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## Using Predator Vocalizations to Deter Raccoon Predation on Nests of Diamondback Terrapins (*Malaclemys terrapin*)

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USING PREDATOR VOCALIZATIONS TO DETER RACCOON PREDATION ON NESTS OF  
DIAMONDBACK TERRAPINS (*MALACLEMYS TERRAPIN*)

By  
Colleen E. Naeger

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Submitted in Partial Fulfillment of the  
Requirements for the Degree of Master of Science in  
Coastal Marine and Wetland Studies in the  
School of the Coastal Environment  
Coastal Carolina University

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# **Using Predator Vocalizations to Deter Raccoon Predation on Nests of Diamondback**

## **Terrapins (*Malaclemys terrapin*)**

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### **ABSTRACT**

Raccoons are a dominant predator on eggs of Diamondback Terrapins (*Malaclemys terrapin*), an estuarine specialist turtle endemic to saltmarshes of the eastern and gulf coasts of the United States. The purpose of this study was to determine if broadcast predator vocalizations could potentially deter raccoons from foraging on Diamondback Terrapin eggs. I used artificial nests arrays to test two hypotheses: 1) predator vocalization playbacks (barking German shepherd dog) reduce number of artificial nests depredated by raccoons compared to non-predator vocalization playbacks (gray fox) or no-sound control treatments, and 2) predator vocalization playbacks reduce frequency of visits by raccoons and overall foraging time compared to non-predator and no-sound control treatments. Sound treatments were randomly assigned to each night of a three day trial, with three trials conducted at four experimental sites. I counted the number of depredated artificial nests and used trail cameras to document number of raccoon visits and raccoon foraging time following each sound treatment. On average,

51% of artificial nests were depredated in the predator vocalization treatment, 66% in the non-predator treatment and 81% of nests in the no-sound control treatment. Average number of raccoon visits was about three times higher in the no-sound control treatment compared to the predator treatment, but auditory treatment did not affect time spent foraging. Response to the predator vocalization was attenuated by repeated exposure to recorded predator playbacks. Variation in type of predator vocalization, length, and frequency of playbacks may increase effectiveness of auditory deterrents on predators of Diamondback Terrapin nests.

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CHAPTER I: USING PREDATOR VOCALIZATIONS TO DETER RACCOON  
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## INTRODUCTION

Consumption of turtle eggs by terrestrial predators is a major cause of mortality for many aquatic turtle species (Iverson 1991; Barton and Roth 2008). Nest predator species vary geographically, however in North America, raccoons (*Procyon lotor*) (Linnaeus) are the dominant nest predator (Klemens 2000). Raccoons are generalist mesocarnivores that occur throughout most of the United States and southern third of Canada and thrive in proximity to human habitation (Hoffman and Gottschang 1977; Roosenburg and Place 1994; Prange and Gehrt 2004; Engeman et al. 2006; Bozek et al. 2007). The efficiency with which raccoons locate and consume turtle nests is likely due to their acute olfactory and tactile senses, along with their ability to quickly identify available food sources (Zeweloff 2002; Burke et al. 2005; Geller 2012; Buzulecieu et al. 2016).

Diamondback Terrapins (*Malaclemys terrapin*) (Latreille) are estuarine specialists found exclusively in coastal salt marshes of the eastern, southeastern, and Gulf Coast of the United States (Ernst et al. 1994). Diamondback Terrapins are a species of conservation concern over most of their geographic range due to habitat loss, pollution, crab pot mortality, boat strikes, roadway construction, and depredation on eggs and juveniles (Roosenburg 1991; Butler et al. 2006; King and Ludlum 2014). Raccoons are a dominant predator of Diamondback Terrapin nests across their geographic range (Stancyk et al. 1980; Stancyk 1982; Prange and Gehrt 2004; Butler et al. 2006; Barton and Roth 2007). In North Inlet of Winyah Bay, South Carolina, Diamondback Terrapin nesting areas are limited by availability of suitable open, sandy, habitats lying above the

mean high tide line (Buzuleciu et al. 2016). Limited availability of suitable nesting habitats results in high nest densities in favorable areas, which allow foraging raccoons to easily locate and exhume a high number of Terrapin nests at a given nesting site (Seigel 1980; Munscher et al. 2012).

