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Turtles and trail cameras: non-invasive monitoring using artificial platforms

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Freshwater turtles often utilize basking habitats, allowing researchers to obtain population estimates and relative abundances from visual observations via spotting scopes in addition to other traditional trapping methods. Emerging technologies, such as camera trapping with wildlife trail cameras have been extensively utilized in other taxa, primarily mammals and in reptiles such as terrestrial tortoises, but to a lesser extent for monitoring freshwater turtles. Given their ability to bask, combining readily available non-invasive camera traps with standardized platforms may aid researchers study freshwater turtle populations and basking behavior. We assessed this method by deploying a novel artificial basking platform design in tandem with camera traps for weekly monitoring of turtles at a small semi-urban pond in central North Carolina for six months (April to September 2018). Basking behavior was documented with 1098 observations, with the number of turtles utilizing platforms varying according to season, and overall peak use during late spring and early fall. We also noted shifts in artificial basking structure use by species, with Painted turtles, *Chrysemys picta*, replacing Yellow-bellied slider turtles, *Trachemys scripta*, as the dominant basking species over time. Conservation managers should consider using both platforms and trail cameras, for monitoring of freshwater basking turtle populations and as a metric for turtle presence or for detailed studies of behavior.

Key words: basking ecology; *Chrysemys picta*; non-invasive monitoring; reptile conservation;

Management of turtle populations often requires some knowledge of species presence, as some species or individuals may be cryptic in nature and only visible when seasonally active (Roe & Georges, 2007; Olivier *et al*., 2010). Traditional methods of surveying freshwater turtles for survey occupancy studies include baited hoop trapping (Brown *et al*., 2011), and use of basking traps (Gamble, 2006), while less invasive methods for species presence include visual encounters and spotting scope surveys (Lindeman, 1999). However, these non-invasive visual methods of observing turtles may cause turtles to flee basking sites when observers are detected by turtles. While camera traps have been used frequently to assess terrestrial mammal diversity (Glen *et al*., 2013), they have been applied more recently to reptiles (Ariefiandy *et al*., 2013; Chowfin & Leslie, 2014; Welbourne *et al*., 2015; Mohd-Azlan *et al*., 2016), and even in concert with pitfall traps (Richardson *et al*., 2018). In addition, camera traps have been increasingly used to document terrestrial movement of aquatic turtles (Mali *et al*., 2016), nesting behavior (Geller, 2012), and monitor ter-

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Figure 1: Artificial basking platforms deployed during this study showing 1 adult and 1 juvenile *Trachemys scripta* with arrow highlighting trail camera (left) and underside of platforms composed of several wood support frames and polyethylene foam attached with zip ties for increased floatation (right).

restrial tortoises (BALLOUARD *et al*., 2016). Consequently, any method that has the potential to improve detectability of freshwater turtles through less invasive survey techniques for monitoring Chelonians, i.e. affordable trail cameras, should be investigated.

Basking is vital to turtles as ectotherms, primarily serving as a method of thermal control (BOYER, 1965), and as a potential method for monitoring. Turtles inhabiting urban or heavily altered environments may be at increased risk of disturbance, altered basking behavior, and lack of adequate basking habitat (PETERMAN & RYAN, 2009; LAMBERT *et al*., 2013). However, many turtles are capable of utilizing a variety of basking structures, both natural and artificial. Artificial basking substrate has been used primarily to augment habitat for freshwater turtles (ALVAREZ, 2006), however few studies have quantified their use by freshwater turtles using readily available camera traps (BLUETT & SCHAUBER, 2014). Herein, we assessed the efficacy of camera traps to monitor novel artificial basking platform use by freshwater turtles.

