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Influence of Bait Type on Capture Success of *Clemmys guttata* and *Chrysemys picta* Using Small Hoop Nets in Shallow Wetlands

Many passive sampling devices exist for sampling aquatic and semiaquatic turtles, such as basking traps, fyke nets, hoop nets, trammel nets, and modified crab traps (Lagler 1943; Vogt 1980; Chandler et al. 2017). Hoop nets are one of the most commonly used sampling devices because they are lightweight, portable, require only one worker to assemble and deploy, and provide easily quantifiable results (Davis 1982; Dodd 2016). Hoop nets are typically baited, with canned sardines being the most common type of bait used to attract turtles (e.g., Ernst 1965; Voorhees et al. 1991; Brown et al. 2011). However, species are known to differ in bait preferences, which can affect capture efficiency when sampling (Thomas et al. 2008; Mali et al. 2012, 2014; Munscher et al. 2017). Recently, Richardson et al. (2017) found that wet cat food was as effective as sardines for attracting *Chelydra serpentina* (Snapping Turtle) and *Chrysemys picta* (Painted Turtle) to hoop nets at urban ponds in Missouri. Cat food is substantially less expensive than sardines, typically costing US $0.54/can and US $0.96/can of cat food and sardines, respectively, and thus would be a preferable bait when it is as (or more) effective as an attractant to traps.

Clemmys guttata (Spotted Turtle) is a species of conservation concern throughout most of its geographic distribution in the eastern United States and Canada. Many states, including West Virginia, are currently engaged in *C. guttata* population surveys and monitoring to improve our understanding of the species' status and distribution. Populations are being passively sampled using small hoop nets or modified crab traps that are baited with sardines (Howell et al. 2016; Chandler et al. 2017). However, to our knowledge, no published studies have investigated bait preference for *C. guttata*. Based on the findings of Richardson et al. (2017), wet cat food may be a more cost-effective alternative to sardines, without sacrificing capture success. The purpose of our study was to test the effectiveness of using wet cat food as bait for freshwater turtles occupying shallow wetlands in West Virginia, with a focus on *C. guttata*.

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Methods

Our study was conducted at three wetland field sites in the eastern panhandle of West Virginia (specific locations withheld in compliance with state of West Virginia sensitive species data practices). Site 1 was a publicly owned wetland complex in Hampshire County. Habitat on the field site consisted of a matrix of seasonally flooded shallow grassy marshes, forest ponds, and dry upland grassland and forest. The wetland complex is bisected by a small, moderate-flow stream, which *C. guttata* appear to use as a travel corridor (Oxenrider et al. 2018).

The additional two sites were privately owned and located in Jefferson County. Site 2 is a marl wetland, consisting of swamp forests, shrubby thickets, and shallow grassy marsh. Marl is a soft lime compound mixed with clay that underlies the wetland and is fed by multiple limestone springs. Site 3 consisted of shrubby thicket and small forested wetlands bordering a small impoundment. Below the small dam the habitat is dominated by cattail (*Typha* spp.) and shallow grassy marsh. A narrow, paved maintenance road occurs alongside the edge of the impoundment, bisecting the impoundment from the lower marsh.

We trapped turtles at the three sites using hoop nets that measured 61 cm long × 30 cm wide and had a mesh width of 1 cm and a mouth at each end (Howell et al. 2016). Traps were encircled with poultry netting (91 cm wide with 2.5-cm hexagonal mesh) and staked into the ground to protect captured turtles from mammalian predators and deter large *C. serpentina* from entering traps. To investigate bait preference, we placed traps in pairs, with traps separated by ca. 1 m (Fig. 1). We baited one trap with half a can of sardines in oil (Bumble Bee®) and one trap with half a can of seafood-flavored wet cat food (Purina Friskies®). We placed the bait in small plastic containers with holes to allow for scent dispersal (Ernst 1965; Jensen 1998) and changed bait daily. We separated trap pairs by ≥ 30 m.

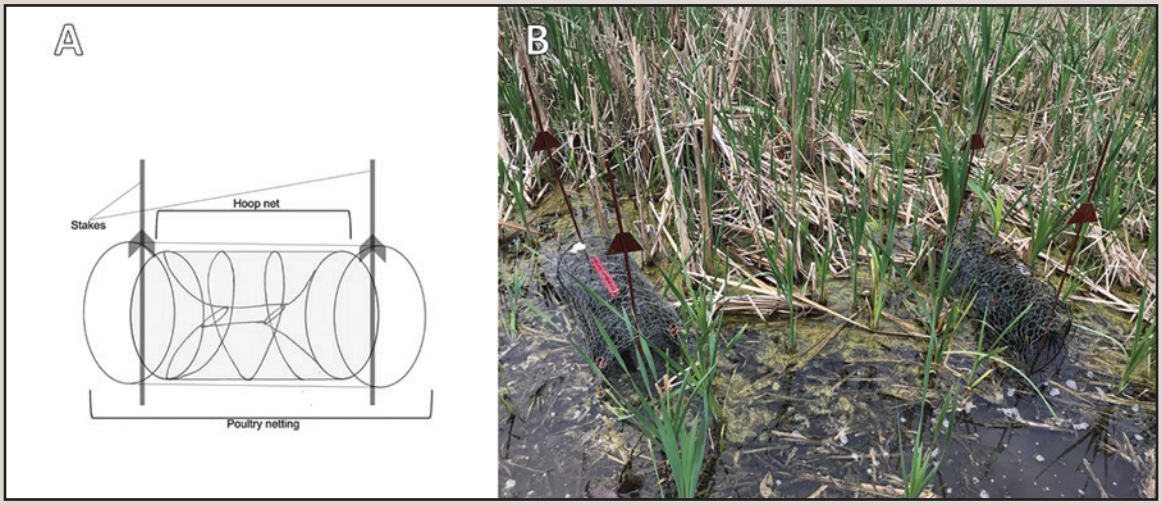

FIG. 1. Example of the trap used (A) and paired hoop net design used (B) to assess bait preference for freshwater turtles occupying shallow wetlands in West Virginia, with a focus on *Clemmys guttata* (Spotted Turtle). Note the use of poultry netting and stakes to protect captured turtles from mammalian predators.