Comprehensive conservation plans for most threatened or endangered aquatic turtle species include strategies that mitigate egg mortality due to nest predators (Schroeder 1981; Stancyk 1982; Barton and Roth 2007). One approach to reducing turtle nest depredation is to protect individual nests with exclusion devices such as protective nest “cages” (e.g. Buhlmann and Osborn 2011; Riley and Litzgus 2013; Engeman et al. 2014; Buzuleciu et al. 2015), and larger nesting areas using electric fences (Geller 2012) or nest protection boxes lined with electric wiring (Quinn et al. 2015). Alternatively, removal of raccoons can reduce depredation pressure on nesting sites (e.g. Ratnaswamy et al. 1997; Ratnaswamy and Warren 1998; Barton and Roth 2007; Munscher et al. 2012). While these methods may be effective in some situations, cages and electric fencing require considerable logistical and monetary investment to set-up and maintain (Bennett et al. 2009; Kurz et al. 2012). In contrast, auditory deterrents may provide a relatively cost-effective, non-lethal method of reducing raccoon depredation at turtle nesting sites.

Auditory deterrents produce sounds that focal animal species perceive as a warning or threat, therefore eliciting a fear or avoidance response (Boudreau 1972; Koehler et al. 1990; Seamans et al. 2013; Suraci et al. 2016). Commonly used auditory

deterrents consist of explosions, clanging and banging sounds (Bomford and O'Brien 1990; Koehler et al.1990). In contrast, only a few studies have explored using predator vocalizations to induce an avoidance response in predator species, such as raccoons. For example, broadcast vocalizations of barking dogs have been successfully used to deter raccoons from preying on intertidal invertebrates (Suraci et al. 2016). However, to our knowledge, no studies have tested whether predator vocalizations are effective at reducing raccoon depredation on turtle nests.

The aim of this study was to determine if broadcasted predator vocalizations deter raccoons from foraging on Diamondback Terrapin eggs. I constructed a series of artificial nests at known or predicted Diamondback Terrapin nesting sites and played pre-recorded vocalizations of domestic dogs, a known raccoon predator (Suraci et al. 2016; Washington Department of Fish and Wildlife 2020), to evaluate the effects on number of depredated nests and raccoon foraging behavior. Artificial nests are used as a proxy for actual Terrapin nests, and this approach allows researchers to design replicated experiments to test specific hypotheses that would not ordinarily be feasible using natural nests (Marchand et al. 2002; Burke et al. 2005; Strickland et al. 2010; Buzuleciu et al. 2016; Edmunds et al. 2018). I tested two hypotheses: 1) Broadcast predator vocalization playbacks reduce number of artificial nests depredated by raccoons compared to non-predator vocalization playbacks or control (no-sound) treatments and 2) Broadcast predator playbacks reduce frequency of visits by raccoons and overall foraging time at sites.

## METHODS

### *Field Site Description*

Research was conducted at North Inlet - Winyah Bay National Estuarine Research Reserve (WBNER), Georgetown County, South Carolina (33.35 °N, 79.20 °W) from June through November 2019. The reserve consists of approximately 7,082 ha of maritime forest and salt marsh habitat including extensive *Spartina* spp. (cordgrass) flats, tidal creeks, and barrier islands. A total of four experimental sites, separated by at least 200 m were used (Figure 1). Study sites were selected based on presence of habitat characteristics typical of Diamondback Terrapin nesting sites: open, sandy, sunny habitats, with sparse ground cover adjacent to the salt marsh (Roosenburg 1994). Two of the study sites were located in known Terrapin nesting areas (Buzuleciu et al. 2016) and two were located in areas of suitable habitat, but not previously identified as Terrapin nesting sites.

### *Construction of Artificial Nests and Camera Monitoring*

Prior to application of vocalization treatments (described below), I used a soil coring auger to construct 30 artificial nests each night of a three-night trial period according to the protocol described in Buzuleciu et al. (2016). After soil was removed by the auger, it was then replaced with the trowel. The number of artificial nests differed between trial 1, site one (40 nests) and trial 1, site two (20 nests) because these sites were initially used as pilot locations at the beginning of the study. Each artificial nest consisted of a cylindrical hole about 6 cm wide × 10-12 cm deep and placed at least 1.5 m apart from other artificial nests within an area of approximately 8.5 m x 6.5 m. On the day

prior to application of the vocalization treatments, two types of artificial nests were constructed. In six artificial nests, I placed a chicken egg into the cavity and backfilled with previously excavated soil. The remaining artificial nests were excavated and soil immediately replaced with no additional manipulation. I lightly packed soil into each nest cavity and removed visually conspicuous evidence of nest location. Soil disturbance alone is a sufficient cue to stimulate raccoons to excavate turtle nests (Burke et al. 2005; Geller 2015; Buzuleciu et al. 2016; Edmunds et al. 2018); however, I also used chicken eggs as a reward to encourage raccoons to maintain interest in artificial nest arrays.

