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Reproductive and Hatchling Ecology of the Alabama Red-Bellied Cooter (*Pseudemys alabamensis*): Implications for Conservation and Management

David H. Nelson[1], Gabriel J. Langford[1,2], Joel A. Borden[1], and William M. Turner[1]

[1]*Department of Biological Sciences, University of South Alabama, Mobile, Alabama 36688 USA*
[dnelson@usouthal.edu; joel.borden@usm.edu]

[2]*Present Address: School of Biological Sciences, University of Nebraska-Lincoln, Lincoln, Nebraska 68588 USA*
[farancia@gmail.com] (corresponding author)

Abstract. – We studied the reproductive, nesting, and hatchling ecology of the endangered Alabama red-bellied cooter (*Pseudemys alabamensis*) from 1997 to 2001 and in 2003 in the Mobile–Tensaw Delta, Alabama, USA. Nesting activity peaked in June and July and mean clutch size was 13 eggs ($n = 31$), with a strong positive correlation between clutch size and female carapace length. Females may lay multiple clutches in single- or multiple-chambered nests; adult and juvenile females dig false nests. Nonoverwintering hatchlings had a development period of 101 days ($n = 21$ nests); overwintered hatchlings emerged beginning in March of the next year. Mean hatchlings weight was 11.7 g with a carapace length of 39.1 mm ($n = 262$). We tested a headstart program on 6 hatchlings raised in captivity for 16 months and released as large, juvenile turtles; results suggest that the headstart program is a feasible approach to increase juvenile survivorship. We propose the following plan to prevent further population declines: 1) construction of a permanent barrier to prevent nesting females and hatchlings from being killed by vehicular traffic on the Causeway (US 90/98), 2) limitation of disturbance to nesting habitat in the Mobile–Tensaw Delta, and 3) initiation and evaluation of a 1-year headstart program to increase recruitment.

Key Words. – Reptilia; Testudines; Emydidae; *Pseudemys alabamensis*; turtle; reproduction; ecology; conservation; Alabama; USA

The Alabama red-bellied cooter (*Pseudemys alabamensis* Baur 1893) has a very restricted geographic distribution compared to other members of the genus *Pseudemys* (Ernst et al. 1994). Except for a recently discovered population in the lower Pascagoula River, Mississippi, USA (Leary et al. 2003), *P. alabamensis* has been reported only from the rivers in and peripheral to the Mobile–Tensaw Delta (MTD) in Mobile and Baldwin counties, Alabama, USA (Mount 1975; Nelson and Turner 2004, Leary et al. 2008). The turtles in the MTD represent a single population with concentrations of individuals around Gravine Island and Meaher State Park (Nelson and Turner 2004). Movement between these locations occurs most frequently in early spring when males travel throughout the MTD (Nelson 1998). The species is primarily an inhabitant of lentic freshwater and brackish streams, rivers, and shallow bays with soft bottoms and extensive beds of submergent vegetation (Nelson and Turner 2004). Shallow waters provide abundant aquatic vegetation, which comprises a majority of the adult diet (Ernst et al. 1994; Turner 2001).

The MTD population is characterized by a skewed sex ratio, with few males captured during systematic trapping efforts (Dobie 1985; Nelson 1997). Nesting opportunities in the MTD are limited, and human encroachment is forcing turtles to nest on sites used heavily by humans or along hazardous roadways (Nelson and Turner 2004). The primary nesting site for *P. alabamensis* was thought to be the northern portion of Gravine Island on a manmade, sandy spoil bank along the Tensaw River (Dobie 1986; Meany 1979). Additionally, a large number of females nest on sand spoil banks along a slightly elevated Causeway (US 90/98) that transects the southern tip of the MTD.

The Alabama red-bellied cooter was designated an endangered species by the US Fish and Wildlife Service (USFWS) in 1987 due to its limited distribution, encroaching development, pollution, pet-trade collection, and potential disturbance from tropical storms (USFWS 1987). The designation was also based upon a decline in juvenile turtles between 1971 and 1983, apparently resulting from a decline in recruitment (Dobie 1985). In support of Dobie's observations, recruitment appears to be low because of nest disturbance and egg predation (Boschung 1976; Mount 1986; Dobie and Bagley 1990; Nelson 2003; Nelson and Turner 2004; Leary et al. 2008).

