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Telescoping turtles: a comparison of smartphone telephoto magnifiers to non-invasively observe and identify freshwater turtles

Javier Escobar[1], Mark A. Rollins[1] & Shem D. Unger[1]

[1]Department of Biology, Wingate University, Wingate, North Carolina, 28174, USA

Sampling freshwater turtles using traditional trapping methods can present significant economic investment to researchers. However, collecting baseline data on turtle relative abundance and species presence requires limited investment and can be non-invasive. Recent advances in performance of readily available smartphone cameras enable collection of high quality digital photos of wildlife, accessible to both researchers and citizen scientists. We report on the feasibility of using several low cost and lightweight telephoto lens attachments for smartphones to identify turtles from various observational distances. All three magnifiers provided a reliable, effective method for counting turtles with increased standard image resolution, with the number of basking turtles correctly enumerated and identified increasing with decreasing distance to observers (Spearman rank correlation = -0.719). The most consistently usable images for species identification were taken with 10X at distances under ~15 m and in urban pond settings where individuals are potentially less easily startled or where ambient noise is common. Ultimately, these magnifiers can be successfully incorporated into university outdoor biological laboratories, undergraduate research and community citizen science programs.

Key words: conservation, *Trachemys*, emydidae, freshwater ecology, survey techniques

INTRODUCTION

Amphibians and reptiles are facing declines across many of their natural habitats (Stuart et al., 2004; Bohm et al., 2013). Monitoring wildlife using emerging digital technologies has provided affordable methods for researchers to assess populations of a variety of flora and fauna using non-invasive methods (Schofield et al., 2008; Davis et al., 2017). Citizen science programmes using volunteers in research have recently been recognised as important in providing valuable data on occurrence and reporting of species (Burr et al., 2014; Pescott et al., 2015). Moreover, as the widespread use of smartphones with high quality digital cameras develops, incorporation of these technologies into research projects may allow researchers with new and valuable tools to monitor presence, abundance and behaviour of common herpetological species (Dickinson et al., 2012; Scott, 2016; Todd et al., 2016).

Observation and identification of pond turtles presents challenges, as many basking or surface swimming turtles will readily retreat or flee once observers are detected (Moore & Seigel, 2006). Current techniques for non-invasive surveying of freshwater turtles includes the use of binoculars (Lambert et al., 2013), spotting scopes (Lindeman, 1999) and, more recently, trail camera traps (Bluett & Schauber, 2014) that allow observation from far distances and timely collection of turtle basking behaviour at multiple sites (Vogt, 2012). However, few if any studies have assessed the use of recently available telephoto smartphone lens for turtle identification and enumeration. Moreover, the use of telephoto lens attachments for smartphones could provide an assortment of important biological data in studies of freshwater turtles including evidence of competition for basking sites, identifying signs of disease and collecting data on co-occurrence of species and possibly even behaviour interactions among species present.

Here, we provide a comparison of clarity and resolution of digital images used for identification for common south-eastern U.S.A. basking pond turtles using multiple lightweight telephoto smartphone attachments (8X, 10X, and 12X). We also report on ideal observational distances for documenting basking behaviour using smartphones in urban environments.

MATERIALS AND METHODS

Study site

We enumerated and identified turtles to species level with smartphone telephoto attachments at two ponds (Fig. 1). Study site 1 was located on Wingate University campus, a small private university in Union County, North

Correspondence: Shem Unger (s.unger@wingate.edu)

Carolina. Study site 2 was located at the Arboretum Pond in a more urban site (directly behind a large shopping complex) in Charlotte, North Carolina. Site 1 is a partially forested ~55,200 m^2 pond, while the arboretum pond is ~22,000 m^2 urban pond. Both sites have a limited amount of downed woody debris/rocks for basking habitat based on a combination of visual surveys of basking sites, which makes observation of common basking turtles ideal given the limited basking sites available. Common basking pond turtles of the south-eastern United States and readily observed in our study sites include the yellow-bellied slider (*Trachemys scripta*), the eastern river cooter (*Pseudemys concinna*) and the painted turtle (*Chrysemys picta*; Palmer & Brasswell, 2013).