On the morning following each vocalization treatment, I counted the number of depredated artificial nests and each depredated nest was replaced with a newly constructed nest at a distance of 0.5m from the original position. After conducting auditory treatments (see below) for three days at each of two sites, the same procedure was repeated at two new sites on the WBNER property.

Raccoon visits to each site were documented using Moultrie® M-880 motion-activated trail cameras (Moultrie® Game Spy® M-880 Mini 8.0 Megapixel Digital Game Camera, Moultrie Feeders, Alabama, USA). Cameras were fastened to wooden posts at a height of 2.4m above the ground. At the onset of the study, I had access to six trail cameras, with three cameras allocated to each of two experimental sites which were tested simultaneously. One camera malfunctioned at the beginning of the study, hence I allocated the remaining five cameras between the two study sites: site 1 was monitored by three cameras, site 2 was monitored by two cameras, site 3 was monitored by three

cameras, and site 4 was monitored by two cameras. Cameras were angled towards the ground to capture animal movement at the simulated nests, and when triggered by animal movement, trail cameras recorded images using a three picture multi-shot mode with a five second photo delay, documenting both species identity and time spent on site. Camera FOV encompassed a majority of artificial nests at each site; however, a small number of artificial nests (< 8) on the periphery lay outside the FOV. Because raccoons typically searched extensively throughout artificial nest arrays while foraging, it is unlikely that raccoons visiting experimental sites would not have been captured by trail cameras.

#### *Vocalization Treatments*

To quantify effects of vocalization treatments on raccoon nest depredation, I broadcasted recorded mammalian vocalization playbacks using a ICOTec GEN2 GC350 Programmable Game Call machine (ICOTec Inc, Toledo, OH) over a three-night interval at each of the study sites. Vocalization treatments consisted of a predator (barking German Shepherd dog, *Canis lupus familiaris*), non-predator (gray fox, *Urocyon cinereoargenteus*), and a no-vocalization control (no broadcasted vocalizations). I predicted that the sound of aggressive barking dogs would induce a fear and avoidance response in foraging raccoons (Suraci et al. 2016). I chose gray fox vocalizations as a neutral control (non-predator treatment) because they are common in the area (Buzuleciu, et al., 2016) and are not a known raccoon predator (South Carolina Department of Natural Resources 2020). Accordingly, I judged that raccoons would presumably hear gray fox vocalizations during nightly foraging but not perceive them as a predatory

threat. I recorded the barking sounds from a three-year old female German shepherd dog (Smart Mobi Tools (2020) *Voice Recorder App*. (Version 8.2.1) [Mobile App] Google Play Store) and the gray fox vocalization was obtained from stock recordings included with the game calling device. Predator and non-predator calls were each individually edited by the program Audacity 2.3.2 (Audacity ® software © 1999-2020 Audacity Team) to create a sound file that played the vocalization for 270s, followed by 30s of silence before repeating the sound file. I measured sound levels produced by the vocalization playbacks at a distance of 0.3 m, 4.5 m and 110m from the game call speaker using a BAFX decibel reader (Muskego, WI, USA; accuracy  $\pm 1.5$  dB, range 30 dB – 130 dB). The game-calling device was set to maximum volume, producing a sound intensity of about 92 db at 0.3 m from the speaker, 75 to 80 db at 4.5 m, and about 25 db at 110 m from the source. Decibel measurements were made during clear weather with 1 to 5 km h<sup>-1</sup> wind.

