Influence of Hoop-net Trap Diameter on Capture Success and Size Distribution of Comparatively Large and Small Freshwater Turtles

Alissa L. Gulette[1,*], James T. Anderson[1], and Donald J. Brown[1,2]

Abstract - We investigated the influence of hoop-net trap size on number and size of captures for comparatively large (*Chelydra serpentina* [Snapping Turtle]) and small (*Chrysemys picta* [Painted Turtle]) freshwater turtle species. We trapped turtles at 32 ponds throughout West Virginia in the summers of 2016 and 2017, with each pond sampled for 5 consecutive days using five 0.91-m–diameter and five 0.76-m–diameter baited hoop-net traps. We captured a total of 98 and 283 unique Snapping Turtles and Painted Turtles, respectively. Larger-diameter traps captured more Snapping Turtles and smaller-diameter traps captured more Painted Turtles. Mean carapace length was greater for both species in larger-diameter traps, but this result was possibly influenced by the ability of the smallest Painted Turtles to escape through the mesh of the larger traps. Our results indicate that hoop-net–trap diameter can substantially influence both number and size distribution of captures, and thus, trap size is an important sampling design consideration for freshwater turtle research and monitoring using hoop-net traps.

Introduction

Estimation of abundance and demographic structure (e.g., age or size distribution, sex ratio) is a fundamental component of population-monitoring programs (Buckland et al. 2000, Campbell et al. 2002). Many statistical methods have been developed to facilitate accurate estimates of population and community parameters, but they all rely on the data meeting the assumptions of the model to avoid biased estimates (Tyre et al. 2003, Yoccoz et al. 2001). Thus, there is strong interest in developing sampling techniques and protocols that minimize sampling bias (e.g., Brown et al. 2017, Mali et al. 2014, Sterrett et al. 2010).

A variety of tools and techniques exist for sampling aquatic and semiaquatic turtles (Lagler 1943, Vogt 1980), and new sampling devices continue to be developed (e.g., Chandler et al. 2017, Lindeman 2014). Passive sampling using baited hoop-net traps is one of the most commonly used approaches (Davis 1982). Compared to many other sampling devices for freshwater turtles (e.g., basking traps, fyke nets, trammels), hoop-net traps have the advantages of being lightweight and portable, requiring only 1 worker to assemble and deploy, and providing easily quantifiable results.

Despite their advantages, several studies have found that data obtained from hoop-net trapping can result in biased demographic and abundance estimates

[1]School of Natural Resources, West Virginia University, Morgantown, WV 26506. [2]Northern Research Station, US Forest Service, Parsons, WV 26287. [*]Corresponding author - alissagulette@gmail.com.

Manuscript Editor: Todd Rimkus

(Koper and Brooks 1998, Ream and Ream 1966, Tesche and Hodges 2015). However, identifying and mitigating the factors that cause biases is complicated because baited hoop-nets work by attracting individuals into the trap, and that attraction (i.e., probability of capture) can differ by species, sex, size, individual, and previous capture history (reviewed by Mali et al. 2014). One proposed solution has been to use multiple types of sampling methods to increase among- and within-species representation (Koper and Brooks 1998, Sterrett et al. 2010, Tesche and Hodges 2015). This solution appears to be particularly useful for community-level studies due to large species-specific differences in capture probability for individual sampling methods (e.g., Gamble 2006, Sterrett et al. 2010). The advantages of using multiple types of sampling methods is less clear for population-level studies, given that each method has its own sampling biases, and thus robust data sets are required to properly account for biases of each sampling method in population models.

Regardless of the benefits and drawbacks of using multiple sampling methods, there is a need to improve our knowledge of the biases of individual sampling methods. Understanding these biases can lead to more-appropriate sampling designs, and can result in more-accurate estimates of population parameters by accounting for them in the sampling design or statistical models. The majority of previous studies investigating hoop-net trap biases has focused on the influences of bait type, having other turtles in traps, and escape from traps (reviewed by Mali et al. 2014). Little attention has been given to capture biases resulting from size of hoop-net traps. Howell et al. (2016) determined that a miniaturized hoop-net trap was effective for sampling *Clemmys guttata* (Schneider) Spotted Turtle, but did not compare capture efficiency to larger hoop-net traps.

