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Addition of Inexpensive Lights to Aquatic Turtle Traps Improves Trapping Efficiency in Early Spring

Jenna B. Myers
University of North Georgia, jbmyer2760@ung.edu

Michael J. Bender
University of North Georgia, michael.bender@ung.edu

Maggie M. Woodall*
University of North Georgia, mmwood5981@ung.edu

Jennifer L. Mook
University of North Georgia, jennifer.mook@ung.edu

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ADDITION OF INEXPENSIVE LIGHTS TO AQUATIC TURTLE TRAPS IMPROVES TRAPPING EFFICIENCY IN EARLY SPRING

Jenna B. Myers, M.J. Bender, Maggie M. Woodall, and J.L. Mook
Department of Biology
University of North Georgia
3820 Mundy Mill Road, Oakwood, Georgia, 30566
Corresponding author: michael.bender@ung.edu

Abstract. Aquatic turtles are essential contributors to many freshwater ecosystems, but they face a myriad of threats, necessitating periodic monitoring of population status. Increasing turtle trapping efficiency has the potential to improve conservation efforts, particularly when population sizes are low or sampling conditions are suboptimal. In an effort to improve trapping efficiency, we added LED lights to turtle traps in an attempt to attract kinosternid turtles. Our investigation into the effectiveness of LED lights as an attractant was based on evidence suggesting that these turtles may forage using both visual and olfactory cues. Lights significantly increased captures of kinosternid turtles during early spring, but the increased efficiency did not persist later in the season, possibly due to lights facilitating escape from traps as turtle activity levels increased. To our knowledge, this study is the first research into the efficacy of using lights to increase trapping success of freshwater turtles. Given our encouraging results during early spring and the low cost of LED lights, we encourage researchers to explore the possibility of adding lights to traps to increase captures in challenging trapping conditions.

Keywords: trapping efficiency, light bait, LED lights, turtle trapping, freshwater turtles, Kinosternidae, *Sternotherus odoratus*, *Kinosternon subrubrum*, visual cue

INTRODUCTION

Turtles are essential contributors to ecosystem functioning because of the wide range of ecological processes they influence, including nutrient cycling, seed dispersal, vegetation control, soil formation and maintenance, and maintenance of habitat heterogeneity (Lovich et al. 2018). For a thorough discussion of the status and history of turtle ecology research we encourage readers to review Gibbons and Lovich (2019) and the numerous citations within. Unfortunately, many turtle populations are facing accelerating rates of decline, which is a growing conservation concern because depauperate turtle communities are less capable of fulfilling valuable ecological roles (Lovich et al. 2018; Stemle 2017, Stemle et al. 2019). While the primary threats to turtle populations are habitat destruction and overexploitation, population declines are exacerbated by a combination of factors that threaten many reptile species, such as invasive species, diseases, pollution, and climate change (Chandler et al. 2017; Gibbons et al. 2000; Lovich et al. 2018; Stemle 2017). Because there are a myriad of interacting factors that can potentially influence turtle populations, and also because declines in reptile populations are often difficult to detect (Gibbons et al. 2000; Stemle et. al 2019), it is important to monitor the status of turtle populations periodically (Chandler et al. 2017; Gibbons et al. 2000).

Monitoring the status of turtle populations typically requires the trapping and handling of individuals (Chandler et al. 2017), therefore, increasing trapping efficiency can enhance conservation efforts (Antonishak et al. 2017; Liebgold and Carleton 2020). A greater trapping efficiency will be most impactful to population assessment when populations are small or trapping conditions are suboptimal (MacKenzie et al. 2005; Spence-Bailey 2010). Fortunately, researchers have been interested in increasing turtle trapping success for many decades (Cagle 1942; Chandler et al. 2017; Lagler 1943; Mali et al. 2012, 2014; Munscher et al. 2017; Oxenrider et al. 2019; Ream and Ream 1966; Tinkle 1958). In general, these studies document effective trap designs and compare effectiveness of various food baits. Although many food baits have been investigated in attempts to increase trap effectiveness, genetic evidence suggests that many aquatic turtles have reduced olfactory senses and therefore forage using visual cues and olfactory cues in concert (Hulse 1974; Schuyler et al. 2014; Vieyra 2011). Therefore, our objective for this project was to investigate the use of light bait in conjunction with food bait as an inexpensive and simple method to increase freshwater turtle trapping efficiency.