Order of vocalization treatments (i.e., predator, non-predator, or control) was randomly assigned to each night of a three-day experimental trial. Each treatment was first assigned a number (1, 2, or 3) and then assigned to the nightly sound treatment using a random number table. Vocalization treatments were applied simultaneously to two of the four sites at a time; however, the order of the vocalization treatment was randomized for each trial at each site. One call machine was placed at each site and located at least 1.5 m from the closest artificial nest. Each vocalization treatment was played from 1600h to 0900h for one night of the three-night trial, which made for one complete trial at the site. Each time a vocalization treatment was initiated, playbacks were monitored for

several minutes to make sure the call machine was working properly. Volume levels were not changed throughout the experiment. In all cases, the call machine was functioning the following morning when sites were checked for nest depredation, indicating that broadcast vocalizations played throughout the night. Trials were repeated three times at each site, with a 72 h pause between trials. Access to two sites was temporarily blocked during the study due to road closures resulting from downed trees and flooding caused by Hurricane Dorian. Accordingly, I resumed the experiment with the next scheduled randomized vocalization playback or the next trial once I regained access to the testing sites. A total of 340 nests were constructed for the predator treatment, 360 nests were constructed for the non-predator treatment and 360 nests were constructed for the control treatment ( $n_{\text{total}} = 1,060$  artificial nests).

#### *Determination of Number of Raccoon Visits and Time Spent at Sites*

I recorded number of raccoon visits and time spent on-site using time stamped images, as a function of treatment, to determine if vocalization treatment affected raccoon foraging behavior. Raccoon visits were assessed as number of raccoons recorded on camera each night. Raccoons that left the camera field of view (FOV) and returned within 60 s or less, or did not fully leave the camera FOV were considered a single visit. Raccoons that left the FOV and returned within 60 s typically did so at about the same location, hence I believe I could distinguish between newly arrived individuals and raccoons remaining on-site. Total amount of time spent on-site was assessed as the duration of time (minutes) beginning with first appearance of a raccoon in the FOV and

ending when the individual left for more than 60 s. When multiple raccoons were observed foraging on a given night, time spent was calculated as the average time spent on site across all individuals in the FOV. I did not include North Boundary Road Site 2 in calculations or statistical analyses of number of raccoon visits and time spent foraging due to a camera malfunction, which prevented accurate documentation of raccoon presence.

### *Statistical analyses*

I conducted statistical analyses using SPSS statistical software (IBM SPSS Statistics 26 Armonk, NY). I evaluated the effect of vocalization treatment (predator, non-predator, and no-vocalization control) on nest depredation (depredated vs non-depredated) using logistic regression with treatment, night per trial, trial, and site as fixed factors (Lewis 2004).

I evaluated the effect of vocalization treatment on number of raccoon visits per night and time spent on-site using an analysis of variance (ANOVA) with treatment, night per trial, trial, and site as fixed factors. I tested the assumption of a normal distribution using a skewness test for each of the dependent variables. Alpha values  $\leq 0.05$  were considered statistically significant.

## **RESULTS**

### *Nest Predators*

Several mammalian species, other than raccoons, were detected by trail cameras at the four study sites, but were not documented as preying on any of the artificial nests. The most common nest predator species was the raccoon, which accounted for 89.5% (1875/2096) of the total species images. Other potential nest predators included Virginia opossum (*Didelphis virginiana*) 1.3% (27/2096), Coyote (*Canis latrans*) 0.76% (16/2096), and bobcat (*Lynx rufus*) 0.29% (6/2096).

### *Depredated Nests*

Number of depredated artificial nests differed among the three vocalization treatments (Table 1). Overall, 51% (173/340) of artificial nests in the predator vocalization treatment were depredated compared to 66% (239/360) of nests in the non-predator and 81% (292/360) of nests in the control treatments (Fig 2A). The odds of artificial nest predation were about 13.7 times higher in the predator treatment compared to the control whereas the odds of predation were about 3 times higher in the non-predator treatment compared to the control (Table 3). Overall frequency of depredated artificial nests differed both among nights within trials, and trial number (Table 1). Frequency of depredated artificial nests was lowest on first and second nights compared to the third night of the trials independent of order in which playbacks were broadcast (Figure 3). On average, percentage of depredated artificial nests was about four times higher on the third night of the trial period compared to the first night (Figure 3). Similarly, number of depredated nests differed among the three trials (Table 1), with overall depredation frequency lowest in the first trial and highest in the third trial (Figure 3).