The purpose of this study was to determine if the diameter of baited hoop-net traps has a significant effect on number and size of captures for comparatively large and small aquatic turtles. We used *Chelydra serpentina* (L.) (Snapping Turtle) and *Chrysemys picta* (Schneider) (Painted Turtle) as representative species for the larger and smaller size classes, respectively. Painted Turtles included *Chrysemys picta picta* (Schneider) (Eastern Painted Turtle) and *Chrysemys picta marginata* (Aggasiz) (Midland Painted Turtle). We hypothesized that hoop-net trap diameter would have no influence on number or size of smaller turtle captures, but that number and size of larger turtle captures would be greater in larger hoop-net traps.

Field-site Description

We conducted this study at 32 ponds spread across West Virginia (i.e., Barbour, Berkeley, Greenbrier, Jefferson, Mason, Preston, and Upshur counties). Sixteen of the ponds were portions of restored wetlands conserved through the Agricultural Conservation Easement Program of the Natural Resources Conservation Service. Ponds were located on private land, typically adjacent to agricultural land, with the exception of 2 ponds located on a state wildlife-management area and 1 pond located on publicly accessible land owned by the Audubon Society. Most pond edges were generally covered with *Typha* spp. (cattails), *Carex* spp. (sedges), *Juncus* spp. (rushes), *Leersia oryzoides* L. (Rice Cutgrass), or *Sagittaria* spp. (arrowheads). Pond area

varied from 0.012 ha to 8.865 ha (mean = 0.472 ha, SE = 0.279). All ponds contained fish populations. We detected *Lepomis macrochirus* (Rafinesque) (Bluegill Sunfish) at all but 4 ponds and *Ictalurus punctatus* (Rafinesque) (Channel Catfish) at many of the ponds. In addition to the focal species of this study (i.e., Snapping Turtles and Painted Turtles), we captured 4 additional turtle species, including *Apalone spinifera* (LeSueur) (Eastern Spiny Softshell), *Sternotherus odoratus* (Latreille) (Eastern Musk Turtle), *Trachemys scripta elegans* (Schoepff) (Red-eared Slider), and *Pseudemys rubriventris* (LeConte) (Northern Red-bellied Cooter).

Methods

We performed this study from 16 July to 9 September 2016 (22 ponds) and 3 June to 15 July 2017 (10 ponds). We trapped each pond for 5 consecutive days, using 10 traps set around the perimeter of each pond at 3–10-m intervals, depending on pond size. We used 5 smaller- and 5 larger-diameter traps at each pond, and alternated between the 2 trap sizes to reduce the potential for trapping location to influence results. The hoop-net traps were ~1.8 m long, and included 3 steel hoops and a single mouth with a circular throat (Memphis Net and Twine County, Memphis, TN). The larger and smaller traps measured 0.91 m (3 ft) and 0.76 m (2.5 ft) in hoop diameter, respectively. Larger traps had a mean un-stretched mouth diameter of 18.8 cm (SD = 2.53) and mesh width of 5.08 cm, and smaller traps had a mean un-stretched mouth diameter of 15.8 cm (SD = 1.28) and mesh width of 2.54 cm. Traps were held taut using 2 wood posts connected to the terminal hoops, and mouths were held open by tightening, then knotting the rope that opened them. This design allowed our traps to float and did not require that we use a ground stake to keep the mouth open. We placed flotation devices in all traps to prevent drowning of captures. We baited traps with a half-can of sardines in oil placed in plastic bottles with holes to allow for scent dispersal (Ernst 1965, Jensen 1998), and changed bait daily.

We checked traps daily. We identified, sexed, measured, marked using unique individual carapace notches, and released all captured turtles (Cagle 1939). We used calipers (Haglof, Madison, MS) to measure straight-line carapace length (SCL) and width (SCW), plastron length and width, and body depth to the nearest 1.0 mm. We weighed individuals to the nearest 10 g using spring scales (Pesola, Baar, Switzerland). We determined sex using secondary sexual characteristics (Ernst and Lovich 2009).

