ESCAPES FROM HOOP NETS BY RED-EARED SLIDERS (*TRACHEMYS SCRIPTA*)

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Abstract—We investigated the influence of sex and depth of body on escapes from hoop nets by red-eared sliders (*Trachemys scripta*) to assess if escapes from traps potentially biased estimates of structure of populations. Turtles remained in traps ≥34 h and traps were checked at ca. 12-h intervals. Depth of body was not a significant variable in escapes from hoop nets, but sex was a significant variable, with only females escaping. This study provides evidence that previous reports on the inefficiency of hoop nets and on rates of captures that are male-biased could result from escapes rather than differential attraction to traps.

Resumen—Investigamos la influencia del sexo y profundidad del cuerpo en los escapes por las tortugas de orejas rojas (*Trachemys scripta*) de trampas de aros para evaluar si los escapes de trampas podrían sesgar las estimaciones de la estructura de poblaciones. Las tortugas permanecieron en trampas ≥34 horas, y fueron revisadas en intervalos de cerca a 12 horas. La profundidad del cuerpo no fue una variable significativa en escapes de las trampas, pero el sexo sí fue una variable significativa con sólo las hembras escapando. Este estudio proporciona evidencia de que los informes anteriores sobre la ineficiencia de trampas de aro y de las tasas de captura a favor de los machos podrían resultar de escapes en lugar de atracción desproporcional a las trampas.

Determining and monitoring structures of populations often are key components of research and management of wildlife (Campbell et al., 2002; Bolen and Robinson, 2003; Dinsmore and Johnson, 2005). Fully censusing populations typically is not feasible (Witmer, 2005); thus, sampling techniques are used to provide estimates of structure within or among populations (Buckland et al., 2000; Cooper et al., 2003; Lancia et al., 2005).

Many techniques have been developed for sampling populations of aquatic turtles (Lagler, 1943; Vogt, 1980). Hoop nets are among the most common turtle-trapping devices used today (Davis, 1982; Conant and Collins, 1998; Thomas et al., 2008), and they are superior to most other passive-trapping devices (i.e., basking traps, fyke nets, and trammels) because they are lightweight, easily portable in large numbers, require only one worker, and provide easily quantifiable results. Despite these advantages, previous research has demonstrated that hoop nets might lead to biased estimates (Ream and Ream, 1966; Frazer et al., 1990; Gamble, 2006). Hoop nets are baited to attract turtles, and thus, are an incentive-based method of capture. If the incentive favors one sex or age-class over another, estimates of demographic parameters could be inaccurate (Voorhees et al., 1991; Thomas et al., 2008). Further, captured individuals attract additional turtles (Ream and Ream, 1966; Frazer et al., 1990). This might lead to male-biased captures during mating seasons as males are attracted to females in traps (Cagle and Chaney, 1950).

The ability of turtles to escape traps is another potential source of bias. Hoop nets are designed to provide turtles with easy entrance and difficult exit, but do not prevent escape from the trap. Frazer et al. (1990) reported that 80% of painted turtles (*Chrysemys picta*) and 25% of snapping turtles (*Chelydra serpentina*) escaped hoop nets over a 24-h period, indicating that interspecific differences likely exist in rates of escape. Size, strength, and behavioral differences between sexes and among age-classes might influence intraspecific rates of escape. The purpose of our study was to determine if sex or depth of body influenced escapes of red-eared sliders (*Trachemys scripta*) from hoop nets.

We performed our experiment 16 May–1 July 2009 in an 8.2-ha oxbow lake at the Nature Conservancy of Texas Southmost Preserve (25°51′N, 97°23′W; near Brownsville, Texas). We used 76.2-cm diameter, single-opening, single-throated, widemouth hoop nets with 2.54-cm mesh and 4 hoops/net (Memphis Net and Twine Company, Memphis, Tennessee). Traps were kept taut using wooden posts connected to the first and last hoop. Two stretcher posts that were lateral to the opening were used for each trap. Because the type of hoop nets we used had wide ellipsoid openings (ca. 50 cm unstretched), depth of body (i.e., plastron to uppermost point on the carapace) was chosen as the relevant size parameter for testing the influence of size.

Height of openings of traps is a proxy for the area available for turtles to find the escape route. Because individual traps differed in height of opening, they also differed in potential for escape. To mitigate the influence of individual traps, we measured height of underwater, flaccid openings of 25 new hoop nets to the nearest 0.25 cm and chose traps between the 30th (1.27 cm) and 70th (2.03 cm) percentile of the height of openings to be used for this experiment. For the duration of the study, 14 hoop nets were individually numbered with metal tags and they were not moved. Distances between traps were 2–4 m. To simulate a realistic trapping environment, traps were baited with sardines in non-consumable containers with holes to allow escape of scent; bait was refreshed every 2 days. Flotation devices were placed between the two middle hoops to prevent drowning and to keep traps parallel with the surface of the water. By lifting each trap out of the water each day, we inspected traps for holes and damage. To mediate undetected bias due to inherent differences in traps, we replaced individual traps if more than one turtle escaped, which occurred one time during this study. Although turtles were not assigned randomly to traps, we typically assigned turtles by their individual number, resulting in essentially random placement.