Light can serve as a behavioral cue for many animals (Liebgold and Carleton 2020; Ward et al. 2008) including sea turtles and Eastern painted turtles (*Chrysemys picta*; Liebgold and Carleton 2020; Roth et al. 2021; Witherington and Bjorndal 1991). While animal behaviors in response to lights is complex, positive phototaxis, movement towards light, may be related to feeding efficiency whereas negative phototaxis, movement away from light, may be related to increased predation risks (Longcore and Rich 2004). Although behavioral responses to light are often dependent on intensity and wavelength, many animals exhibit positive phototaxis and light baits have been successfully employed as attractants for marine invertebrates, fish, amphibians, and reptiles. (Antonishak et al. 2017; Liebgold and Carleton 2020; McLeod and Costello 2017; Wang et al. 2006; Witherington and Bjorndal 1991). However, to our knowledge lights have never been investigated as a method to increase trapping efficiency of freshwater turtles. We hypothesized that the addition of lights to shallow-water traps would improve capture success of species that exhibit nocturnal foraging activity during the early portion of the spring when turtle trapping is suboptimal, turtle movements are likely restricted (Ennen and Scott 2013; Rowe et al. 2009; Tuma 2006), alternative food items may be limited, and optimizing foraging activities could have survival and fitness consequences (Ford and Moll 2004; Mahmoud 1969).

METHODS

To determine if light baits affect turtle trapping efficiency, we used box-style traps to capture aquatic turtles in two ponds on the University of North Georgia campus in Hall County, Georgia. The two ponds were similar in size (~0.6 - 0.8ha) in primarily lawn-like grassy areas with close proximity to anthropogenic features including buildings, roads, and parking lots. Traps were approximately 66 x 36 x 36 cm, constructed of metal hardware cloth with 1.27 cm mesh size, and based on a design used effectively for striped mud turtles (*Kinosternon baurii*) by Stemle (2017). Partially submerged traps allow small turtles to enter via a ramp opening that excludes larger turtles. This trap design was used to target turtles of the Kinosternidae family, including *Sternotherus odoratus* and *K. subrubrum*, which are small, non-basking, primarily benthic turtles which exhibit both nocturnal and diurnal activity (Carr and Mast 1988; Hulse 1974). Light baits were constructed by attaching 5mm blue LED lights to CR2032 lithium batteries with electrical tape. Lights were sealed inside a 50ml centrifuge tube, which was attached to the interior of the traps using a zip tie. Each light cost less than $1.00 (battery = $0.42; LED light = $0.02, centrifuge tube = $0.28) to construct and would last approximately 7-10 days before the battery would expire and need to be changed.

Initially, 2-8 traps baited with hotdogs (Bar-S Brand Classic Jumbo Franks made with chicken and pork) were deployed 1 night/week until we confirmed turtle foraging activity in both sample ponds (i.e., bite marks on hotdogs or capture success). During all sampling activity after this point, all traps were baited with hotdogs, and light baits were randomly assigned to half of the traps. Ponds were not always sampled concurrently, but each night a pond was sampled four traps were deployed in the same pond (2 traps with light and 2 without) with ⩾10m between each trap. Traps were generally set between 9:00-13:00 and left undisturbed for approximately 24 hours. Throughout the remainder of this manuscript we refer to this ~24-hour sampling period as a 'sample night' and define a 'trap night' as a single trap deployed for ~24 hours. At the end of each sample night, traps were retrieved, number of captures was recorded, and all captures were identified to species based on morphological features (Jensen et al. 2008) before being released at the point of capture. Turtles were not marked prior to release, so recognition of recaptures in subsequent sample efforts was not possible. All traps were moved to new locations for consecutive sampling nights. Water temperature was measured using an analog tube thermometer in the margin of the pond when traps were retrieved.