Sampling techniques

We conducted visual surveys of turtles basking daily during peak basking times (~1200-1400) on the 17th [Site 1] and 26th of May 2017 [Site 2] during early summer. Surveys were made by three observers (all authors working as a group) carefully walking the periphery of the lake and visually scanning from the bank for the presence of basking turtles, or turtles swimming near the surface with at least half of their heads protruding above the surface. We defined basking as any individual turtle lying quiescent on an object above the water surface or lying in shallow water with any part of the carapace above the water surface according to Obbard & Brooks (1978). For each individual observation of basking, we attempted to obtain at least one to three usable digital photos with a Samsung Galaxy S7 phone equipped with either an 8X, 10X, or 12X clip on telephoto attachment for smartphones (each ~75 g and under £15 GBP) at a resolution of 72 dpi (4031 pixels width X 3024 pixels height) and saved as JPEG files. In addition, for each individual observation of basking, two photos were taken without any telephoto attachment for comparison (smartphone camera only). Smartphones were secured to a 127 cm tripod with a cellphone mount adapter. All photos were taken by the first author with the same phone for all telephoto magnifications with all authors present. Positive species identification was confirmed by comparing smartphone photos with reference photos taken by one observer with a Nikon Coolpix 21X zoom digital camera. We used a Nikon 8397 laser rangefinder to measure the distance of basking turtles from our point of observation and digital capture to the nearest meter. Temperature of basking habitat surface was recorded using an Etekcity digital infrared (IR) thermometer to the nearest 0.1° C.

Data Analysis

We qualitatively ranked photos based on; 1) ability to count total number of turtles basking (identify how many turtles were present in an image) and 2) positive identification of turtles down to probable species based on size and morphological traits. All photos were manually examined on a laptop using digital zoom and enlarging for inspection of morphological traits useful for identification. To identify turtle species, we used an assortment of physical characteristics including shape, scute arrangement, size and contour of carapace, head colour and markings on head; and overall body size (Conant & Collins, 1998; Buhlman et al., 2008). We excluded field photos in which any turtles moved during photo capture or if images were of poor resolution. Observations and image review were conducted by all authors. Images were examined by each author initially separately, then the number of turtles per image and probable species were compared as a group with all authors present. To validate the number of correct turtles enumerated and correct species identification, we compared images captures with no telephoto smartphone attachment, or photos taken with only a smartphone (0X), and those with 8X, 10X, and 12X with those taken at the same time with a Nikon Coolpix 21X zoom digital camera. The 21X images allowed for direct comparison of images taken with various telephoto attachments with a known, correct reference species identification and number of turtles. We used spearman rank correlation in R to determine the relationship between the number of turtles correctly identified across all 4 types of smartphone magnification photos (0X, 8X, 10X, and 12 X) and the distance of basking turtles to observers.

RESULTS

On the 17th and 26th of May 2017, we observed a total of 12 instances of basking turtles (singular and group) totaling 28 individuals across both sites. Out of these, we selected nine basking observations across both sites for image analysis (total of 121 images) in which turtles were present for all series of telephoto lens. In only one instance (basking identification number four or B4), was the species of reference turtle unknown using the Nikon Coolpix 21X zoom digital camera (Table 1). During three occasions, turtles moved off basking structures during photo capture. Therefore, we excluded these three instances of basking from analyses. Most turtles were basking on partially submerged logs, one artificial basking structure, or exposed rock. We successfully identified three species of turtles basking at our study sites using smartphone telephoto lens and reference photos taken with 21X zoom handheld camera, including painted turtles (*C. picta*), yellow bellied sliders (*T. scripta*;) and river cooter (*P. concinna*; Table 1). The closer an observer was to a turtle resulted in increased positive identification and in all instances, telephoto smartphone attachments provided greater image resolution than photos taken with only the smartphone (no lens attachment) (Fig. 2). At short to mid distances, the quality of the image enabled identification, whereas turtles farther away from observer couldn't be accurately identified due to low image detail (low image quality per pixel). The majority of pictures taken with the 10X consistently provided ideal images, allowing for positive identification (ideal spatial image resolution or picture clarity) of basking turtle number and in some cases down to species if observer was within ~ 15 m of basking turtle. The number of turtles correctly identified to species using 8X, 10X, and 12X telephoto lens was 44.4%, 77.8% and 33.3%, respectively. The number of basking turtles correctly enumerated varied across

Figure 1. Study site 1 located on Wingate University campus in Union County, North Carolina (34°59'13.71"N,-80°25'49.98"W; bottom) and study site 2 located at Charlotte Arboretum Shopping Center in County, North Carolina (35°5'42.18"N, -80°46'49.68"W; top). Study site 1 is a small rural ~55,200 m^2 pond with surrounding land partially forested, while study site 2 is a smaller sized ~22,000 m^2 urban pond (compliments of Google Earth). Basking locations denoted by sun icon.

