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## Hoop Net Escapes and Influence of Traps Containing Turtles on Texas Spiny Softshell (*Apalone spinifera emoryi*) Captures

Hoop nets are probably the most commonly used device for sampling aquatic turtles because they 1) are lightweight, easily portable in large numbers, and comparatively easy to hide; 2) provide easily quantifiable results; and 3) do not require intensive labor to operate (Conant and Collins 1998; Lagler 1943; Thomas et al. 2008). Several authors have reported escapes from hoop nets (Brown et al. 2011a; Frazer et al. 1990; Gamble 2006; Koper and Brooks 1997). Escape rates may be species-specific (Frazer et al. 1990) and turtles may not only be attracted by bait placed in the trap, but also influenced, either positively or negatively, by other turtles present in the trap (Cagle and Chaney 1950; Frazer et al. 1990; Ream and Ream 1966). Of particular interest is the suggestion that hoop nets are a male-biased sampling method because males are attracted to females caught in traps (Cagle and Chaney 1950; Vogt 1979). Frazer et al. (1990) tested this hypothesis and caught more Painted Turtles (*Chrysemys picta*) in traps containing females than in traps without turtles. However, Vogt (1979) found no differences in number of male Painted Turtle captures between female-baited and male-baited traps. Because few studies have been conducted on this topic and these studies have obtained conflicting results, it is currently unclear whether turtles present in traps bias future captures.

Differential escapes from and attraction to hoop nets could also be an influential source of bias when estimating population size and structure of freshwater turtles. We are aware of only one study that directly assessed differential escapes from hoop nets.

Brown et al. (2011a) found that significantly more female than male Red-eared Sliders (*Trachemys scripta elegans*) escaped hoop nets in lentic water bodies. Thus, differential escapes rather than differential attraction could explain why hoop nets are perceived to be male-biased. However, the applicability of these results to other taxa and aquatic environments is currently unknown. The purposes of our experiment were to determine if sex or body size influenced Texas Spiny Softshell (*Apalone spinifera emoryi*) escapes and to determine if “seeded” traps (i.e., traps with turtles placed in them) attracted more turtles than unseeded traps.

**Materials and methods.**—In the summer months of 2010 through 2012 we trapped and seeded turtles at three sites along the Rio Grande in Texas. In 2010, the study site was Big Bend National Park (29.18304°N, 102.9907°W), Brewster Co. In 2011, the study site was Black Gap Wildlife Management Area (BGWMA; 29.56139°N, 102.77798°W), Brewster Co. In 2012, the study sites were BGWMA and Southmost Preserve (25.84070°N, 97.38863°W), Cameron Co. The stretch of Rio Grande in Brewster Co. contains abundant Texas Spiny Softshells and Big Bend Sliders (*Trachemys gaigeae*), with a potentially growing population of non-native Red-eared Sliders (Jackson 2010), while the stretch of Rio Grande in Cameron Co. contains abundant Texas Spiny Softshells and Red-eared Sliders (Brown et al. 2011b). In addition to trapping the Rio Grande to obtain individuals for this experiment, we also trapped adjacent lentic water bodies to increase the sample size.

We used the same 76.2-cm diameter single-throated, single-opening, widemouth hoop nets with 2.54-cm mesh used by Brown et al. (2011a). Distance between the traps ranged from 5–100 m depending on availability of vegetation to secure the traps. All traps were set with entrances facing downstream (Lagler 1943) and baited with canned sardines placed in non-consumable containers containing holes for scent dispersal (Brown et al 2011a; Gamble 2006). We replaced bait every two days. In 2010, we completed 160 trap-days from 4–8 June. In 2011, we

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completed 449 trap-days from 14–19 June. In 2012, we completed 132 trap-days at BGWMA, from 8–10 May and 65 trap-days at Southmost Preserve from 27 May–8 June. We excluded all trap-days prior to seeding turtles (Table 1).