We defined three sample periods for analyses: **early spring** (04 March-14 April 2021; 100 trap nights), **late spring** (19 April-29 April 2021; 40 trap nights) and **combined** (04 March-29 April 2021, 140 trap nights). The cutoff date between early and late spring was initially based on a perceived increase in turtle activity and a frequent absence of residual food bait at trap checks regardless of whether or not turtles were captured. The observed increase in activity was anecdotal, as we had no way to reliably assess the activity levels of turtles during this study; however, it is generally accepted that turtle activity increases from spring to summer (Ford and Moll 2004; Glorioso and Cobb 2012; Mahmoud 1969; Rowe et al. 2009; Tuma 2006). Subsequent analyses support the separation date between early and late spring periods as an important shift point for trap efficiency (Figure 1). Data from the early spring and late spring sample periods were combined for analysis to determine if any significant effects of light bait persisted throughout the entire study period.

For each analysis period, we calculated trap efficiency (number of kinosternid captures/number of trap nights) and conducted a Chi-square analysis in R (version 3.6.1) to determine if there was a significant effect of lights on captures. Chi-square analyses are appropriate when attempting to measure the amount of difference between the observed frequencies and expected frequencies for a particular set of data (Buckalew and Pearson 1981). For all Chi-square analyses, we assumed that, if light bait did not affect capture rate, 50% of captures should occur in traps that contained lights. All analyses excluded sample nights that were conducted before light baits were added, nights when one or more traps were disturbed by people, and any turtles captured that did not belong to the family Kinosternidae.

RESULTS

A total of 165 trap nights (a single trap deployed for ~24 hours) were conducted between 03 February and 29 April 2021, however 25 were excluded from all analyses. Fifty-five turtles were captured, including *S. odoratus* (N=30), *K. subrubrum* (*N*=12), *Trachemys scripta* (*N*=10), and *Chrysemys picta* (*N*=3). The 140 trap nights and resulting captures used for analyses occurred over a 9-week period that spanned from 04 March to 29 April 2021, with at least 4 trap nights occurring each week. Average water temperature was significantly cooler during early spring (17°C) than late spring (22°C; t-test, $t(108) = -8.867$, $p < .001$).