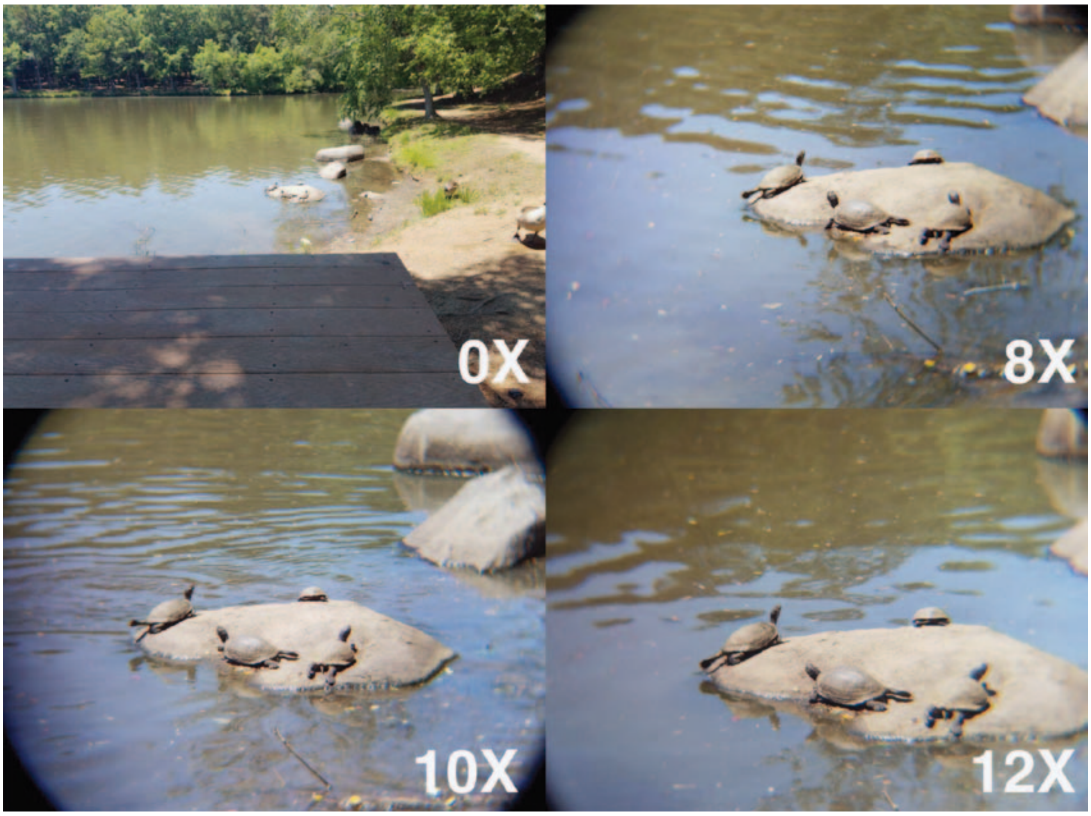

Figure 2. Comparison of image quality of the same four Trachemys scripta individuals (B8, or Basking identification number eight) observed from 8 m at site 2 (Top left: smartphone no attachment or 0X, top right: 8X telephoto, bottom left: 10X telephoto, bottom right: 12X telephoto). Note slight variation in resolution of telephoto attachments 8X, 10X, and 12X, with 10X providing most clear spatial resolution for all four turtles with the least amount of blurring. Photo: Escobar, J.

Table 1. Basking identification number, number of turtles identified by traits using telephoto attachments (0X or smartphone with no attachment, 8, 10, & 12 X), total number and species validation (using 21X zoom camera), and distance (basking turtles to observer) during study. Basking identification number corresponds to nine observations of turtles basking in which photos were captured for all telephoto attachments. Species identification (ID) positive when noted.