Currently, little published information is available on the reproductive, nesting, and hatchling ecology of the Alabama red-bellied cooter (but see Ernst et al. 1994; Leary et al. 2008). The objectives of our study were to examine the reproductive, nesting, and hatchling ecology of *P. alabamensis* by determining 1) clutch size and frequency, 2) nesting behavior, 3) nest predators, 4) hatchling natural history, and 5) hatchling growth in the laboratory (to assess the feasibility of a headstart program).

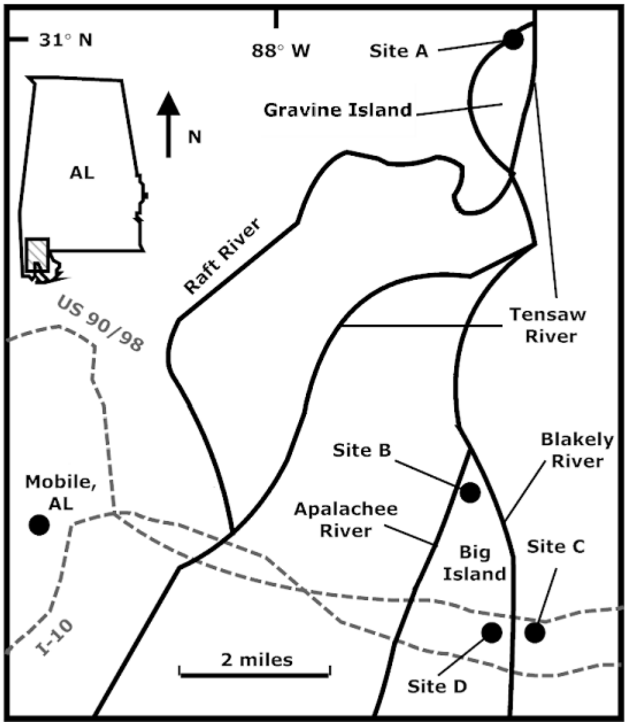

Figure 1. Location of *Pseudemys alabamensis* nesting sites in the Mobile–Tensaw Delta, Mobile and Baldwin Counties, Alabama, USA.

METHODS

Study Area. — We conducted our study in the Mobile–Tensaw Delta (MTD) which contains approximately 100,000 ha of aquatic and wetland habitats, located in Mobile and Baldwin counties in southwestern Alabama. A vast majority of the MTD, known as the Mobile–Tensaw Delta and W.L. Holland Wildlife Management Area (MTDWMA), is owned and operated by the Alabama Department of Conservation and Natural Resources (ADCNR). Hunting, fishing, and other recreational activities are permitted within the MTDWMA.

We monitored 4 nesting sites during the course of this study (Fig. 1). Site A was a spoil bank at the northern end of Gravine Island (on the Tensaw River) located in Baldwin County, within the MTDWMA. The spoil bank was composed of sandy deposition from river-bottom substrate, collected during dredging of the Tensaw River (Turner 2001). The dredging created a 5-ha spoil bank approximately 6.5 m above water level at its highest point. Although a variety of trees and herbaceous vegetation lined the periphery of the spoil bank, most of the bank lacked substantial vegetation. Sites B, C, and D were located on the Mobile Bay Causeway (US 90/98). The Causeway was built across the Mobile Bay in the 1920s to connect the eastern and western shores. The dredging and dumping of spoil for bridge abutments produced elevated spoil banks used by female turtles during the nesting season. Site B was a spoil bank located at the northeastern end of Big Island. The spoil bank on Big Island occupies 10 ha and has a maximum elevation of 3 m, with patches of grass and bare sand. Site C was located on private property to the south of the Causeway, along the eastern shore of the Blakely River. Site C was 2 ha, with a maximum elevation of 1.5 m along the Causeway; although, most of the site was low-lying. Site C was essentially a maintained lawn, with a mature bald cypress (*Taxodium distichum*) canopy covering 25% of the property. Site D, located in Meaher State Park, was a 7-ha public-access park located directly south of the Causeway. The Blakely River forms the eastern border of the park with Mobile Bay located to the south. A 2-ha, slightly raised (1 m) nesting area was located in the middle of the park, along Mobile Bay. The nesting area was a mixture of exposed sand, mowed grass, and camping sites. Mature long-leaf pine trees (*Pinus palustris*) create a sparse canopy throughout a majority of the nesting area.

