Switching Bait as a Method to Improve Freshwater Turtle Capture and Recapture Success with Hoop Net Traps

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Abstract - We surveyed freshwater turtles at sites in the Lower Rio Grande Valley and Bastrop Lost Pines ecoregions of Texas annually since 2008 and 2009, respectively, and found that captures and recaptures per unit effort (CPUE and RPUE, respectively) decreased annually. In 2011, we tested whether or not switching the type of bait used to attract turtles affected CPUE and RPUE. Under the assumption that bait preferences affect capture probabilities both among and within species, we hypothesized that switching bait would increase CPUE in 2011 by attracting individuals not captured in previous years. We also hypothesized that low recapture success in previous years was due to an olfactory-induced trap-shy response. We tested this hypothesis by determining if RPUE increased when we switched the type of bait used to attract turtles. We found that switching from fish-based bait to red meat significantly increased CPUE, but not RPUE, for *Trachemys scripta elegans* (Red-eared Slider). We also found weak evidence that *Apalone spinifera emoryi* (Texas Spiny Softshell) preferred red meat over fish-based bait. The results of this study indicate that switching bait can be an effective way to maximize CPUE across multiple years when monitoring freshwater turtles using baited hoop nets. However, switching bait did not affect RPUE, which indicates that the apparent trap-shy behavior of turtles in our study areas is not driven by an olfactory-induced response to the type of bait used.

Introduction

Capture-recapture sampling is one of the most widely used techniques for monitoring demographic components of wildlife populations (Nichols 1992). A major assumption of this method is that all individuals in a population at the time of sampling have the same probability of capture (Carothers 1979, Koper and Brooks 1998). Post-capture changes in animal behavior can bias demographic estimates (Carothers 1979, Feldhamer and Maycroft 1992, Nichols et al. 1984). These behavioral changes are commonly referred to as "trap-happy" responses (i.e., probability of recapture increases relative to probability of initial capture [Chao et al. 2004, Deforce et al. 2004]) and "trap-shy" responses (i.e., probability of recapture decreases relative to probability of initial capture [Brocke 1972, Carothers 1979]).

In addition to potential biases introduced through post-capture behavioral changes, sampling tools can inherently select for certain segments or individuals in a population. For instance, the two most common sampling tools for freshwater turtles are hoop nets and basking traps (Koper and Brooks 1998, Ream and Ream 1966), and hoop nets have been shown to be inherently male-biased (Ream and Ream 1966). Despite this, hoop nets are probably the most commonly

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used sampling method for freshwater turtles (Davis 1982, Lagler 1943, Thomas et al. 2008). Hoop nets are typically baited, with the type of bait chosen based on species-specific preferences (Ernst 1965, Jensen 1998, Thomas et al. 2008). Bait is usually placed in closed containers with numerous holes to allow scent dispersal while eliminating the potential for bait consumption (Lagler 1943, Nall and Thomas 2009).

We are aware of four studies that examined the efficiency of different bait types used for hoop-net sampling of freshwater turtles (Ernst 1965, Jensen 1998, Thomas et al. 2008, Voorhees et al. 1991). Ernst (1965) found that turtles were most attracted to sardines among six types of bait. Voorhees et al. (1991) used seventeen different types of bait and found that bait with jelly-like fluid (fresh mussel, canned creamed corn, and canned sardines) was the most successful in capturing nine species of freshwater turtles. Jensen (1998) found different bait preferences for *Macrochelys temminckii* Troost (Alligator Snapping Turtle) and *Trachemys scripta elegans* Wied-Neuwied (Red-eared Slider), with Alligator Snapping Turtles preferring fresh fish and Red-eared Sliders preferring fresh chicken entrails. Thomas et al. (2008) found that freshwater turtles preferred frozen fish and canned mackerel over creamed corn. In addition, Deforce et al. (2004) noted a "trap-happy" behavior of *Phrynops gibbus* Schweigger (Gibba Turtle) towards hoop nets baited with chicken meat.