Overall percentage of depredated artificial nests increased 1.5 times between trial one and trial two and by nearly 2.5 times between trial one and trial three. Accordingly, the number of depredated nests increased with daily exposure to vocalization treatments (Figure 3). Nest depredation frequency differed among the four study sites, except for site 1 and site 4, and site 2 and site 3 (Table 1).

#### *Frequency of Raccoon Visits and Time Spent Foraging*

Average frequency of raccoon visits per night to experimental sites differed among vocalization treatments with number of visits reduced in predator vocalization treatments compared to the control (Table 2). On average, number of raccoon visits were more than three times higher in the control treatment compared to the predator and about 2.5 times greater than the non-predator treatments, whereas number of visits did not differ between predator and non-predator treatments (P: 3.6, NP: 5.8, C:14.4, Figure 2b). Frequency of raccoon visits did not differ among nights within trials; however, overall number of raccoon visits increased as a function of trial number, with the lowest number of visits occurring during the first trial, and the highest number of visits occurring during the third trial (Figure 3). Overall average number of raccoon visits across treatments was about four times higher in the third trial compared to the first trial (trial 3: 13.4 visits vs. trial 1: 3 visits, Figure 3). The average number of visits did not differ between trial 1 and trial 2 or trial 2 and trial 3 (Table 2). Frequency of raccoon visits did not differ among sites, and time spent foraging was not affected by vocalization treatment, night per trial, trial number or site (Table 2).

## DISCUSSION

Predator playbacks reduced nest depredation, number of raccoon visits and raccoon foraging time; however, these responses were attenuated by repeated exposure to vocalization treatments. Compared to the control, gray fox vocalization reduced frequency of nest depredation in the first and second trial, and the deterrent effect was less than that of the predator vocalization treatment. Both number of depredated nests and frequency of raccoon visits increased with successive trials, and there was a similar trend towards increased time spent foraging by the third trial period. Nest depredation frequency also increased between the first and third nights within trials. Overall, these results suggest that broadcast predator playbacks deterred raccoon foraging, but raccoons became habituated to recorded predator playbacks after repeated exposure.

In a prior study, recorded playbacks of barking dogs reduced raccoon foraging on intertidal invertebrates following exposure to both short (10 s) predator playbacks triggered when raccoons entered the study area, and month-long repeated broadcast predator vocalizations (Suraci et al. 2016). In contrast to this study, Suraci et al. (2016) did not report evidence of raccoon habituation to predator vocalization treatments. A key difference in design of the two studies is that our predator replays consisted of one repeated canine vocalization exemplar, Suraci et al. (2016) used multiple, variable-length, canine predator exemplars. These observations suggest that increased variability and unpredictability of predator playbacks may delay habituation. A habituation effect from auditory methods was also observed in deer when attempting to deter them from intruding on farmland near a river and fence intersection, using a mix of olfactory, visual

and auditory deterrents. Sound devices were found to act as short term deterrents, while the effectiveness appeared to decline when used long term (Honda 2019).

In addition to raccoons, I documented several other potential nest predators at the study sites including bobcats, coyotes, and opossum. With the exception of opossums, I did not observe any evidence of nest depredation by these species. The small number of depredated artificial nests that I attribute to excavation by opossums were dug out in a manner distinct from the very precise excavation strategy used by raccoons. Raccoons excavate artificial nests by digging out the column of soil displaced by the auger, whereas opossums excavate a large shallow depression larger than the diameter of the core produced by the soil auger during artificial nest construction. Our results parallel previous studies indicating that raccoons are the principal nest predator of Diamondback Terrapin nests (Burger 1977; Feinberg and Burke 2003; Butler et al. 2004; Munscher et al. 2012).

#### *Comparisons with other Deterrent Methods*

Several methods have been used to protect nests of non-marine turtle species from depredation by raccoons with varying levels of success. Caging nests is a commonly used and relatively inexpensive method of protecting turtle nests from predators. For example, about 70% of artificial Diamondback Terrapin nests remained intact when protected with flexible cages constructed using wooden dowels resembling “bird cages” (Buzuleciu et al. 2015), and about 83% (84/101) of Blanding’s Turtle nests (*Emydoidea blandingii*) were successfully protected using wooden-frame box cages (Standing et al. 2000). One disadvantage to caging nests is that it requires researchers to identify locations of

individual nests, which may not be feasible or practical in some circumstances.