Reproduction. — In 1997–2000, we used x-ray radiography on turtles as a noninvasive method of determining the clutch size of wild turtles (sensu Gibbons and Greene 1979). As part of a mark–recapture and radiotelemetry study, we captured turtles in aquatic hoop-trap assemblies placed in the Tensaw River adjacent to site A (Nelson 2000). We palpated females in the field and transported those that appeared gravid to Rehm Veterinary Clinic, Mobile, Alabama, for x-rays. The procedure revealed presence and number of shelled eggs in each female. We recaptured 3 females multiple times in 1 year (2×, 2×, 3×), providing some data on clutch frequency. We measured the carapace length (CL; midline), carapace width (CW), and plastron length (PL; midline) to the nearest mm with Haglof–Mantax tree calipers, and recorded body mass with a Pesola spring scale to the nearest g as part of the mark–recapture study (Nelson 2000). We identified turtles by individually marking them on their marginal scutes with a triangular file or portable drill.

Nesting Ecology. — In 2000, 2001, and 2003 we recorded the number of depredated nests from May to September at sites B and C to assist in determining the nesting season of *P. alabamensis*. We located depredated nests by walking systematic, parallel transects with 2–4 people (1 m apart) throughout the entire site at least twice per week, May through September. All egg fragments were collected and counted to estimate clutch size following the discovery of depredated nests. To prevent recording false nests, we recorded only depredated nests with egg fragments; this is likely to be a conservative approach that underestimates depredated nests (see Predation below). Turtles that lay eggs similar to *P. alabamensis* (e.g., *Pseudemys concinna*) are not known to nest at our sites; thus, we were fairly confident nests were dug by *P. alabamensis*. We noted any obvious signs of predation, such as nest scars (i.e., mammal claw marks), egg shredding (i.e., raccoons (*Procyon lotor*) often sliced eggs into several pieces) or single punctures (i.e., birds often punctured eggs and ate the contents of the egg, leaving a single hole), and mammalian scat with egg fragments (see also Feinburg and Burke 2003). In 2001, we also visually estimated percent vegetative cover (mostly grasses) of nests at site B and placed them in 4 categories (1 = 0%–25%, 2 = 26%–50%, 3 = 51%–75%, 4 = 76%–100%).

In 2001 (sites B and C) and 2003 (sites C and D) we surveyed for active nesting females. We conducted our survey at least 5 days a week from June through August. We observed nesting turtles, with binoculars, behind artificial and/or natural covers from a distance of 10–200 m for 1–6 hours at a time during the day (0630–2000 hours). When a turtle came ashore we observed her nesting behavior and then captured her after nesting was complete. We palpated turtles to determine if they laid a full or partial clutch because disturbed females (normally caused by the observer) may suspend nesting activities without depositing a full clutch. If we did not observe eggs being deposited in the nest cavity, we excavated the nest to determine if eggs had been laid and reburied the nest. We placed predator-excluders over nests to protect eggs from potential predators. Our predator excluders were each constructed from a 40 × 40-cm wooden frame with a piece of 1-cm^2 hardware cloth stapled across the top. We used bricks and wire stakes to secure the nest covers to the sand substrate.

Beginning in late August, we visited nest covers at least twice daily, to check for natural emergence. On 13 October 2001 we were forced to excavate remaining nests because of extensive flooding. In 2003 (28 November), we excavated all remaining nests because of low ambient air temperatures and concern regarding nest disturbance over winter months when nests could not be monitored consistently. We assumed that remaining hatchlings would overwinter in their nest cavities, based on data from a previous study indicating that some clutches overwinter (Nelson 2001). Upon emergence or excavation we recorded the number of eggs (hatched and undeveloped) and the condition of the eggs/hatchlings and nest cavity, we noted the presence of standing water (i.e., eggs floating), ants actively harvesting eggs and/or hatchlings, roots growing throughout the cavity and onto eggs, and fungi growing throughout the nest cavity and onto eggs.