We have surveyed freshwater turtles annually in the Lower Rio Grande Valley (LRGV) ecoregion of Texas since 2008 and in the Bastrop Lost Pines ecoregion of Texas since 2009. We found that captures and recaptures per unit effort (CPUE and RPUE, respectively) decreased annually (Fig. 1). Unfortunately, allowing for long periods of time between re-sampling (ca. 1 year) did not mitigate this

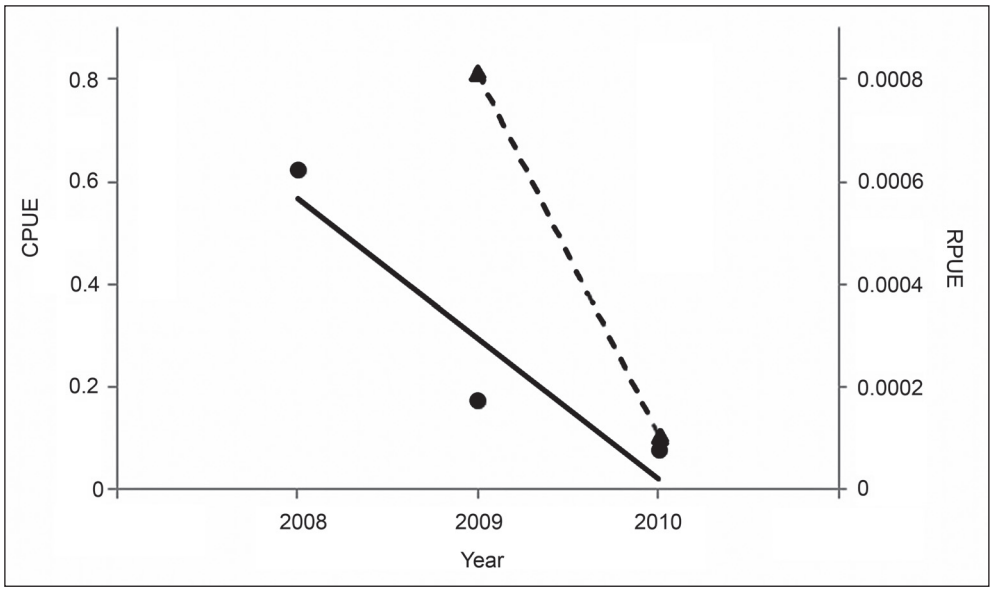

Figure 1. Mean capture per unit effort (CPUE, —●—) and recapture per unit effort (RPUE, – –▲– –) of *Trachemys scripta elegans* (Red-eared Slider) at ponds (n = 4) in the Lower Rio Grande Valley (LRGV) of Texas trapped annually since 2008 using hoop nets baited with sardines.

perceived trap aversion. In 2011, we tested whether or not switching the type of bait used to attract turtles affected CPUE and RPUE. Under the assumption that bait preferences affect capture probabilities both among and within species, we hypothesized that switching bait would increase CPUE in 2011 by attracting individuals not captured in previous years. We also hypothesized that low RPUE in previous years was due to an olfactory-induced trap-shy response. We tested this hypothesis by determining if RPUE increased when we switched the type of bait used to attract turtles.

Field-Site Description

We conducted this study using 15 ponds that were surveyed for multiple consecutive years as part of a statewide assessment of freshwater turtle populations in Texas. Eleven ponds were located in the LRGV in south Texas (Cameron, Hidalgo, and Willacy counties) and contained Red-eared Sliders and *Apalone spinifera emoryi* Agassiz (Texas Spiny Softshell). Four ponds were located in the Bastrop Lost Pines ecoregion in central Texas (Bastrop County) and contained Red-eared Sliders and *Chelydra serpentina* L. (Common Snapping Turtle). Additional information on the study areas can be found in Brown et al. (2011a, b, c).

Methods

Of the 15 ponds used in this investigation, we trapped six annually from 2008 to 2011 (including two that were not trapped in 2010), seven since 2009, and two since 2010. We trapped all ponds during the summer months when the turtles were likely to be most active (Thomas et al. 1999). We used 76.2-cm-diameter single-opening, single-throated, widemouth hoop nets with a 2.54-cm mesh size and four hoops per net (Memphis Net and Twine Co., Memphis, TN). We stretched the nets open using two wooden posts connected to the first and last hoop. We attempted to keep the locations within ponds and total area trapped consistent among years.