We employed paired randomization tests with 10,000 iterations to determine if number of captures and mean size of individuals differed between larger- and smaller-diameter hoop-net traps for Snapping Turtles and Painted Turtles. When sample sizes are relatively small such as in our study (n = 32 sites), randomization tests are an appropriate alternative to t-tests because the statistical distribution is derived from the randomized data, rather than assuming the data follow an underlying parametric distribution (Sokal and Rohlf 1995). The P-values for randomization tests are also intuitive, representing the proportion of trials with a mean difference between samples that is as or more extreme than what we obtained in the study. We inferred statistical significance at $\alpha = 0.05$.

Ponds served as the sampling unit in the analyses, with trap sizes paired within ponds. For each species, we calculated the total number of unique individuals captured per trap size. Thus, the same individual could be represented up to 2 times in the data, if it was captured in both trap sizes. For the size comparison, we used the mean SCL of unique individuals captured per trap size at each pond. We constructed histograms to assess differences in size-class distributions based on trap diameter. The larger and smaller traps differed in mesh size (5.08 cm and 2.54 cm, respectively), so, we also investigated the potential influence of mesh size on captures for the small focal species. Specifically, we determined if number of captures and mean size of individuals differed between larger- and smaller-diameter hoop-net traps after excluding Painted Turtles <8.0 cm SCW, representing the maximum stretch width for the mesh of larger traps. Finally, we investigated the possibility that Snapping Turtle captures biased our Painted Turtle capture results. For this assessment, we computed the mean Painted Turtle catch-per-unit-effort (CPUE) in traps with and without Snapping Turtles at each site, and then tested for a difference in mean CPUE. We performed statistical analyses in program R 3.3.2 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

The total number of unique captures of Snapping Turtles and Painted Turtles was 98 and 283, respectively. Unique individuals captured per site of Snapping Turtles and Painted Turtles varied from 0 to 18 (mean = 3.06, SE = 0.66) and 0 to 113 (mean = 8.84, SE = 3.94), respectively. The numbers of individual Painted Turtles recaptured 1–4 times were 66, 13, 4, and 3, respectively. We recaptured 8 individual Snapping Turtles once, but recaptured none more than once. We recaptured only 1 Snapping Turtle in the same trap as the previous capture. For individuals that moved, the straight-line distance between capture locations varied from 4 m to 90 m (mean = 39, SE = 3.12). We recaptured 11 Painted Turtles in the same trap as the previous capture. For individuals that moved, the straight-line distance between capture locations varied from 9 m to 82 m (mean = 31, SE = 1.63).

For Snapping Turtles, the mean number of captures was significantly greater in larger-diameter hoop-net traps ($P = 0.014$; Table 1). For Painted Turtles, the mean number of captures was significantly greater in smaller-diameter hoop-net traps ($P = 0.022$). For Snapping Turtles, mean SCL was significantly greater in larger-diameter hoop-net traps ($P = 0.023$), but we captured all size classes in both trap diameters (Fig. 1a). For Painted Turtles, mean SCL was also significantly greater in larger-diameter hoop-net traps ($P = 0.019$). In contrast to Snapping Turtles, the smallest and largest Painted Turtle size classes were only captured in the smaller and larger diameter traps, respectively (Fig. 1b). When we excluded from analysis Painted Turtles with an SCW < 8.0 cm, the mean number of captures and mean SCL were not significantly different between small- and large-diameter hoop-net traps ($P = 0.088$ and $P = 0.564$, respectively). Mean CPUE of Painted Turtles was not significantly different for traps with and without Snapping Turtles ($P = 0.424$).

Discussion

Our results indicate that hoop-net trap diameter can influence capture success for freshwater turtles, with larger traps being more efficient for larger species, and smaller traps more efficient at capturing smaller species. Though the data supported our hypothesis that hoop-net trap diameter would be positively correlated with the number of Snapping Turtles captured, we also found the opposite effect for Painted Turtles. However, our analyses suggest we cannot exclude the possibility that fewer Painted Turtle captures in larger traps was caused by the potential for small individuals to escape through the mesh of larger traps, rather than by trap diameter. Other research indicates that species smaller than Painted Turtles, such as Spotted Turtles, have higher capture success with even smaller hoop-net traps (i.e., 0.14 m [0.5 ft] diameter; Howell et al. 2016), although no trap-choice experiment has been conducted to confirm this preference. We recommend that additional trap-choice experiments that use a broad range of hoop-net trap diameters, and a standardized mesh width of ≤2.54 cm, be conducted to further clarify how species-specific capture success scales with trap diameter. Based on current evidence, smaller diameter traps should be used to maximize captures of smaller species, and larger traps should be used when targeting larger species.