Hatchling Ecology. — When the first hatchling in a nest emerged, we excavated the entire nest to release remaining hatchlings. We transported hatchlings to the University of South Alabama Vertebrate Natural History Museum (VNHM). Hatchlings were photographed and recorded for the following measurements (midline): CL, widest-point CW, PL, and tail length (TL) to the nearest mm with calipers; hatchling mass (after towel drying) was also recorded with a digital scale to the nearest mg. We housed hatchlings at the VNHM for 2–3 weeks. Hatchlings were not released until they had absorbed the majority of their yolk sacs and became sufficiently mobile (< 12 days). During captivity we separated hatchlings by clutch and housed them in 10-gallon aquaria, where they were fed a combination of ReptoMin® turtle food and local aquatic plants. We released hatchlings on the beach nearest their nests and observed the hatchlings until they entered the water and disappeared.

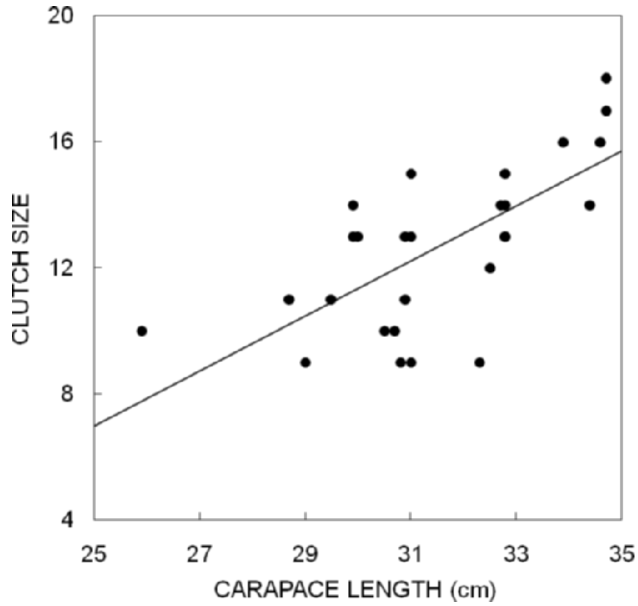

Figure 2. Relationship between female size and clutch size of *Pseudemys alabamensis* ($F_{1,\ 29} = 34.18$, $p = < 0.0005$, $r^2 = 0.913$). Turtles were collected from 1997 to 2000 in the Mobile–Tensaw Delta, Baldwin and Mobile Co, Alabama.

Between April 2004 and August 2005, we rescued 6 hatchlings from the Causeway and transported them to the VNHM for participation in a preliminary headstart program. We recorded morphological measurements (listed above) and placed hatchlings in a 55-gallon aquarium containing vegetation, logs, and a mud/sand substrate. We fed the hatchlings commercial aquatic turtle food once a day and aquatic plants 2–3/wk. A basking light was used 12 h/d. We recorded morphological characteristics every 2 months, for 16 months to estimate growth. Following the study we released the hatchlings near their point of capture.

Data Analysis. — Our statistical analyses were run using Minitab 15 (Minitab Inc, State College, PA [2007]). We used linear regression to examine the relationship between female size (CL) and clutch size. We used a chi-squared goodness-of-fit test to compare expected values of vegetational cover at nest sites with observed behavior of nesting females selecting vegetational cover. Means are given ± 1 Standard Deviation (SD). Alpha was set at 0.05 for all statistical procedures.

RESULTS

Fecundity and Clutch Frequency. — Using x-rays we found a mean clutch size of 13.3 ± 3.0 eggs (range = 9–17, $n = 31$), and a strong positive correlation between female size and clutch size (Fig. 2; $F_{1,\ 29} = 34.18$, $p = < 0.0005$). Mean CL of females captured for x-rays was 319 ± 20.4 mm ($n = 31$, range = 259–358 mm). Only 2 females were both recaptured and x-rayed; 1 female had clutches of 15 and 13 eggs separated by 22 days and another had clutches of 17, 17, and 18 eggs separated by intervals of 20 days each. A third female, captured during our nesting survey in 2003 (not x-rayed), also laid 2 clutches. She was observed laying 11 eggs on 11 July 2003 and then laid 10 eggs on 1 August 2003. The mean time between clutches laid was 20 ± 0.8 days ($n = 3$, range = 20–22).