Basking identification number	Number of turtles identified by traits using telephoto attachments	Total number and species validation	Distance (m)
B1	0X: 1 turtle 8X: 2 turtles 10X: 2 turtles, carapace shape & yellow stripe on head visible, ID positive 12X: 2 turtles, reduced clarity	2 (*Trachemys scripta*)	17
B2	0X: 0 turtles 8X: 3 turtles 10X: 3 turtles; distinct carapace & neck extension visible, ID positive 12X: 2 turtles	3 (*T. scripta*)	47
B3	0X: 0 turtles 8X: 0 turtles 10X: 1 turtle, head stripe visible 12X: 0 turtles	1 (*T. scripta*)	58
B4	0X: 0 turtles 8X: 2 turtles 10X: 4 turtles 12X: 3 turtles	4 turtles, species unknown	50
B5	0X: 1 turtle 8X: 1 turtle, marginal scutes & head coloration visible, ID positive 10X: same as above 12X: same as above	1 (*T. scripta*)	37
B6	0X: 0 turtles 8X: 1 turtle, ID positive 10X: same as above 12X: same as above	1 (*T. scripta*)	59
B7	0X: 5 turtles (depending on observer) 8X: 6 turtles, 10X: 6 turtles, carapace patterns & shape, colors well defined, ID positive 12X: 6 turtles, central neck pattern visible	6: 2 (*Pseudemys concinna*) & 4 (*T. scripta*)	31
B8	0X: 4 turtles, neck patterns & shell blurry 8X: 4 turtles, similar to above 10X: 4 turtles, well defined color & neck patterns, ID positive 12X: 4 turtles, similar to smartphone & 8X	4 (*T. scripta*)	8
B9	0X: 1 turtle, ID not possible 8X: 1 turtle, ID positive 10X: 1 turtle, ID positive, Scute pattern on carapace clear 12X: 1 turtle, ID not possible, carapace blurry	1 (*T. scripta*)	5

telephoto type (10X = 100%, 8X = 77.8%, 12X = 66.7% & 0X = 33.3%). We did observe greater vignetting (shading around edges) in all telephoto attachments. Turtles at site 2 (urban pond with a fountain present) were more likely to remain basking compared to site 1, based on our limited observations of turtles abandoning basking sites and fleeing once authors on bank approached turtles at site 1. Basking temperature averaged 28.0° C for the nine observations of basking and ranged from 25.5° C to 29.3° C, while average observation distance of photo capture to basking turtles was 34.7 m. Spearman rank correlation for the number of turtles correctly identified in telephoto analysis and distance of basking turtles to observer was -0.719 (p = 0.035, degrees of freedom = 7), indicating a strong correlation or that the number of turtles correctly identified increases as observation distance decreases.

DISCUSSION

The prevalence of "digiscoping" (use of a digital camera held up to spotting scopes or binoculars) for observation of birds (Larson & Craig, 2006) is less frequently applied for herpetological surveys. However, traditional spotting scopes used for observation of turtles may be large, expensive and difficult to carry in the field. We recommend incorporation of affordable lightweight telephoto attachments for conservation monitoring projects to increase turtle species identification in sites where turtle species are typically found within ~15 m or less observed from the bank, or at urban sites where turtles do not readily flee their basking sites or are seen swimming near the water's surface. In these scenarios, we anticipate telephoto attachments may be helpful validating total numbers of turtles, but potentially aiding in both species identification and depending on proximity, sexing turtles if male's anterior claws are viewable, as we observed at site 2. Moreover, we unexpectedly observed 10X telephoto attachment for smartphones to provide a more accurate species identification than a 12X, possibly due to either the specific manufacturer resolution, quality of lens, and focal length (relationship between total area captured in image and magnification). Alternatively, 10X may provide the ideal telephoto smartphone attachment for the optimal observer viewing distance near the water to most of the basking turtle sites in our study.

Previous studies in birds have found improved readability of long term tags with digital cameras over traditional telescope surveys (Saunders et al., 2011). However, care must be taken when relying on photographic identification of species. This includes taking multiple photos to increase the likelihood of obtaining high quality usable photos. Studies in small cetaceans recommend a minimum of five photos per observation for increase probability of identification even with a traditionally large (~300 mm) telephoto lens (Wursig & Jefferson, 1990). In addition, it is important to use photos in which individual animal markings are more clearly visible or in which individuals are correctly oriented as has been noted in studies relying on photographic identification in fish (Marshall & Pierce, 2012).

While the use of digital cameras, spotting scopes and binoculars clearly has advantages for viewing turtles from distances greater than 15 m, telephoto attachments need further testing as digital smartphone camera technologies improve. Citizen scientists have helped to track monthly changes in bird distribution using smartphones (Pimm et al., 2015) and it is likely the use of smartphone technology will increasingly be applied to herpetological surveys. The increased use of smartphone photo identification by researchers, citizen scientists and volunteers if concomitantly incorporated into reporting smartphone applications to wildlife agencies can go a long way to address gaps in knowledge in monitoring common and rare herpetological species (Reisser et al., 2008; Tingley et al., 2016).

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