Alternatively, electric fencing has been used to protect nesting areas of the Ouachita map turtle (*Graptemys ouachitensis*) from raccoon depredation with about 85% of nests surviving (Geller 2012). A disadvantage of electric fence deterrence is that material cost, installation effort and maintenance requirements may be high, particularly if large areas require protection.

Our results suggest that recorded predator playbacks are a potentially effective method to discourage raccoon depredation of turtle nests, provided steps are taken to mitigate habituation of nest predators to auditory deterrents. On average, about 26% of artificial nests were depredated in the predator vocalization treatment in the first two trials, which is comparable to published depredation rates of nests protected by predator exclusion cages. Examples of procedures that could delay habituation include broadcasting playbacks of multiple types of raccoon predators, using a variety of recorded exemplars for a given predator, varying duration and order of playbacks and varying number and position of speaker locations in a given site (Koehler et al. 1990; Suraci et. al. 2016).

Raccoons likely locate nests of Diamondback Terrapins and other non-marine turtle species using the scent of freshly disinterred soil resulting from nest construction (Geller 2015; Buzuleciu et al. 2016). The majority of nest depredation occurs within 24h of nest construction (Burger 1977; Roosenburg 1992; Feinberg and Burke; 2003; Butler et al. 2004), hence nests that remain undetected for more than 24h likely have a greater

chance of avoiding depredation. Predator playbacks at key time points, such as at the beginning and/or peak of nesting season may help increase probability of egg survival to hatching, especially if combined with anti habituation measures or other protective measures such as caging.

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Table 1: Logistic regression and pairwise contrasts of effects of vocalization treatment (predator, non-predator, control), night per trial (night 1,2, and 3), trial number (trial 1, 2, and 3), and site on number of depredated artificial *Malaclemys terrapin* nests.

Variable	Contrast	df	$\chi^2$	<i>P</i>	Depredation Pairwise Result
<b>Depredated Nests</b>					
	Treatment	2	131.84	<0.001	P<NP<C
	Night per trial	2	5.78	0.028	N1<N3=N2
	Trial	2	489.66	<0.001	TR1<TR2<TR3
	Site	3	67.38	<0.001	S1<S2=S3 S1<S3 S2<S4 S3<S4

Table 2: Statistical contrasts (ANOVA) of effects of vocalization treatment (predator, non-predator, control, night per trial (night 1, 2, and 3), and trial number (trial 1, 2, and 3), and site on number of raccoon visits and time spent foraging at study sites (n = 3) in North Inlet, Winyah Bay National Estuarine Reserve, Georgetown County, SC. The abbreviation n.s = non significant results.

Variable	Contrast	df	F	<i>P</i>	Result
<b>Number of Visits</b>	Treatment	2	4.01	0.039	$P < C$
	Night per Trial	2	0.13	0.879	n.s.
	Trial	2	3.32	0.062	n.s.
	Site	2	2.34	0.128	n.s.
<b>Time Spent</b>	Treatment	2	2.12	0.153	n.s.
	Night per Trial	2	0.61	0.555	n.s.
	Trial	2	1.90	0.182	n.s.
	Site	2	1.07	0.368	n.s.

Table 3: Odds ratios and 95% confidence limits for the logistic regression model for the number of depredated artificial nests. Odds ratio values are listed for treatment (P, NP, C), trial (1, 2, 3) and night per trial (1, 2, 3). Values for site variables in terms of nest depredation are not included.

Contrast	Odds Ratio	95% Confidence Limits	
<b>Treatment C vs NP</b>	2.955	1.948	4.480
<b>Treatment C vs P</b>	13.705	8.388	22.391
<b>Treatment NP vs P</b>	4.638	2.933	7.336
<b>Trial 1 vs 2</b>	0.289	0.200	0.418
<b>Trial 1 vs 3</b>	0.003	0.001	0.008
<b>Trial 2 vs 3</b>	0.011	0.004	0.027
<b>Night 1 vs 2</b>	0.828	0.531	1.291
<b>Night 1 vs 3</b>	0.482	0.310	0.751
<b>Night 2 vs 3</b>	0.583	0.377	0.900