Nesting Behavior. — The duration of the nesting season of *P. alabamensis* based on nest depredations was 68 days in 2000 (8 May to 14 August), 135 days in 2001 (1 May to 12 September), and 70 days in 2003 (28 May to 5 August). Depredation peaked twice during the 2003 reproductive season (Fig. 3), and once in 2000 and 2001. The nesting duration based on monitoring nesting beaches was 95 days in 2001 (25 May to 27 August), and 56 days in 2003 (13 June to 7 August). During nesting seasons female *P. alabamensis* were commonly seen wandering on the Causeway apparently searching for suitable nesting habitats. During a road-kill survey conducted from 2001 to 2006 a total of 444 (101 gravid females and 326 hatchlings) Alabama red-bellied cooters were found crushed on the road (D. Nelson, unpubl. data, 2007).

In 2001, females nested more often in vegetated nesting sites over bare ground nest sites ($n = 47$, χ^2 goodness-of-fit = 15.93, df = 1, $P = 0.007$). In 2003, the mean distance that females nested from the nearest water access was 63 ± 28 m ($n = 20$, range = 30–123). The mean amount of time nesting females took to complete nesting activities, defined as the time from when the female began digging until she left the nest, in 2003 was 44.5 ± 10.6 minutes ($n = 12$, range = 30–60). Females nested most often in the late afternoon and early evening; of the 24 females observed nesting in 2003, 17 (71%) began nesting between 4:00 PM and 8:00 PM.

During our initial observations, we noticed that females appeared to lay 1-chambered nests. We did not always observe the entire nesting process, however, and during nest excavation we noticed that some (~20%) nests had 1–2 side cavities containing 1–2 eggs. Apparently, 1-chambered and multichambered nests were dug by *P. alabamensis*. Based on nest dimensions from intact depredated and covered nests we found the main chamber had an average depth of 10.5 ± 2.1 cm ($n = 93$, range = 7.1–15) and width of 6.9 ± 2.1 cm ($n = 93$, range = 5–10.2). If side chambers were present they had a depth of approximately 3–6 cm. We also observed females digging false nests, which by definition contained no eggs.

Nest Predation. — One-hundred and sixty depredated nests were found in 2000, 2001, and 2003 at sites B and C. We recorded evidence of predation by fish crows (*Corvus ossifragus*), raccoons, nine-banded armadillos (*Dasypus novemcinctus*), and imported red fire ants (*Solenopis invicta*) on nests of *P. alabamensis*. When the source of predation was known ($n = 30$) we found 20 (67%) nests depredated by mammals, 7 (23%) nests depredated by birds, and 3 (10%) nests depredated by ants. Fish crows searched systematically for nests (and nesting females) in groups, crows even snatched eggs from ovipositing females. Imported red fire ants attacked nesting females and killed many hatchlings they encountered (see Mount 1975).

Nest and Hatchling Success. — Of the 40 nests that were covered with predator excluders in 2001 and 2003, 78% of the nests produced ≥ 1 live hatchling. The remaining 9 nests were unsuccessful because of flooding ($n = 6$; 67%), penetration of eggs by plant roots ($n = 2$; 22%), and covering of eggs by an unidentified white fungus ($n = 1$; 11%). Successful clutches had a mean developmental period (defined from the date of oviposition to natural emergence) of 101 ± 18 days ($n = 20$, range = 67–123; Table 1). The first hatchlings we encountered emerged on 5 September and the last naturally emerging hatchlings on 11 November. The 40 nests covered by predator excluders produced 262 hatchlings which were transported to the VNHM.

Hatchling Growth. — We kept 6 hatchlings at the VNHM to evaluate the viability of a headstart program for the Alabama red-bellied cooter. After 15 months in a 55-gallon aquarium the hatchlings increased their mean weight from 14.9 g to 311.4 g and reached a mean CL of 126.3 mm (Fig. 4).