The study site selected for this research was a small 5.5 ha pond called Campus Lake, at Wingate University in North Carolina, United States (34.986288°N, -80.429363°W). This area is in the proximity of the Charlotte Metropolitan area, one of the largest urban areas in the state, and presently contains limited natural basking sites (downed wood) as it was once a golf course pond. Area surrounding the permanent pond consists of a mix of semi-urban and semi-natural forest (*Quercus spp*., *Pinus spp*., and *Juniperus spp*.), with walking trails, and frequent use by local fisherman. Native turtles both trapped and observed in this pond include primarily painted (*Chrysemys picta*), yellow-bellied slider (*Trachemys scripta*), and common snapping turtles (*Chelydra serpentina*; ESCOBAR *et al*., 2018). We selected two bays (hereafter referred to as Bulldog and Turtle Bay) within this pond to deploy artificial basking platforms.

We designed, built, and deployed two novel wood artificial basking platforms to standardize basking area and background available to turtles, to aid in identification and enumeration of turtles. Artificial basking platforms consisted of two sections of 1.2 m x 0.13 m x 0.05 m plywood, with two cross beam (0.9 m x 0.13m x 0.05m) of plywood for support. Both ends of the two sections include a 45 degree angled ramp to allow for individual turtles to climb out of water and onto platforms from two sides. On top of this structure we secured 10 smaller plywood sections with nails (Fig. 1). The bottoms of platforms contained inflatable polyethylene foam attached to wood by plastic cable ties, to aid in buoyancy to account for multiple basking turtles. Platforms were secured to the bottom of the pond by three fence posts tied with rope to allow for any changes in water level across seasons. Platforms were deployed at two stations, Bulldog and Turtle bay at Wingate Campus Lake.

Camera traps were deployed facing platforms to allow for seven full days of image capture, from 3 April to 6 October 2018 at both bays. Camera traps were place at a standard length of within 0.25 m immediately west (to capture ideal images and minimize interference from the sun) at 45° angles directly facing artificial basking platforms (Fig. 1). Camera traps were secured to 2 m metal fence posts at a height of ~1 m above water level by a combination of two stainless steel eye bolts inserted and tightened to posts which allowed flexibility of attachment angle. We used two Bushnell Bandit Trail Cameras (model 119637C) set with the following parameters: camera mode, 14-megapixel image capture, one photo per capture, LED control medium, night vision shutter medium, camera mode = 24 hrs. In addition, we ran cameras with both motion sensor mode and field scan mode, with images captured from both 10:00 hr to 20:00 hr (field scan), and when any motion set off cameras. Once cameras were retrieved, images were downloaded from standard SC 32 GB memory cards. In total, six sample events and corresponding images in 2018 included sample events hereafter referred to as April (04/04-04/10), May (04/25-05/01), June (06/15-06/21), July (07/17-07/23), August (08/27-09/02), and September (9/30-10/06) sample periods.

We manually examined downloaded images from cameras to experimentally test the feasibility of both camera traps and artificial basking platform use as a monitoring method. As trail cameras captured several hundred to several thousand images per seven-day deployment, we selected a subset of photos for analysis. One image was selected per deployment day from each basking platform, as a proxy for maximum use of the platform (highest total number of basking turtles observed per day). Concomitantly, images selected for analysis contained readily identifiable physical and capture features (shell shape, size, head stripes, coloration, ample light, high resolution, and minimal reflectance). This resulted in 14 photos per month, for a total of 84 images captured over six months with a minimum of seven days per deployment. We obtained temperature in °C, time, and date of image capture directly from each trail camera image. The total number of turtles using the platform was enumerated according to species by A. Santana, and any turtles unable to be identified by both authors were labeled as unknown. In addition, presence of any juveniles on basking platforms was also documented from images based on size comparisons for species. To ensure quality control, all images were reviewed by S. Unger until both authors achieved greater than 95% agreement for total number of basking turtles present on platform and species. As our data was not normally distributed, we ran a Kendall tau Rank correlation test (Gilbert, 1987) between temperature and the maximum number of turtles observed daily (our subset of 84