We used exclusively fish-based bait (primarily canned sardines) between 2008 and 2010 and exclusively red meat from beef brisket in 2011. The ponds that were initially trapped in 2010 were exclusively used for comparison between 2011 and the first year the sites were trapped using sardines and excluded from other analysis. In all years, we replaced the bait every two days. Annual trapping intensity varied among years and among sites, depending on study goals in a given year (see Brown et al. 2011a, b). In 2011, we completed 40 trap days (either 40 traps set for one day or 20 traps set for two days) at each site except one, where we completed 20 trap days (10 traps set for two days). Although we acknowledge that annual differences in trap days could bias our CPUE comparisons, we found in previous research that CPUE in these study areas was comparable if more than 10 trap days were completed (Brown et al. 2011b), which was also the case for all sites and years in this study.

We individually marked hardshell turtles using the numbering system of Cagle (1939) and a portable rotary tool (Dremel, Racine, WI). We marked softshell turtles by engraving individual numbers on the posterior end of the carapace

using the same rotary tool. We determined sex using secondary sexual characteristics (Conant and Collins 1998, Gibbons and Lovich 1990).

We used paired randomization tests with 10,000 iterations for all comparisons of CPUE and RPUE between years. The *P*-values in these tests represent the proportion of trials resulting in capture differences as great as or greater than those obtained (Sokal and Rohlf 1995). Thus, a small *P*-value means that it is unlikely our results were obtained by random chance given the inherent distribution of the data. For each species, we analyzed only those sites that corresponded with their geographic distribution. Red-eared Sliders were found in both study areas, Texas Spiny Softshells were found only in the LRGV, and Common Snapping Turtles were found only in the Bastrop Lost Pines ecoregion, with the exception of a single individual representing a Hidalgo County record in 2009 (Dickerson et al. 2009).

For Red-eared Sliders, we first tested if there was a significant decrease in CPUE between the first year and the last year the site was trapped with sardines (n = 13). This analysis was used to determine whether or not CPUE decreased over time. We then tested if CPUE differed between 2011 and the first year the site was trapped (n = 15), and whether CPUE differed between 2011 and the last year the site was trapped prior to 2011 (n = 13). These analyses were used to determine if switching bait affected CPUE. If CPUE in 2011 increased relative to the first year the sites were trapped, that would indicate a species-level bait preference for the new type of bait. However, if CPUE decreased significantly in 2011 there would not be strong evidence for species-level bait preference for the original bait, given the negative impact of trap-shy behavior on CPUE in subsequent years. If CPUE in 2011 increased relative to the last year the sites were trapped, but not relative to the first year the sites were trapped, that would indicate that bait preference varied intraspecifically. For the first and last comparisons, we excluded two sites because they were first trapped in 2010.

For Red-eared Sliders, we also determined if RPUE significantly decreased in consecutive years prior to 2011. A significant decrease would indicate trap-shy behavior. For this analysis, we used the study sites that were trapped every year since 2008 (n = 4). We then determined if Red-eared Slider RPUE differed between 2011 and the prior year the site was trapped (n = 12). If RPUE increased in 2011, that would indicate that turtles become trap-shy due to a negative olfactory response associated with hoop nets. For this analysis we excluded the two sites that were initially trapped in 2010, as well as one site that was first trapped in 2009, because no Red-eared Sliders were captured. For Texas Spiny Softshells (n = 11) and Common Snapping Turtles (n = 4), we only tested CPUE due to small sample sizes and low RPUE.

We inferred statistical significance at $\alpha = 0.05$. However, because of the relatively small sample sizes, we considered $\alpha = 0.1$ to indicate a result that was nearly significant and thus potentially biologically meaningful. We conducted statistical analyses using program R 2.7.2 (The R Foundation for Statistical Computing, Vienna, Austria). We calculated CPUE and RPUE using the following formulas:

CPUE = # captures / # trap days
RPUE = (# recaptures / # marked individuals from previous years) / # trap days

For this study, one trap day was defined as one trap in the water for 24 hours. Note that RPUE explicitly accounted for differences in number of marked individuals at the beginning of each year.