DISCUSSION

Reproductive Ecology. — The clutch size for *P. alabamensis* was previously reported to be 6 eggs (range = 3–9; Meany 1979; Dobie 1986); yet we found the average clutch size to be 13 eggs, and Nelson (2000) found a single road-kill turtle carrying 20 shelled eggs. It seems likely the original assessments were based on females that laid partial clutches. Our method (x-ray radiography) is a reliable method of determining clutch size (Gibbons and Greene 1979); therefore, we consider the previous data to represent an underestimate (supported by Leary et al. 2008).

This is the first published record of multiple clutches in *P. alabamensis* from Alabama (but see Leary et al. 2008). Many members of the genus *Pseudemys* have been found to lay multiple clutches (Ernst et al. 1994). Our estimated mean time between clutches was 20 days; thus, even during the shortest nesting season (56 days in 2003) females could have laid 2–3 clutches. Presumably it takes approximately 20 days for the Alabama red-bellied cooter to calcify shells for oviposition; however, this aspect of reproduction needs further study.

The nesting season of *P. alabamensis* varied greatly between years and was probably dependent upon annual weather variation, such as temperature, cloud cover, and large rainfall events (e.g., tropical storms and hurricanes). For example, on 11 June 2001 tropical storm Allison passed near Mobile, Alabama, saturating our nesting areas