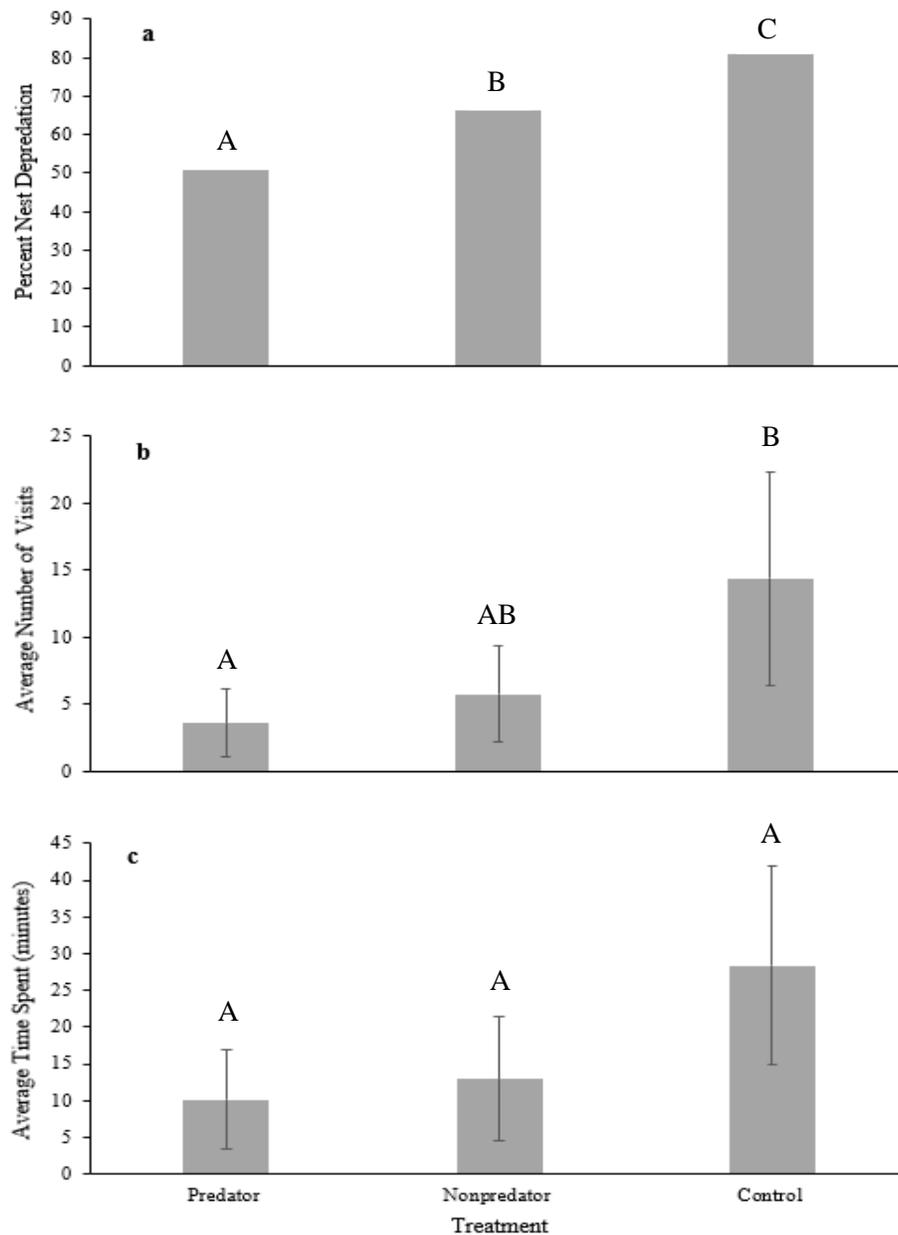


Figure 2. Effects of vocalization treatment on raccoon (*Procyon lotor*) depredation behavior on artificial nests of Diamondback Terrapins (*Malaclemys terrapin*) at experimental study sites in North Inlet, Winyah Bay National Estuarine Reserve, Georgetown County, SC during June – November, 2019. Overall percentage of depredated nests (a), average frequency of raccoon visits ( $\pm$ SE) (b), and average time

spent foraging ( $\pm$ SE) (c), as a function of vocalization treatment, predator (German shepherd barking), non-predator (gray fox vocalizations) or no-sound control (no broadcasted vocalizations). Different letters indicate significance and same letters indicate no significance.