Results

Red-eared Sliders

Mean CPUE was 0.31 the first year sites were trapped and 0.09 the last year sites were trapped using sardines; this decrease was significant ($P < 0.001$, $n = 13$; Fig. 2, Table 1). Mean CPUE was 0.19 in 2011 and 0.28 the first year each site was trapped. Although mean CPUE decreased, the difference between the two years was not significant ($P = 0.12$; $n = 15$). However, we found that CPUE in 2011 increased relative to the previous year the sites were trapped (mean = 0.21 and 0.09, respectively; $P < 0.001$, $n = 13$). Mean RPUE was 0.0007 in 2009 and 0.0001 in 2010; this decrease was significant ($P < 0.05$). Mean RPUE was 0.0016 in 2011 and 0.0015 the previous year the sites were trapped; this difference was not significant ($P = 0.44$).

Texas Spiny Softshell and Common Snapping Turtles

For Texas Spiny Softshells, mean CPUE was 0.04 in 2011 and 0.01 the first year each site was trapped; this increase was nearly significant ($P = 0.07$; Table 1). For Common Snapping Turtles, mean CPUE was 0.03 in 2011 and 0.06 the first year each site was trapped; this decrease was also nearly significant ($P = 0.09$).

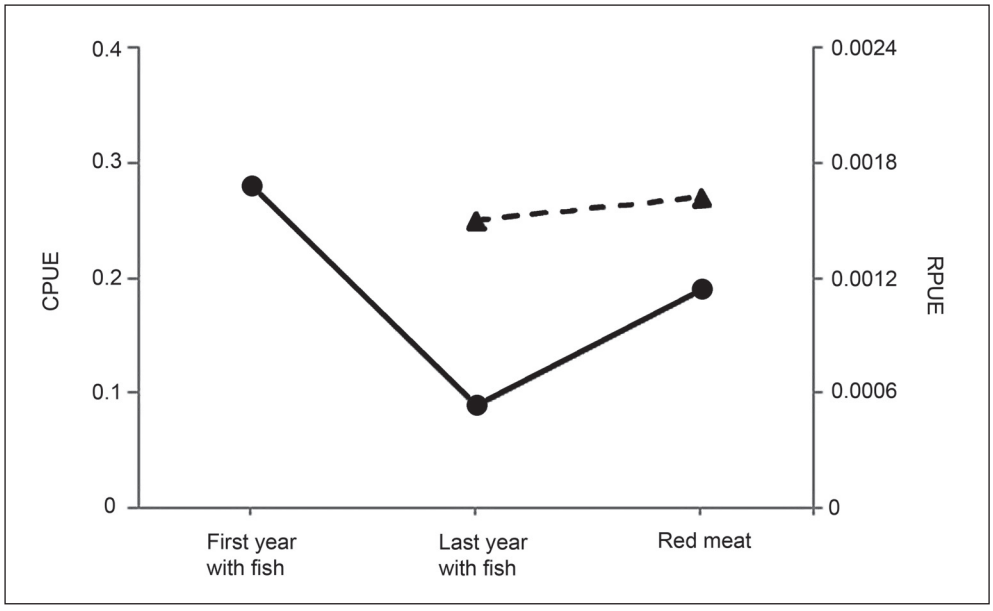

Figure 2. Mean capture per unit effort (CPUE, —●—) and recapture per unit effort (RPUE, – –▲– –) of *Trachemys scripta elegans* (Red-eared Slider) at ponds in the Lower Rio Grande Valley (LRGV) and Bastrop Lost Pines ecoregions of Texas during the first and last year sites were trapped with hoop nets using fish as bait, and in 2011, when sites were trapped with hoop nets using red meat as bait.

Table 1. Captures-per-unit-effort (CPUE) and recaptures-per-unit effort (RPUE) for *Trachemys scripta elegans* (Red-eared Slider) and *Apalone spinifera emoryi* (Texas Spiny Softshell) at 11 ponds in the Lower Rio Grande Valley (LRGV) of Texas and *Trachemys scripta elegans* (Red-eared Slider) and *Chelydra serpentina* (Common Snapping Turtle) at four ponds in the Bastrop Lost Pines ecoregion of Texas. We trapped turtles using baited hoop nets in the summer months from 2008 through 2011 in the LRGV and 2009 through 2011 in the Bastrop Lost Pines ecoregion. We used fish-based bait (primarily canned sardines) from 2008 to 2010. We used red meat in 2011 to determine if switching the type of bait used affected CPUE and RPUE. Note that not all sites were included in each statistical analysis, and thus not all mean values are identical to those given in the Results section.

