REPTILES & AMPHIBIANS

Effects of Hoop-Net Mouth Opening on Capture Success of Rio Grande Cooters (*Pseudemys gorzugi*)

Sierra N. Shoemaker[1] and Ivana Mali[2]

[1]Eastern New Mexico University, Department of Biology, Portales, New Mexico 88130, USA (Sierra.Shoemaker@enmu.edu)
[2]North Carolina State University, Department of Forestry and Environmental Resources, Raleigh, North Carolina 27695, USA (imali@ncsu.edu)

For decades, the use of conventional hoop-net traps has been considered one of the most effective means of sampling aquatic turtles because they are lightweight, easy to move, and relatively easy to hide (Lagler 1943; Mali et al. 2013, 2014; Gulette et al. 2019). Factors such as bait type, trap mouth and mesh size, trapping duration, and trap placement can influence capture rates and estimates of community and population compositions and abundance (Mali et al. 2014; Ennen et al. 2021). Attraction of turtles to baited hoop-nets can differ by species, individual size, sex, behavior, previous capture history, individual bait preferences, and habitat characteristics (Mali et al. 2012; Mali et al. 2014; Gulette et al. 2019). Therefore, identifying and minimizing these biases, especially when studying elusive and conservation-sensitive species, is important.

The Rio Grande Cooter (*Pseudemys gorzugi*) is a medium to large riverine turtle whose range is limited to the lower Rio Grande watershed in New Mexico and Texas in the USA and Tamaulipas, Nuevo León, and Coahuila in Mexico (Degenhardt et al. 1996; Ernst and Lovich 2009). This species can be locally abundant in the USA, but the overall densities across its range are low (Bailey et al. 2014). The Black River, a tributary of the Pecos River in Eddy County, New Mexico, is the only system where juvenile *P. gorzugi* are readily observed and captured via hoop-nets (Mali et al. 2018). Systematic annual surveys using traditional hoop nets to capture *P. gorzugi* in the Black River began in 2016 (Mali et al. 2018). During the first six years, we caught turtles of various sizes (straight-line carapace length = 33–300 mm). More recently, however, the proportion of juveniles captured in

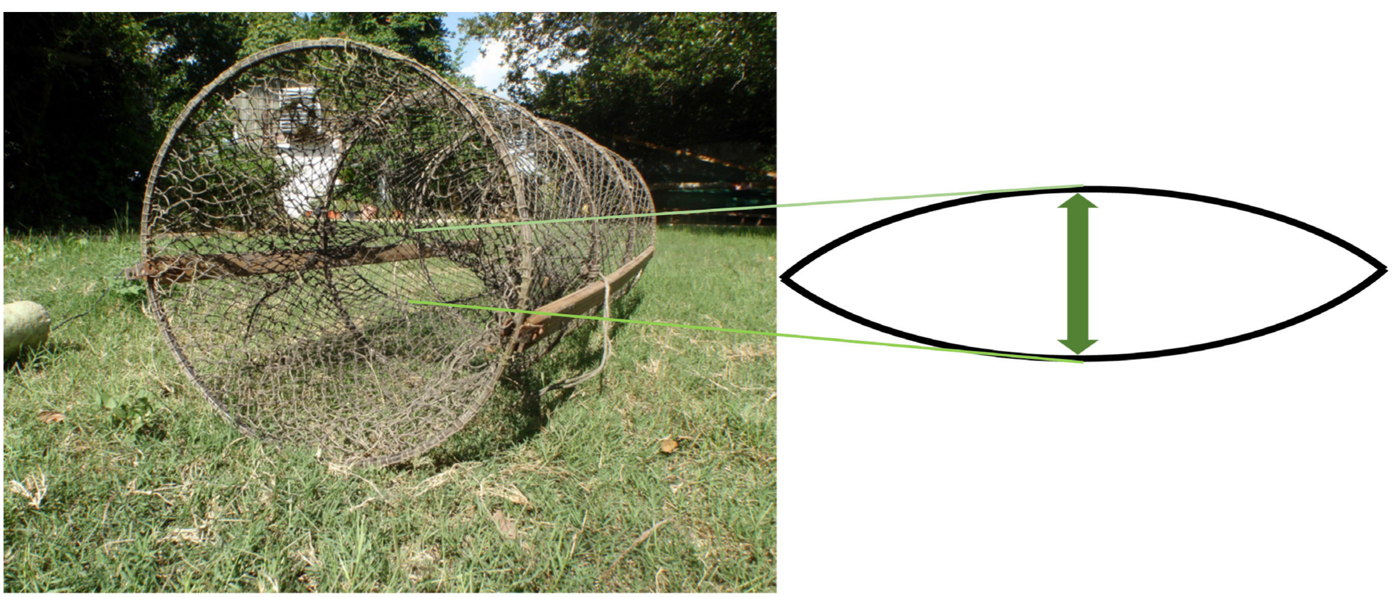

Figure 1. A standard hoop-net trap employed in this study (left) and a diagram of the ellipsoid trap mouth (right). The arrow denotes how we measured the size of the mouth opening. Figure adapted from Mali et al. (2014).