TABLE 1. Number of freshwater turtles captured in hoop nets with different bait types in shallow wetlands in the eastern panhandle of West Virginia. P-values represent the results of paired randomization tests to determine if total captures, *Clemmys guttata* (Spotted Turtle) captures, and *Chrysemys picta* (Painted Turtle) captures differed by bait type. We did not analyze data from the additional species due to small sample sizes.

Bait Type	*Clemmys guttata*	*Chrysemys picta*	*Chelydra serpentina*	*Glyptemys insculpta*	*Sternotherus odoratus*	Total
Sardines	31	67	8	2	2	110
Cat food	27	63	3	0	1	94
Total	58	130	11	2	3	204
P	0.810	0.650				0.426

TABLE 2. Number of *Clemmys guttata* (Spotted Turtle) captured in hoop nets, by site and bait type during each session. Total numbers of traps deployed are represented by N. Total numbers of turtles captured are described by the number of turtles found in traps containing sardines or cat food. Paired traps were not deployed at site 3 during the first trapping session.

	Site 1			Site 2			Site 3			Total		
Session	N	Sardines	Cat food	N	Sardines	Cat food	N	Sardines	Cat food	N	Sardines	Cat food
10–20 April	10	6	0	2	9	0	–	–	–	12	15	0
1–25 May	10	4	15	9	10	9	7	2	3	26	16	27
Total	20	10	15	11	19	9	7	2	3	38	31	27

We trapped turtles from April to May of 2018 during sessions consisting of four consecutive trapping days, with sites 1 and 2 being trapped for two sessions, and site 3 being trapped for one session, for a total of 38 paired traps. We set trap pairs along edges of temporary pools, in between vegetation tussocks, and in rivulets flowing through shallow grassy marshes. All captured turtles were identified, counted, and released. All captured *C. guttata* were sexed, measured, marked using unique individual carapace notches (Cagle 1939) and Passive Integrated Transponder (PIT) tags, and released.

We used paired randomization tests with 10,000 iterations to determine if total captures, *C. guttata* captures, and *C. picta* captures differed by bait type. Randomization tests are appropriate for use when sample sizes are small, as in our study (N = 38 sites), because the statistical distribution is derived from randomized data rather than assuming the data follow a 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. The data used consisted of the total number of captures per trap within each trapping session, paired by trap pair. For *C. guttata*, which were individually marked, the total number of unique individuals per trap within each trapping session. Thus, the same individual could be represented up to two times in the data, if it was captured in both bait types. We inferred statistical significance at $\alpha = 0.05$.

We further assessed bait preference in *C. guttata* by conducting independent surveys in April 2019. Independent surveys were completed at sites 1 and 2 and a privately owned wetland in Hampshire County. Surveys were completed using identical traps and similar survey methods. One trap was used at each trap location and bait type was randomly assigned. We used a simple randomization test with 10,000 iterations to determine

if *C. guttata* captures differed by bait type and inferred statistical significance at $\alpha = 0.05$. We performed statistical analyses using program R.3.3.2 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

We captured 204 turtles representing 5 species, including 130 *Chrysemys picta*, 58 *Clemmys guttata*, 11 *Chelydra serpentina*, 3 *Sternotherus odoratus* (Eastern Musk Turtle), and 2 *Glyptemys insculpta* (Wood Turtle; Table 1). We found no significant difference in total captures between traps containing sardines (N = 110) and cat food (N = 94; P = 0.426). We captured 31 *C. guttata* in traps containing sardines and 27 in traps containing cat food, which was not significantly different (P = 0.810). During the first trapping session, we captured *C. guttata* only in traps containing sardines, but during the second trapping session we caught almost double the individuals in traps containing cat food (Table 2). Only 5 individual *C. guttata* were recaptured in paired traps during the study, with 3 individuals captured in both bait types. During independent surveys, we captured a total of 35 *C. guttata* across 45 trap sites for an average of 0.667 *C. guttata* in traps containing sardines (N = 18) and an average of 0.852 in traps containing cat food (N = 27), which was not significantly different (P = 0.256). We captured 67 *C. picta* in traps containing sardines and 63 in traps containing cat food, which also was not significantly different (P = 0.650).

Discussion

Our study suggests that wet cat food is an effective alternative to sardines for attracting *Clemmys guttata* and *Chrysemys picta* to small hoop nets in shallow wetlands, supporting the findings of Richardson et al. (2017). We recommend that other researchers and biologists consider testing wet cat food as a bait for *C. guttata* at other locations, and for other freshwater turtle species, to determine if it is a consistently reliable alternative to sardines.

Our study also indicates potentially strong individual-level bait preferences, given that only three individuals were captured in traps containing both bait types. However, the low overall recapture success suggests that *C. guttata* at our sites become trap shy after their initial capture, thus it is difficult to draw strong conclusions regarding bait preference at the individual level. While at first glance the temporal pattern in captures appears to indicate a seasonal shift in *C. guttata* bait preference between early and late spring, different individuals were captured between sessions, thus there is not strong evidence to support this hypothesis.

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