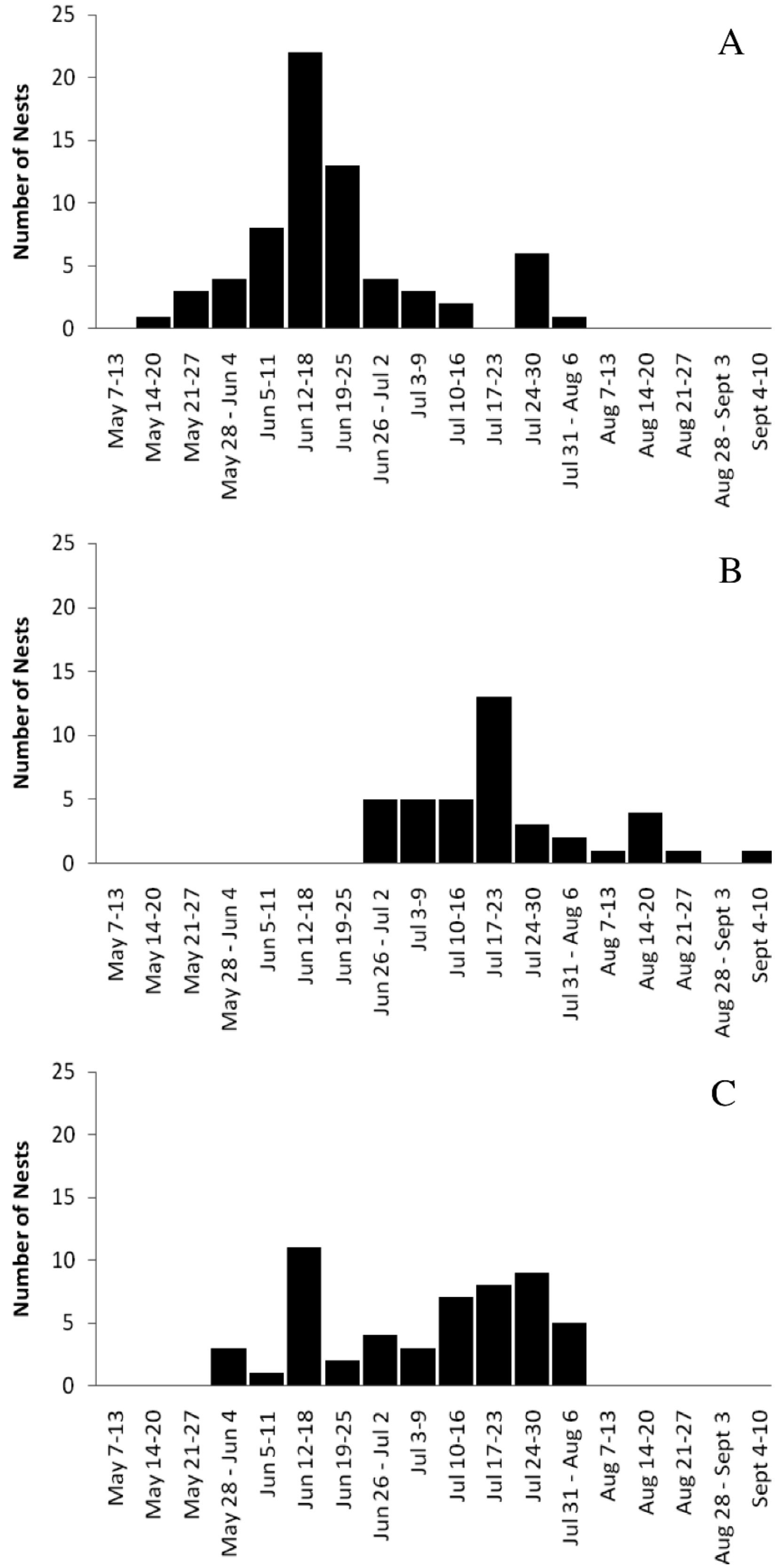

Figure 3. Number of depredated *Pseudemys alabamensis* nests recorded per week along the Causeway (US 90/98) from (A) 2000 ($n = 67$), (B) 2001 ($n = 40$), and (C) 2003 ($n = 53$) in the Mobile–Tensaw Delta, Baldwin and Mobile Co, Alabama, USA.

Table 1. Reproductive traits of *Pseudemys alabamensis* from nests laid adjacent to the Causeway (US 90/98) in the southern Mobile–Tensaw Delta, Baldwin and Mobile Co, Alabama, USA. Mean development period was recorded only for naturally (i.e., nonexcavated) emerging nests (2001 $n = 8$, 2003 $n = 13$, Total = 21).

Year (No. of nests)	$\bar{x}$ development period (d) ± SD	$\bar{x}$ eggs hatched ± SD	$\bar{x}$ eggs undeveloped ± SD	$\bar{x}$ clutch size ± SD	Min. clutch	Max. clutch
2001 (16)	101.0 ± 16.0	5.7 ± 4.9	5.0 ± 5.5	10.7 ± 2.3	7	15
2003 (20)	99.2 ± 19.3	6.8 ± 4.4	5.0 ± 5.2	11.8 ± 3.7	7	19
Total (36)	100.0 ± 18.0	6.3 ± 4.6	5.0 ± 5.3	11.6 ± 3.2	7	19

for several days. The saturated soils appeared to postpone nesting activities of the Alabama red-bellied cooter, and may be partially responsible for extending the nesting season. Despite some later nesting dates, we consider the normal nesting season to occur from May to August, with peaks of nesting activity in June and/or July.

Nesting Behavior. — We noted that some females dug one or more 'false nests'; cavities that appeared to be suitable for oviposition but in which no eggs were deposited. Females would abandon these nests, dig a new nest (sometimes several meters away), and potentially oviposit in the new nest. The significance of digging a false nest in *P. alabamensis* is unknown; we suspect that females may detect nonvisible cues (e.g., odor, moisture) that indicate nests may be unsuitable. We also witnessed nongravid and immature (based on size and/or palpation) females emerge from the water, dig a false nest(s), and return to the water. To our knowledge this is the first record of immature freshwater turtles engaging in this behavior. Despite the apparent risk of predation and expenditure of resources, *P. alabamensis* commonly engaged in this behavior. The significance of false nesting is unknown.

The digging of 3-chambered nests has been reported in some populations of *Pseudemys floridana* and *P. concinna suwanniensis* (reviewed by Aresco 2004). This study is the first report of multichambered nests in the Alabama red-bellied cooter. During our study we did not knowingly observe a female digging a multichambered nest. However, upon hatchling emergence from covered nests (so we knew they were *P. alabamensis* nests) we noticed the presence of 1–2 eggs in shallow side cavities adjacent to the main nest cavity. We were unable to determine how many nests had side cavities because side cavities were apparent only if eggs had been laid in the side cavities. Thus, it is possible that some females dug only 1 side cavity or none at all.