For all captured turtles we recorded carapace length and width, plastron length and width, and body depth to the nearest 1.0 mm using tree calipers (Haglof, Madison, Mississippi) and determined mass to the nearest 10 g using spring scales (Pesola, Baar, Switzerland). Sex was determined using secondary characteristics; for Texas Spiny Softshells, the pre-cloacal portion of the tail lies beyond the edge of the carapace in males and before or at the edge of the carapace in females (Berry and Shine 1980). We marked softshells by engraving individual numbers on the posterior end of the carapace and marked sliders by notching marginal scutes on the carapace using a rotary tool (Dremel, Racine, Wisconsin). After softshells were processed, we placed them in the hoop nets at random, with one turtle used per trap and each turtle used only one time for the experiment. We seeded between one and 26 traps per day. Therefore, not all traps were seeded at all times, which gave us the opportunity to test if seeded traps attracted more turtles than unseeded traps. Every 24 h we recorded escapes from seeded traps as well as new captures in both seeded and unseeded traps and we released the original turtles used to seed the traps. We conducted this experiment using a total of 107 seeded trap-days and 481 unseeded trap-days. Of the 107 turtles, 88 were originally captured in the river, while the remaining turtles were originally captured in adjacent lentic water bodies.

We used logistic regression to determine whether escapes were sex- or size-biased (Lindsay 1995). We combined the data from all years and tested two models. The first model included body depth as the predictor and hoop net escape as the binary response variable and the second model included both body depth and sex as predictors (i.e., juveniles were removed from this analysis). Likelihood-ratio tests were used to determine if the predictors significantly increased the fit of the data relative to the intercept-only model (i.e., deviance greater than chance alone). We used a randomization test to determine if seeded traps attracted more turtles than unseeded traps (Sokal and Rohlf 1995). All statistical analyses were performed in R 2.8.1 (The R Foundation for Statistical Computing, Vienna, Austria).

**Results.**—Eight of the 107 softshell turtles escaped (7%), including 6 males (8% of males), one female (3% of females), and one juvenile. Body depth was a significant predictor in the model that included only body depth as a predictor, with smaller turtles being more likely to escape (Deviance  $\chi^2_{1,105} = 52.35$ ,  $P = 0.03$ ; AIC = 56.35; Fig. 1). However, body depth was not a significant predictor when sex ratio was added to the model (Deviance  $\chi^2_{1,103} = 48.81$ ,  $P = 0.10$ ; AIC = 58.14). Sex was not a significant predictor (Deviance  $\chi^2_{1,102} = 48.59$ ,  $P = 0.64$ ). In addition to the 107 softshells, we captured 39 sliders during this study. Seeding traps did not affect Texas spiny softshell captures ( $P = 0.52$ ) or overall turtle captures ( $P = 0.87$ ).

**Discussion.**—We found a much lower escape percentage for Texas Spiny Softshells in a river system (7%) than Frazer et al. (1990) reported for Painted Turtles and Snapping Turtles in a lentic system (80% and 25%, respectively) and a higher percentage than Brown et al. (2011a) found for Red-eared Sliders in a lentic system (3.6%). In addition, Brown et al. (2011a) reported escapes were sex-biased, with females escaping more than males, but not size-biased, whereas we obtained the opposite results. The conflicting results among studies indicate there are interspecific differences in escape probability and potentially

TABLE 1. Study locations, number of trap days (excluding initial trap days prior to seeding traps), and number of turtles used to seed traps each year at sites used to investigate hoop net escapes and attraction for Texas Spiny Softshells (*Apalone spinifer emoryi*) in the Rio Grande river in Texas.

Year	Study site	Number of trap days	Number of seeded turtles
2010	Big Bend National Park	120	41
2011	Black Gap Wildlife Management Area	369	29
2012	Black Gap Wildlife Management Area	72	26
2012	Southmost Preserve	36	11
Total		597	107

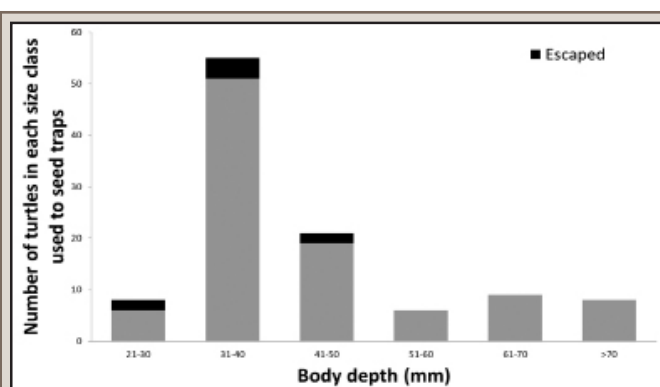


FIG. 1. Total number of Texas Spiny Softshells (*Apalone spinifer emoryi*) used to seed hoop nets along the Rio Grande with numbers that escaped by body depth. Body depth was a significant predictor in the model that included only body depth as a predictor, with smaller turtles being more likely to escape (Deviance  $\chi^2_{1,105} = 52.35$ ,  $P = 0.03$ ).

habitat-influenced differences. Different types of water bodies could potentially change the behavior of turtles within traps and, as a consequence, escape probabilities.