Reptiles & Amphibians ISSN 2332-4961
https://doi.org/10.17161/randa.v31i1.20963

hoop nets, especially the smallest size classes, has decreased (Mali et al. 2021). These changes could be caused by the natural widening of the trap-mouth opening over time (i.e., trap mouths tend to loosen when placed in water for prolonged periods). To test this hypothesis, during the 2022 field season, we sought to determine if trap-mouth size influenced *P. gorzugi* capture rates.

We conducted surveys in May and June 2022 at two sections of the Black River (Mali et al. 2018). Consistent with previous surveys, we used the same traditional fiberglass hoop-net traps with a 50.8 cm diameter. The traps have four hoops per net, are single-opened, single-throated, and have a 2.5 cm mesh size (Memphis Net and Twine Co., Memphis, Tennessee, USA). We separated the traps into two categories based on the size of the mouth opening (Fig. 1): loose-mouth openings (9–12.5 cm) and tight-mouth openings (<7.5 cm), and alternated the placement of each trap type (Mali et al. 2014). We used wooden poles to extend the traps and a floating device inside each trap to prevent captured turtles from drowning. Sardines canned in standard, unflavored oil were used as bait by placing them into small perforated non-consumable plastic containers for scent dispersal. Additionally, a romaine lettuce leaf was placed to float freely in each trap. Traps were checked daily and re-baited every two days.

For each captured turtle, we recorded straight-line carapace length (CL), carapace width, plastron length, plastron width, body depth, and weight (Method D in Iverson and Lewis 2018). Sex was determined using secondary sexual characteristics, including foreclaw morphology and cloacal position relative to the carapace. Turtles <120 mm CL lacked clear secondary sexual characteristics and were considered juveniles. Turtles were marked either by notching marginal scutes (Cagle 1939) with a portable Dremel tool (adults) or by inserting Passive Integrated Transponders (PIT) tags into the anterior inguinal region of the body cavity, parallel to the body spine (juveniles <100mm CL) (Buhlmann and Tuberville 1998).

We used Chi-square goodness of fit tests to assess the differences in overall capture rates between the two trap types. To test whether trap type influenced *P. gorzugi* captures by sex and size, we used generalized linear mixed effect models (GLMM) with binomial distribution. Each captured turtle was assigned one of the two values: "0" if the turtle was caught in a trap with a tight-mouth opening and "1" if the turtle was caught in a trap with a loose-mouth opening. To account for multiple captures of the same turtle, we treated individual turtles as a random effect. We ran all combinations of fixed effects (sex and size) and their interaction and used Akaike Information Criterion (AIC) to select the best-fit model (Burnham and Anderson 1998). We used log-transformed CL as the indicator of turtle size. Analyses were conducted in program R using the package glmmML (R Foundation for Statistical Computing, Vienna, Austria), and we inferred statistical significance at $\alpha = 0.05$.

Over 768 trap days, we caught 217 Rio Grande Cooters in the tight-mouth traps and 168 in the loose-mouth traps. Of the 244 unique individuals captured, 153 were caught only once and the mean number of times a turtle was recaptured was 1.5. No strong evidence suggests that turtles in our study system developed a trap-happy behavior. The frequencies of captures were not equally distributed between the two trap types ($\chi^2 = 6.24$; $p = 0.01$). The mean (± SD) and median CL of turtles captured in tight-mouth traps was 149 (± 35) mm and 140 mm, respectively. The mean (± SD) and median CL of turtles captured in loose-mouth traps was 158 (± 41) mm and 145 mm, respectively. The best-fit generalized linear mixed effect model included turtle size as the explanatory variable (Table 1). According to the model, larger turtles were more likely to be captured in large mouth traps ($p = 0.03$).

In our study, hoop-net mouth size affected turtle capture rates, with a positive relationship between turtle size and loose-mouth traps. Although smaller turtles might have the ability to escape loose-mouth traps, we did not directly test this hypothesis. Overall, *P. gorzugi* capture rates were significantly higher in traps with tight mouths. In contrast, Mali et al. (2014) found that freshwater-turtle capture rates were higher in loose-mouth traps. However, Mali et al. (2014) did not account for individual turtle size, and the majority of turtles in their study were adults. This indicates that capture success with varying trap types can be site-, population-, and species-specific. Notable is that of 91 turtles caught more than once, 61 were caught in both trap types. Considering successful captures of turtles of varying size classes during earlier surveys and the experimental design of the current study, the results of the 2022 sampling effort likely reflect true population demographics. Capture rates of the smallest size classes remained low in comparison to the early survey efforts, which calls for further investigation. With the range of findings surrounding potential hoop-net trap biases, continuing to test

Table 1. Summary of generalized linear mixed effects model sets based on the Akaike Information Criterion (AIC) model selection process to test the probability of Rio Grande Cooter capture in loose trap mouth in comparison to the tight trap mouth opening based on turtle sex (female, juvenile, male) and size (log transformed carapace length). Individual turtles were treated as a random effect.