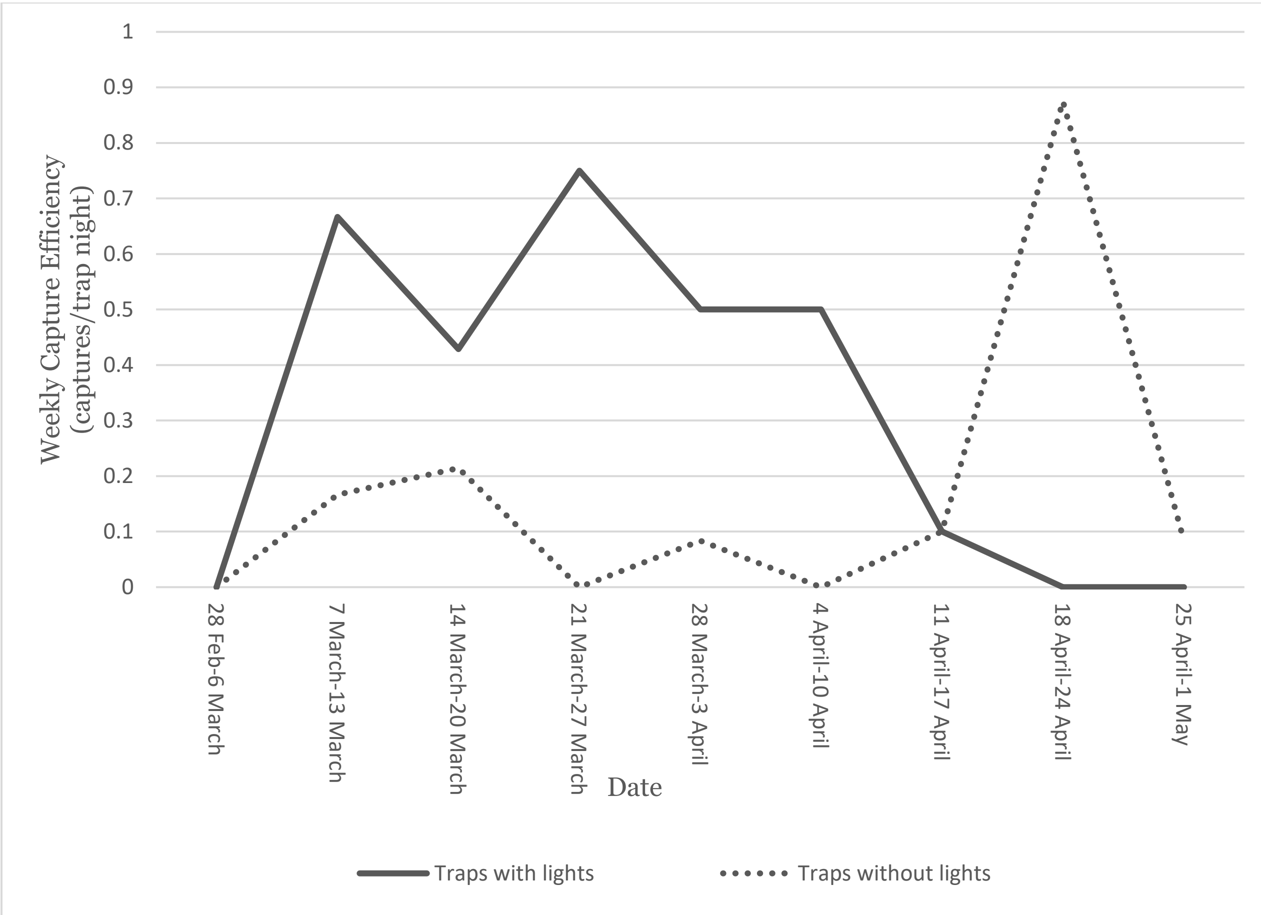

Figure 1. Weekly capture efficiency of box-style freshwater turtle traps baited with hotdogs. Half the traps each week also had LED lights as additional attractants. Weekly capture efficiency is expressed as the number of kinosternid turtles (*Sternotherus odoratus* and *Kinosternon subrubrum*) captured per number of trap nights within a one-week period.

Within the **early spring** sample period (100 trap nights), there were 27 kinosternid captures, resulting in an overall trap efficiency of 0.27 turtles per trap night. *S. odoratus* comprised 20 of the captures (74%), and the remaining 7 captures were *K. subrubrum*. Of these captures, 78% (*N*=21) occurred in traps that contained light baits and 22% (*N*=6) occurred in traps without light baits. Trap efficiency with light baits was 0.42 turtles per trap night, while the trap efficiency with only food bait was 0.12 turtles per trap night (Figure 1). Light baits significantly increased the number of captures $\chi^2(1, N = 27) = 8.33$, $p = .004$.

During the **late spring** sample period, there were 8 kinosternid captures, including three *S. odoratus* and five *K. subrubrum*. Overall trap efficiency of the 40 trap nights was 0.2 turtles per trap night. No captures occurred in traps with light baits, although food bait was typically absent when checked. The trap efficiency with food bait only (no light bait included) was 0.40 turtles/per trap night. During late spring, lights significantly decreased the number of captures χ^2 (1, N = 8) = 8, p = .005.

When data from the early and late spring periods were **combined** for analyses, the 140 trap nights resulted in 35 total kinosternid captures, including 23 *S. odoratus* and 12 *K. subrubru*m. Overall trap efficiency was 0.25 turtles per trap night. Of the captures analyzed, 60% (N=21) occurred in traps that contained lights and 40% (N=14) occurred in traps without lights. Efficiency of traps that included light baits was 0.30 turtles per trap night, while capture efficiency of traps without lights was 0.20 turtles per trap night. No kinosternid captures were recorded in traps with lights after 12 April, and during the combined analysis period the effects of lights on trap efficiency was not statistically significant χ^2 (1, N = 35) = 1.4, p = .237.

DISCUSSION

Although limited in scope, our data suggest that the addition of lights has the potential to increase turtle trapping efficiency, particularly during early spring in small ponds. Because individual turtles were not marked, it is likely that recaptures occurred throughout the sample period, possibly because the turtles in the sampled populations learned to associate the traps with food (i.e., trap-happy behavior; Hollender 2019; Mali et al. 2014). However, trap-happy behaviors should have been equally likely in traps with and without lights, as all traps contained the same food bait. Furthermore, there is little evidence of turtles becoming trap-happy (Hollender 2019; Mali et al. 2014). Therefore, we assume that biases associated with recaptures likely had little impact on the results of this study.