Our study does not support the hypothesis that turtle captures in hoop nets are influenced by the presence or absence of other turtles in the trap. This is contrary to Frazer et al. (1990), who found more *C. picta* in traps that already contained turtles. Thus, interspecific differences may exist for turtle attraction as well as escapes. Unfortunately, due to a low sample size for females, we were unable to determine whether or not sex of the captured turtle matters in terms of potential to attract other turtles. Based on results from the small number of studies that have investigated the efficacy of sampling freshwater turtles using hoop nets, it is clear that there is still much knowledge to be gained.

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## Relationships of Body Size and Male Melanism to Biting Propensity in Red-eared Sliders (*Trachemys scripta*)

Biting is a primitive and versatile behavior of turtles that likely evolved for feeding but is also used for defense and during social interactions (Davis and Jackson 1973). Biting during social interactions has been documented in numerous turtle species (Bury and Wolfheim 1973; Bury et al. 1979; Carpenter 1966; Ernst and Barbour 1992; Lardie 1983; Maffi et al. 2011; Schofield et al. 2007). The standard English names of snapping turtles, *Chelydra serpentina* and *Macrochelys temminckii*, reflect their tendency for defensive biting directed at human handlers. Bite force is generally correlated with body size (Herrel et al. 2002). Therefore, it is not surprising that adults sometimes use defensive biting in situations where juveniles do not (Pritchard 1989) or that larger turtles often prevail in social interactions that involve biting (Carpenter 1966; Lindeman 1999).

The Red-eared Slider (*Trachemys scripta*) is a widely distributed freshwater turtle that occurs in many aquatic habitats (Ernst et al. 1994). Lindeman (1999) observed that aggressive interactions among basking *T. scripta* resulted in larger turtles successfully displacing smaller turtles twice as often as smaller turtles displaced larger turtles. Turtles utilized several aggressive behaviors including biting, clawing and pushing when competing for basking sites (Lindeman 1999). These data support the hypothesis that aggression increases with increasing body size.

Another hypothesis regarding aggression that is specific to male *T. scripta* is that aggression increases as males become melanistic (Cagle 1950; Cahn 1937; Carr 1952; Lardie 1983; Parker 1990; Tucker et al. 1995). This hypothesis is attractive because in diverse taxa, including other turtles (Maffi et al. 2001), there is a correlation between aggressiveness and degree of melanism (Ducrest et al. 2008). Male *T. scripta* exhibit ontogenetic melanism (Lovich et al. 1990). As males approach the body size of sexually mature females in the local population, the green and yellow pigmentation on the integument and shell is replaced with melanin (Cagle 1950; Lovich et al. 1990; McCoy 1966). Although the function of melanism in *T. scripta* is not understood, several hypotheses have been presented including thermoregulation (but see Boyer 1965; Gronke et al. 2006), sexual selection, intra- or interspecific communication, and non-adaptive by-product of hormonal changes (Lovich et al. 1990). Of these, the hypothesis with the most support is the sexual selection hypothesis. In laboratory experiments examining courtship behavior, alternative mating tactics were observed. Nonmelanistic males initiated titillation, a precopulatory behavior consisting of rapid vibration of the foreclaws against the head of a female turtle (Cagle 1950; Jackson and Davis 1972) while melanistic males used chasing and biting as courtship behaviors (Thomas 2002). Anecdotally, melanistic male *T. scripta* have been described as aggressive and socially dominant (Cagle 1950; Cahn 1937; Carr 1952; Lardie 1983; Parker 1990; Tucker et al. 1995).

In the course of our research we handled hundreds of *T. scripta* across the complete range of body size for this species. This provided an opportunity to test two hypotheses: 1) the propensity to bite increases with body size, and 2) the propensity to bite increases with melanin deposition. During 2007–2008 we recorded biting attempts by *T. scripta* during handling. With these data we report the frequency of biting attempts, explore ontogenetic, intersexual and intrasexual differences in biting attempts,

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