Our study also indicates that hoop-net trap diameter can influence the size distribution of captures for both larger and smaller turtle species. Though this factor did not affect the range of sizes captured for our large focal species, and thus may not be perceived as a major bias, we did obtain different size distributions for our small focal species. It is unclear why we did not catch the largest individuals in smaller traps, but again, the bias against catching the smallest individuals in larger traps could have been caused by the larger mesh size allowing for escapes. Previous studies report conflicting results on how size and species influence escape and

Table 1. Summary data for number and mean size of *Chelydra serpentina* (Snapping Turtle), all *Chrysemys picta* (Painted Turtle), and Painted Turtles with a straight-line carapace width (SCW) >8.0 cm captured in comparatively large- (0.91 cm) and small-diameter (0.76 cm) hoop-net traps. For this study, we sampled 32 ponds in West Virginia, with each pond sampled using 5 large and 5 small hoop-net traps. Data include total number of captures, mean number and standard deviation of captures per pond, and mean and standard deviation of straight-line carapace length (SCL) among ponds. Unique individuals were included in both trap-size data sets if they were captured in both trap sizes. *P*-values represent the results of paired randomization tests.

		Large traps			Small traps			
Species	Variable	*n*	Mean	SD	*n*	Mean	SD	*P*
Snapping Turtle								
All SCW	Captures	67	2.1	2.6	36	1.1	1.9	0.014
	SCL		277.0	43.8		247.9	35.9	0.023
Painted Turtle								
All SCW	Captures	95	3.0	7.5	231	7.2	18.8	0.021
	SCL		139.2	12.8		125.7	25.8	0.019
SCW > 8.0 cm	Captures	93	2.9	7.3	163	5.1	12.4	0.088
	SCL		139.2	12.8		136.0	12.6	0.564