	Captures-per-unit-effort (CPUE)[A]				Recaptures-per-unit-effort (RPUE)[B]		
Study area	2008	2009	2010	2011	2009	2010	2011
Red-eared Slider							
LRGV	0.218	0.066	0.062	0.250	0.0001	0	0
LRGV	0.391	0.054	0.075	0.200	0	0.0002	0
LRGV	1.440	0.460	0.150	0.250	0.0006	0.0002	0.0004
LRGV	0.450	0.120	0.025	0.375	0.0600	0.0250	0
LRGV	0.036	0.005	-	0.200	0	-	0
LRGV	0.055	0.226	-	0.475	0	-	0.0020
LRGV	-	0.720	0.225	0.175	-	0.0004	0.0005
LRGV	-	0.160	0.062	0.100	-	0.0015	0
LRGV	-	0.280	0.200	0.350	-	0	0
LRGV	-	0.154	0.038	0.300	-	0	0.0019
LRGV	-	-	0.125	0	-	-	0
Lost Pines	-	0	0.038	0.025	-	-	0
Lost Pines	-	0.114	0.038	0	-	0.0003	0
Lost Pines	-	0.020	0.038	0.075	-	0.0125	0.0083
Lost Pines	-	-	0.050	0.075	-	-	0
Mean	0.432	0.183	0.086	0.190	0.0101	0.0040	0.0009
Texas Spiny Shell							
LRGV	0.081	0.033	0.025	0.050	0	0	0
LRGV	0.023	0.005	0	0.025	0	0	0
LRGV	0	0	0	0	-	-	-
LRGV	0	0.060	0.025	0	-	0	0
LRGV	0	0	-	0	0	-	0
LRGV	0	0	-	0	-	-	-
LRGV	-	0.020	0.100	0.200	-	0	0
LRGV	-	0	0	0	-	-	-
LRGV	-	0	0.038	0.150	-	-	0
LRGV	-	0	0.013	0	-	-	0
LRGV	-	-	0.038	0	-	-	0
Mean	0.017	0.012	0.038	0.039	0	0	0
Common Snapping Turtle							
Lost Pines	-	0.024	0	0.025	-	0	0
Lost Pines	-	0.029	0	0	-	0	0
Lost Pines	-	0.143	0.013	0.075	-	0	0.100
Lost Pines	-	-	0.038	0	-	-	0
Mean	-	0.065	0.013	0.025	-	0	0.025

[A]CPUE = # captures/ # trap days

[B] RPUE = (# recaptures/ # marked individuals from previous years) / # trap days

Discussion

The results of this study indicate that switching bait can be an effective way to maintain high capture-rates in long-term freshwater turtle investigations using baited hoop nets. The increase in CPUE for Red-eared Sliders in 2011 relative to the previous year the site was trapped indicates that within-species bait preferences influence capture probabilities. Thus, maintaining baiting consistency when using CPUE as a metric for comparing relative abundance differences among sites could be important. In terms of species-level responses, we did not find significant bait preferences for any of the species. However, there was weak evidence that Texas Spiny Softshells preferred red meat over fish. Our study indicated that Red-eared Sliders develop a trap-shy response to baited hoop nets, but the trap-shy response did not appear to be olfactory-induced. Thus, it may be that turtles in our study areas develop a negative visual association with the hoop nets. If so, switching the type of trap used could increase RPUE, and we intend to test this hypothesis in the future.

In conclusion, the integration of capture-recapture methods for freshwater turtles using baited hoop nets remains challenging in our study areas. Unfortunately, it is only possible to census ponds (i.e., obtain *N*) if they are pumped dry and turtles are noodled, which in most situations is both logistically impractical and prohibitively expensive. Previous investigators have suggested that the optimal way to maximize CPUE and RPUE is to use multiple sampling tools (Koper and Brooks 1998, Ream and Ream 1966). Unfortunately, different sampling tools have different inherent biases associated with them, and thus using a combination of sampling tools could introduce additional uncertainty in capture-recapture estimates.

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