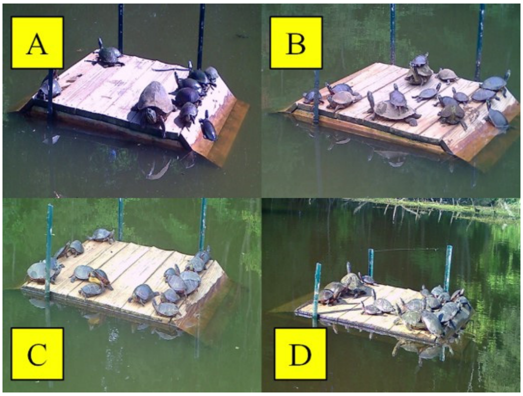

Figure 2: Example images from Bulldog bay camera traps used in analysis from June (A), July (B), August (C), and September (D) sample period in 2018. Note several images contain turtles basking on top of other turtles.

images). We also ran a Friedman test for repeated measures (FRIEDMAN, 1940) to compare overall use by species (painted versus yellow-bellied slider turtles). All statistical tests were run in program R.

Turtles utilized both our artificial basking structures within 24 hours of initial deployment. During the course of our study we obtained a total of 7765 images across both platforms. We report on 1098 individual observations of turtles across a subset of 84 image capture days from two species (painted turtles, *Chrysemys picta* and yellow-bellied sliders, *Trachemys scripta*). We achieved over 99% agreement for quality control of identification of species (painted and yellow-bellied slider turtles, with disagreements only noted for two slider juveniles and one painted turtle out of 1098 individuals). Painted turtles, *C. picta* were the most frequently observed species utilizing basking platforms, with 576 individual total observations of turtles on basking platforms, followed by yellow-bellied sliders, *T. scripta*, with 487 total observations across platforms (Table 1; Fig. 2). In total, 35/1096 (~0.3%) individuals were categorized as unknown species, due to a combination of either other individual turtles blocking the view of a turtle, or turtles facing away from camera not allowing adequate identification down to species. The range of daily maximum turtles on platforms varied from 1 to 37 individuals per day (mean = 13.1), captured between 10:00 hr to 19:29 hr, with temperature ranging from 12 to 37 °C for the same interval. We found a significant correlation within our subset of images for

Table 1: Total numbers of slider, *Trachemys scripta*, painted turtles, *Chrysemys picta*, and unknown species enumerated monthly for Bulldog and Turtle Bay across Spring, Summer, and Fall 2018 at Wingate Campus Lake, Wingate North Carolina. Unknown turtles excluded from total counts.

	Bulldog Bay				Turtle Bay			
	Total	Slider	Painted	Unknown	Total	Slider	Painted	Unknown
April	10	5	4	1	108	54	48	6
May	147	92	52	3	131	57	66	8
June	49	24	23	2	74	42	31	1
July	86	56	30	0	79	53	23	3
August	115	23	92	0	98	32	65	1
September	97	18	71	8	102	31	71	0

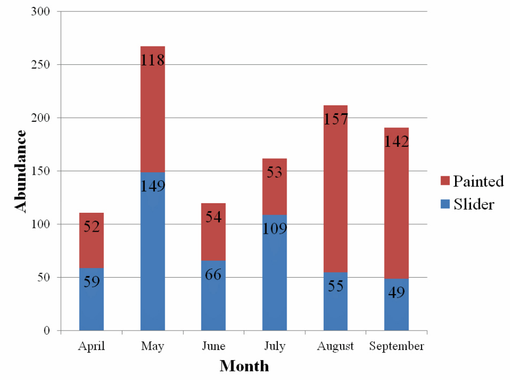

Figure 3: Relative abundance of identified *Trachemys scripta* and *Chrysemys picta* over time. Note in late summer to fall season, painted turtles became increasingly dominant users of artificial basking platforms, with the highest total abundance observed in May 2018.

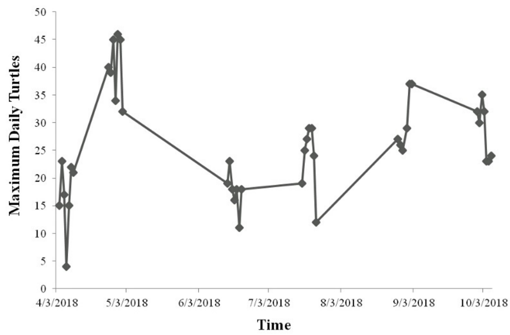

Figure 4: Maximum daily turtles (both species) over time observed on camera traps during deployment times. Note maximum daily use of artificial platforms was highest in May 2018.

temperature and the maximum daily number of turtles observed (τ = -0.189, *p* = 0.015).