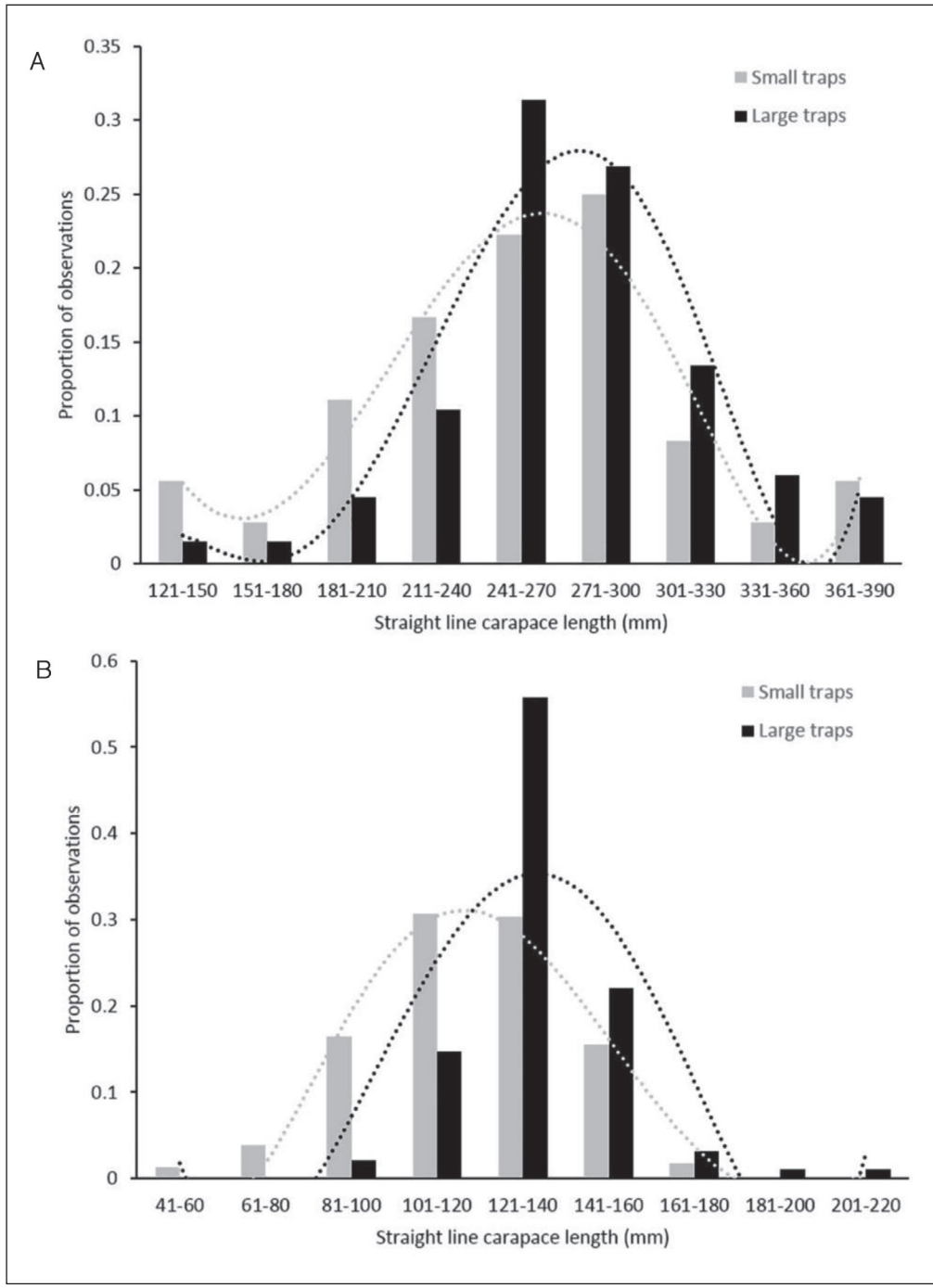

Figure 1. Size-class distribution for (A) *Chelydra serpentina* (Snapping Turtle) and (B) *Chrysemys picta* (Painted Turtle) captured in comparatively large- (0.91 cm) and small-diameter (0.76 cm) hoop-net traps. For this study, we sampled 32 ponds in West Virginia, with each pond sampled using 5 large and 5 small hoop-net traps. Dotted lines represent the size-distribution curves based on a 5th-degree polynomial.

catchability (Brown et al. 2011, Frazer et al. 1990, Mali et al. 2013). In addition, though the diameter of the trap does not limit ability to enter the trap, it might be easier for larger individuals to enter and smaller individuals to escape traps with larger funnel and mouth openings. For example, Mali et al. (2014) found that increasing the ease of access through the mouth of horizontally throated traps (i.e., increasing the vertical open space of un-stretched mouths) resulted in 8 times as many captures for Red-eared Sliders. We note that no studies have tested whether circular or horizontally throated hoop-net traps are more effective for capturing turtles, and this question should be investigated.

In conclusion, the results of our study indicate that diameter of hoop-net traps is an important sampling design consideration for freshwater turtle research and monitoring. If the same trap size is being used across all sites in a study, then the resulting data should be comparable. However, when comparing sampling data among studies, researchers should be aware that the diameter of hoop-net traps can influence both captures-per-unit-effort and the size distribution of individuals. In addition, researchers should consider using traps with smaller mesh to avoid escape of smaller turtles and multiple trap-sizes if their study goal is to assess turtle communities.

Acknowledgments

Our research was funded by the Natural Resources Conservation Service. This work was also supported by the USDA National Institute of Food and Agriculture, McIntire Stennis projects WVA00117 and WVA00122, and the West Virginia Agricultural and Forestry Experiment Station. J.T. Anderson was supported by the National Science Foundation under Cooperative Agreement No. OIA-1458952 during manuscript preparation. We thank R. Wickiser, K. Levat, and K. Matthews for assisting with fieldwork. We are grateful to the West Virginia Division of Natural Resources, Potomac Audubon Society, and many private landowners for graciously allowing us to use their property for several days or weeks. We thank 2 anonymous reviewers for helpful suggestions that improved the quality of this manuscript. Capture and handling methods were approved by the West Virginia Division of Natural Resources (Permits 2016.173, 2016.174, 2017.013) and West Virginia University Institutional Animal Care Use Committee (Protocol 1603001197). Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the US Government. This is Scientific Article No. 3350 of the West Virginia Agricultural and Forestry Experiment Station, Morgantown, WV.

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