We conducted this experiment using 139 red-eared sliders. Of the turtles, 54 were captured by dip nets or hoop nets in the oxbow lake at Southmost Preserve. The remaining turtles were either taken from nearby ponds and reservoirs (n = 77) or captured on roads (n = 8) in Cameron County, Texas. No turtle used in the study had been marked previously, and thus, we assumed that none had been captured previously. Length and width of carapace, length and width of plastron, and depth of body were measured to the nearest 1.0 mm using calipers (Haglof, Madison, Mississippi), weighed to the nearest 10 g using spring scales (Pesola, Baar, Switzerland), and individually marked by notching the carapace with a rotary tool (Dremel, Racine, Wisconsin). We determined sex using secondary sexual characteristics. Male red-eared sliders have elongated foreclaws and the pre-cloacal portion of the tail lies beyond the edge of the carapace

Table 1—Ratios of red-eared sliders (*Trachemys scripta*) that escaped and did not escape from hoop nets by depth of body and sex.

Depth of body (mm)	Males	Females	Juveniles[a]
<40	0:3	1:3	1:20
40–59	0:32	1:11	—
60–79	0:21	0:13	—
80–99	0:6	1:22	—
≥100	—	1:8	—

[a] Juveniles lacked secondary sexual characteristics.

(Gibbons and Lovich, 1990) and females have short foreclaws and the pre-cloacal portion of the tail terminates before or at the edge of the carapace. Turtles with a depth of body <40 mm, which corresponds to a length of carapace of ca. 100 mm, were considered to be juveniles. We were able to confidently determine sex of six juveniles with depths of body >31 mm by their longer foreclaws and lengthened and thickened tails.

To ensure representation among sizes of males and females, we classed turtles into nine categories by sex and depth of body. We released turtles in cohorts of 6–14 individuals, with 1 turtle placed in each trap. Thus, not all traps contained turtles during each release of cohorts. Traps were then checked ≥3 times/release of cohorts at ca. 12-h intervals. We chose this time frame to simulate the longest period a turtle could remain in a trap in a study using daily trap-checking. Checking traps every 12 h allowed us to determine if time spent in the trap influenced number of escapes. Turtles that did not escape were kept in traps ≥34 h. When we had not captured new turtles for the experiment, we left turtles that had not escaped in hoop nets for an additional ca. 12-h interval.

We used logistic-regression models to test for differences in number of escapes from hoop nets (Lindsey, 1995). The first model included depth of body as the predictor and escape from hoop nets as the binary response variable. The second model included both depth of body and sex as predictors, with juveniles of undetermined sex removed from the dataset. We used likelihood-ratio tests to determine if the predictors significantly changed the intercept-only model (i.e., deviance greater than chance alone). We did not formally test time spent in trap due to the low number of escapes. All statistical analyses were performed using R 2.8.1 (R Foundation for Statistical Computing, Vienna, Austria).

Five of 139 turtles (3.6%) escaped from hoop nets; four were female (7.0% of seeded females), one was a juvenile of undetermined sex, and none was male. Depth of body was not a significant variable in either the model with only depth of body (Deviance $\chi^2_{1,137} = 0.045$, $P = 0.832$) or the model with depth of body and sex (Deviance $\chi^2_{1,117} = 0.001$, $P = 0.976$). Sex was a significant variable (Deviance $\chi^2_{1,116} = 7.062$, $P = 0.008$; Table 1). Three individuals escaped within 13 h, and two within 12.5–27 h of being placed into a trap. No individual escaped after 27 h, despite 43 turtles remaining in traps for 45.5–50 h.

The overall rate of escape for red-eared sliders was lower than rates for either the painted turtle or snapping turtle as reported by Frazer et al. (1990). We used similar traps and bait, indicating that substantial interspecific differences exist. However, this could be due to differences in heights of flaccid openings of hoop nets between the two studies. It is likely that larger openings greatly increase the probability of escape. As Frazer et al. (1990) conducted their study in August, we cannot discount seasonality as a potential factor influencing rates of escape, but we are unaware of behaviors that would shift this rate dramatically from early to late summer. Interspecific differences in rates of escape and inherent differences in traps could explain why some researchers have concluded that hoop nets are inferior traps for capturing some species of turtles (Vogt, 1980; Gamble, 2006).

We detected no effect of depth of body on number of escapes. Therefore, at least for red-eared sliders, if biases related to size exist, they are likely a result of attraction to traps and not a consequence of turtles escaping. However, sex did influence escapes from hoop nets. It is unclear why females escaped and males did not, but the lack of a size-related effect indicates that neither size nor strength influences abilities to escape. It is possible that females simply move more in traps, and thus, have a higher probability of finding the opening. When we checked traps, juveniles and males usually were hanging onto the netting at the front of the trap below the throat, whereas locations of females were unpredictable. Differences in rates of escape between sexes could help explain why hoop nets are regarded as a male-biased method of capture (Ream and Ream, 1966). Vogt (1979) noted that for *C. picta*, traps containing males or females captured more turtles than traps without turtles, with no difference detected between sexes when additional captures of females were removed from the dataset.

This study provides evidence that previous reports on the inefficiency of hoop nets and on rates of captures that are male-biased could be, at least partially, a result of escapes rather than attraction. Further investigations should focus on taxa more prone to escapes, such as *C. picta*. It is possible that hoop nets are equally efficient or more efficient than basking traps if the investigator employs a rigorous trap-checking routine.

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