Predictor	K	AIC	ΔAIC	AIC Wt
Turtle Size	3	528.9	0	0.61
Turtle Size + Sex	5	531.3	2.4	0.18
Null	2	531.5	2.6	0.17
Turtle Size * Sex	7	534.2	5.3	0.04

effects of different trap types on estimating population demographics of aquatic turtle populations and habitats is important, as is optimizing survey methodology to decrease biases. Overall, we recommend that future studies on the Black River continue to utilize traps of varying mouth sizes to account for a range of turtle body sizes.

Acknowledgements

We thank the New Mexico Department of Game and Fish (Permit #3621) and the United States Fish and Wildlife Services for funding; the Bureau of Land Management, private landowners, and Eastern New Mexico undergraduate students (Ashlyn Reynolds, Chase Latimore, Joshua Gonzalez, and Zane Seidel) for their help with surveys. The work was conducted under ENMU Institutional Animal Care and Use Committee Permit No. 2019-0226-01A1.

Literature Cited

Bailey, L.A., M.R.J. Forstner, J.R. Dixon, and R. Hudson. 2014. Contemporary status of the Rio Grande Cooter (Testudines: Emydidae: *Pseudemys gorzugi*) in Texas: Phylogenetic, ecological and conservation considerations, pp. 320–334. In: C.A. Hoyt and J. Karges (eds.), *Proceedings of the Sixth Symposium on the Natural Resources of the Chihuahuan Desert Region*. Chihuahuan Desert Research Institute, Fort Davis, Texas, USA.

Buhlmann, K.A. and T.D. Tuberville. 1998. Use of passive integrated transponder (PIT) tags for marking small freshwater turtles. *Chelonian Conservation and Biology* 3: 102–104.

Burnham, K.P. and D.R. Anderson. 1998. *Practical Use of the Information-Theoretic Approach*. Springer, New York, New York, USA.

Cagle, F.R. 1939. A system of marking turtles for future identification. *Copeia* 1939: 170–173.

Degenhardt, W.G., C.W. Painter, and A.H. Price. 1996. *Amphibians and Reptiles of New Mexico*. University of New Mexico Press, Albuquerque, New Mexico, USA.

Ennen, J.R., K.K. Cecala, P. Gould, R. Colvin, J. Denison, D.F. Garig, S. Hyder, L. Recker, and J.M. Davenport. 2021. Size matters: the influence of trap and mesh size on turtle captures. *Wildlife Society Bulletin* 45: 130–137. https://doi.org/10.1002/wsb.1163.

Ernst, C.H. and J.E. Lovich. 2009. *Turtles of the United States and Canada*. Second edition. Johns Hopkins University Press, Baltimore, Maryland, USA.

Gulette, A.L., J.T. Anderson, and D.J. Brown. 2019. Influence of hoop-net trap diameter on capture success and size distribution of comparatively large and small freshwater turtles. *Northeastern Naturalist* 26: 129–136. https://doi.org/10.1656/045.026.0111.

Iverson, J.B. and E.L. Lewis. 2018. How to measure a turtle. *Herpetological Review* 49: 453–460

Lagler, K.F. 1943. Methods of collecting freshwater turtles. *Copeia* 1943: 21–25. https://doi.org/10.2307/1437875.

Mali, I., D.J. Brown, M.C. Jones, and M.R.J. Forstner. 2012. Switching bait as a method to improve freshwater turtle capture and recapture success with hoop net traps. *Southeastern Naturalist* 11: 311–318. https://doi.org/10.1656/058.011.0212.

Mali, I., D.J. Brown, M.C. Jones, and M.R.J. Forstner. 2013. Hoop net escapes and influence of traps containing turtles on Texas Spiny Softshell (*Apalone spinifera emoryi*) captures. *Herpetological Review* 44: 40–42.

Mali, I., D.J. Brown, J.R. Ferrato, and M.R.J. Forstner. 2014. Sampling freshwater turtle populations using hoop nets: Testing potential biases. *Wildlife Society Bulletin* 38: 580–585. https://doi.org/10.1002/wsb.427.

Mali, I., A. Duarte, and M.R.J. Forstner. 2018. Comparison of hoop-net trapping and visual surveys to monitor abundance of the Rio Grande Cooter (*Pseudemys gorzugi*). *PeerJ* 6: e4677. https://doi.org/10.7717/peerj.4677.

Mali, I., S. Shoemaker, and T. Suriyamongkol, 2021. Final Report. Survey of Western River Cooter (*Pseudemys gorzugi*) in New Mexico within Black River Drainage. Submitted to New Mexico Department of Game and Fish, Santa Fe, New Mexico, USA.

R Core Team. 2021. *R: A Language and Environment for Statistical Computing*. R Foundation For Statistical Computing, Vienna, Austria. <https://www.R-project.org/>.