We did note a difference in seasonal use of artificial basking structures, with artificial basking platforms being relatively equally used by basking turtles in April and May, but being disproportionately used to a greater extent by painted turtles in Fall or August and September (Fig. 3). While we observed slight differences in use between specific monthly totals of painted and yellow-bellied sliders (July, August, and September), results of the Friedman test of repeated measures found no significant difference between overall use of platforms by species of turtle, X^2 = 0.653, *p* = 0.419. Overall the highest consistent daily use of artificial platforms by both species occurred in May of 2018 (Fig. 4). We noted 22 juvenile turtles using the basking platform (3 *C. picta* and 19 *T. scripta*), and several instances of painted turtles basking on top of other painted turtles or yellow-bellied sliders. Interestingly, we observed additional species other than turtles setting off motion sensors, resulting in images from multiple Great blue herons (*Ardea herodias*), dragonflies, Muscovy ducks (*Cairina moschata*), and green herons (*Butorides virescens*), in several cases co-occupying the artificial basking structure with ~ 2 to 3 painted turtles.

Our results demonstrate freshwater turtle use of a novel artificial basking platform confirmed by non-invasive trail cameras. We observed a turnover in dominant basking turtles, in which painted turtles became dominant baskers towards the end of our study. *Chrysemys picta* have been previously observed to compete and show aggressive behavior towards other species (Lovich, 1988). While we observed readily basking turtles, researchers using camera traps should obtain not only permits from local or federal agencies, but also proper authorization to access public or private land. Moreover, researchers should be aware of security issues involving theft of cameras or potential concerns over public perceptions of cameras in an urban setting.

As we likely observed many of the same individuals basking on platforms during the course of our study, we recommend researchers use platforms and trail cameras in tandem with more traditional monitoring methods (i.e., hoop traps) to study individual basking behavior, possibly even utilizing non-toxic carapace paint marks for short term behavior studies. For example, while trail cameras provided us with estimates of overall species presence, we were not able to differentiate male and female adult individuals. However, if used in tandem with traditional trapping and individuals are temporarily marked with carapace paint, platform cameras could provide a method to seasonally monitor previously marked individuals of a known gender and age class. Placement (location) of trail cameras and distance to basking structure could be examined further, as could preference for specific basking structures (natural versus artificial) using our method. Moreover, the two turtle species we detected utilizing our basking platforms, account for ~90 % of turtle captures or relative abundance documented during yearly trapping surveys in our site (UNGER, unpublished data), with the only turtle present but not captured on cameras being common snapping turtles, which we have not observed basking at our site. Only a small percentage of juveniles utilized the basking platforms, possibly due to competition or juveniles needing less time for basking as documented in other studies (LEFEVRE & BROOKS, 1994).

Researchers should consider the tradeoffs of motion sensing camera trapping to ensure that camera sensitivity corresponds with study objectives, as post processing images requires substantial time investment. In addition, we observed turtles fleeing (retreating behavior) when observers approached basking turtles, as observed in other studies (PITTFIELD & BURGER, 2017). It is possible we noted less turtles using Bulldog Bay platform during April compared to the other platform at Turtle Bay (Table 1) as it is on a portion of the lake which may get more visitation, and thus disturbance. Our method could be modified to use camera traps to record video which focuses on potential competition, agonistic behavior, breeding behavior, and frequency of movement while basking (i.e. head turns, limb adjustments, etc., LOVITCH, 1990), as well as turtle use of natural basking habitats (downed trees, rocks, shorelines, etc.). Researchers should consider deployment of our method for baseline monitoring behavior or species presence studies, as it requires little financial investment (~$100 for camera and ~$50 platform building supplies), is non-invasive, and turtles readily colonized platforms within the first 24 hours of deployment.

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