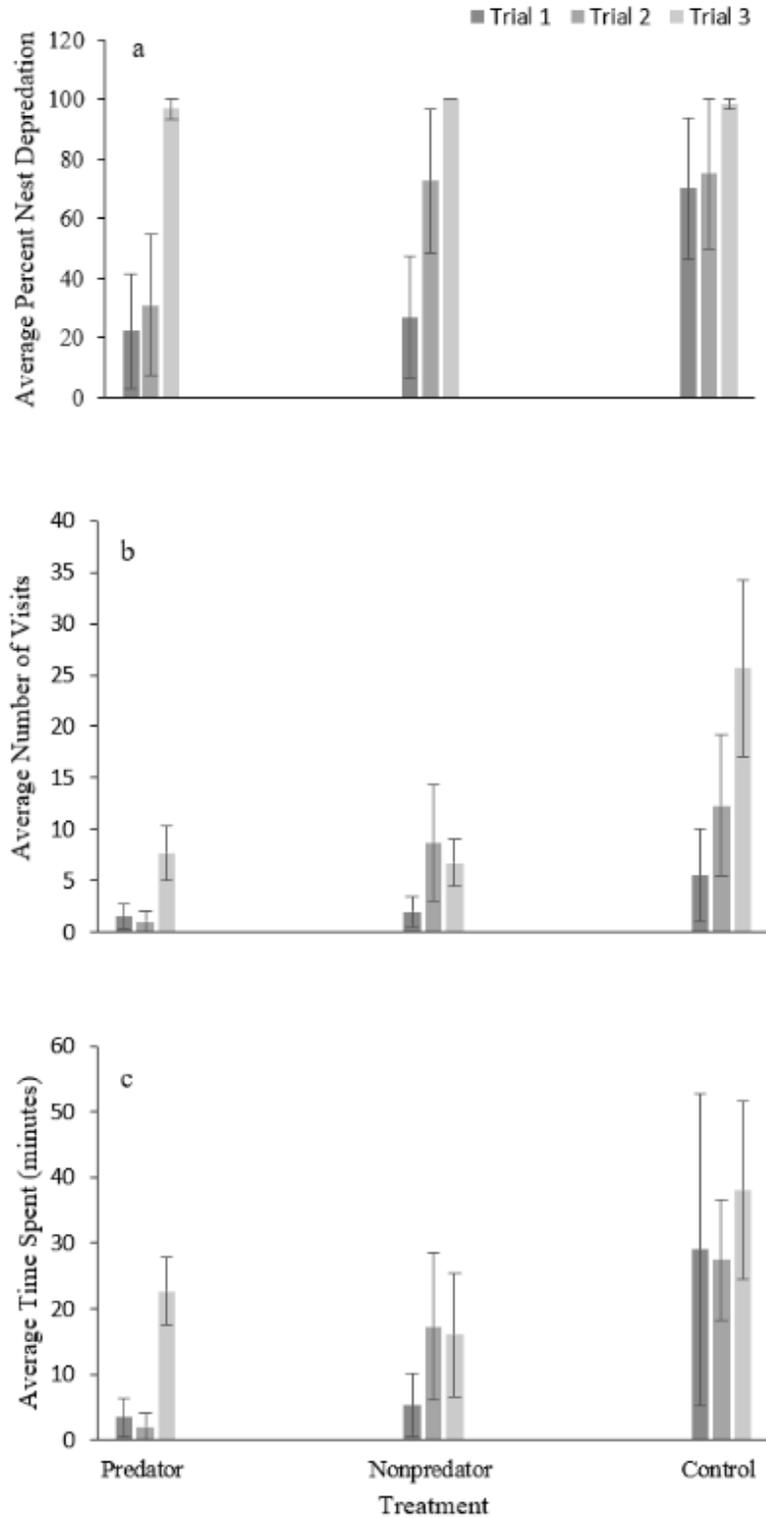


Figure 3: Mean values  $\pm$  SE among trials (1, 2, 3) for percent nest depredation (a) of artificial nests, number of raccoon visits (b), and time spent foraging (minutes) (c) for

predator, non-predator and control treatments at study sites (1(n=4), 2(n=3), 3(n=3), 4 (n=3)) in North Inlet, Winyah Bay National Estuarine Reserve, Georgetown County, SC. Site 2 was excluded from the visits and time spent data analyses due to camera malfunction which prevented accurate assessment of the presence of raccoons on camera.