrapin–crab pot interactions and potential bycatch.

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