The mechanism through which light baits impact turtle trapping success is still unclear and therefore provides opportunities for future research. While light bait could serve as a primary visual cue that attracts curious foraging turtles (Hulse 1974; Schuyler et al. 2014; Vieyra 2011), lights may increase captures by attracting invertebrates or fish to the traps (Davis et al. 2015; Marchesan et al. 2004; McConnell et al. 2010), which then attract turtles. However, we did not note any increase in the number of fish incidentally captured in traps that had lights. An alternative, or complementary, mechanism for increased captures in traps with lights is that the addition of light bait allows the first turtle captured to be seen by and attract additional turtles to the trap (Frazer et al. 1990; Liebgold and Carleton 2020) making multiple captures more likely. The effect of this attraction could be more pronounced in early spring, coinciding with the mating season when male turtles are more likely to be attracted to females (Ford and Moll 2004; Frazer et al. 1990; Rowe et al. 2009). Unfortunately, we cannot draw conclusions about how the mating season impacted our results, as mating dates vary, and we do not know the specific timing of mating in the sampled populations. While the mechanism remains unclear and we acknowledge the limited scope of our project, the low cost and simplicity of adding this type of light bait to traps warrants further investigations into this method as a means to increase trapping efficiency of aquatic turtles. However, we caution that the results may not be applicable to other species, for example species that might inhabit different aquatic habitats or that differ in their feeding ecology.

Comparing the weekly capture efficiency of traps with lights to traps without lights indicates a well-defined point where light bait switched to no longer influencing capture rate (week of 11 April-17 April 2021), and after which lights began to decrease captures (Figure 1). This point corresponds with the separation of the early and late periods of spring used for analyses, as the end of the early spring period occurred midway through the week of equal capture efficiency. Further research is needed to better understand why lights significantly *increased* trapping efficiency during the early spring and significantly *reduced* efficiency in the late spring. It is possible that seasonal changes associated with late spring, such as warmer temperatures, longer daylight hours, and greater food availability, leads to increases in turtle activity (Ford and Moll 2004; Glorioso and Cobb 2012; Mahmoud 1969; Rowe et al. 2009; Tuma 2006) and therefore increases the likelihood that turtles encountered food bait in traps without the assistance of visual cues (Ford and Moll 2004; Spence-Bailey 2010). However, this does not explain why lights significantly reduced efficiency rather than having no effect.

We suspect the ability to escape our traps prior to traps being checked was a function of the general activity level of the turtles, which likely increased as the season progressed towards summer (Ford and Moll 2004; Glorioso and Cobb 2012; Mahmoud 1969; Rowe et al. 2009; Tuma 2006). In many instances during the late spring sampling period we encountered traps with all food bait consumed and no turtle captures. Although speculative at this point, we consider it plausible that the frequent instances of all bait being consumed without any captures during late spring are due to turtles escaping from traps after consuming the food bait (Frazer et al. 1990). Increases in the occurrence of escapes from traps is likely associated with increased activity levels of turtles resulting from seasonal environmental changes in late spring, such as increased daylight length and the documented increase in water temperatures. Unfortunately, our methodology did not allow us to determine turtle activity levels or body temperatures during our project and there is evidence that turtles can maintain body temperatures that differ from general water temperatures via behavioral thermoregulation (Picard et al. 2011).

If our interpretation of empty traps lacking bait is correct, lights may still attract turtles to the traps, but they also further increase the likelihood that those same turtles can locate the exit to the trap and escape after consuming the bait, causing the trap efficiency of traps that included lights to be significantly lower than traps without lights. Therefore, we suspect the benefits of lights as a visual cue offset the potential costs of increased escapes when overall activity is reduced during the early spring. However, during late spring when turtles may be more active, the likelihood of escape increases, and lights may ultimately reduce trapping efficiency.

The results from this study indicate that the impacts of light bait on freshwater turtle trapping success may vary seasonally, possibly due to varying levels of turtle activity. It is also possible that this effect may not extend to other turtle species, or other locations. Although early sampling indicated an increase in capture success due to lights, we recognize limitations to this study are imposed by the small sample size, short sample duration, and restricted spatial extent. Future studies could contribute to understanding the possible benefits of light by reducing these limitations, exploring the possible seasonal variation of the effects, or evaluating if certain light wavelengths are more influential in increasing trapping success. With a more refined understanding of the impacts of lights on freshwater turtle trapping, light baits could be employed in a wide range of field studies as an inexpensive and convenient way to improve captures, therefore benefiting monitoring and conservation programs of freshwater turtle species.

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