Nest Predation. — Nest predation at our sites appeared high, likely due to the numerous nest predators on the Causeway. Urban-adjusted species (e.g., fish crows, raccoons) often exploit human resources (e.g., trash, handouts), which superficially increases their population densities in urban areas (Hygnstrom et al. 1994; Madge and Burn 1994). The nesting areas around sites C and D consist of maintained lawns which appeared to facilitate predator identification of turtles and nests. Easy visual identification coupled with an increase in predator population density may result in increased turtle nest depredation. It is likely that Alabama red-bellied cooters nesting at Sites C and D are subject to an evolutionary trap (see Schlaepfer et al. 2002) in which turtles are attracted to anthropogenically altered habitat that significantly lowers nesting success. However, we are unaware of a study on a natural turtle population that addresses the effects of increased densities of urban predators on nest predation.

We found turtles were more likely to nest in areas with vegetation over bare sand. This was interesting because we found nests that may have been harmed by plant roots. Depredation of turtle eggs by plant roots has been shown to be a significant source of egg mortality in certain turtle species (Feinberg and Burke 2003). Apparently, grasses are able to obtain nutrients from turtle eggs (Lazell and Auger 1981). We found several eggs breached by roots. However, it was not clear when breaching occurred or whether the roots prevented eggs from developing or secondarily invaded after eggs had already been compromised.

Hatchling Ecology. — In October (2001) and November (2003), we excavated hatchlings that did not naturally emerge from the nest cavity. Excavated hatchlings were located deep in the nest chamber and in a state of torpor. The fact that some hatchling Alabama red-bellied cooters overwintered is not surprising given that overwintering is a common phenomenon in many temperate turtles even in the lower Coastal Plain of the southeastern US (Gibbons and Nelson 1978).

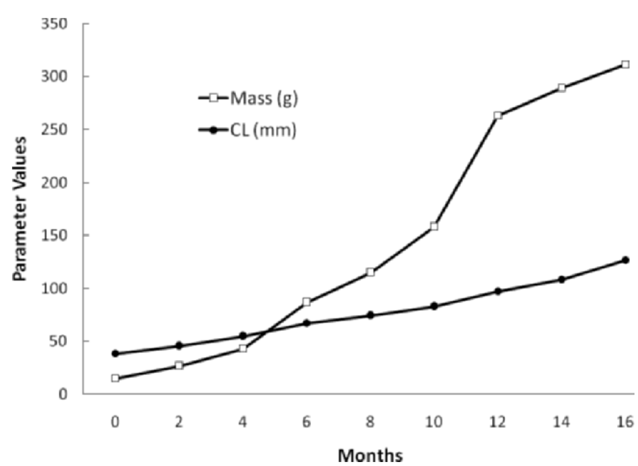

Figure 4. Growth of 6 *Pseudemys alabamensis* hatchlings maintained in captivity as part of a 16-month headstart program. CL = carapace length (midline).

Considering that the Alabama red-bellied cooter was listed as an endangered species partially based on a lack of juvenile recruitment (Dobie 1985), a headstart program should be given serious consideration as a management tool. Our anecdotal evidence suggests that juvenile turtles released after 16 months in the headstart program have outgrown many of their predators, except alligators (*Alligator mississippiensis*), large fish, and humans. Our assumption is supported by a study on *Pseudemys rubriventris* survival, which found headstarted turtles with CL $>$ 65 mm at release had survival rates similar to adult turtles (0.83–0.94), which were significantly higher than survival rates for *P. rubriventris* with CL $<$ 65 mm (Haskell et al. 1996). Hatchlings in our study surpassed 65-mm CL within 1 year; thus, we expect similar survival rates for the closely related *P. alabamensis*. Any headstart program should include a long-term monitoring program, including passive integrated transponders tags and radio-telemetry to assure the survival and health of released juvenile turtles.

Conservation Implications. — Disturbances to the reproductive age class represent the greatest threat to most turtle populations (Congdon and Gibbons 1983; Heppell et al. 1996). Although we cannot understate the importance of reducing adult mortality, *P. alabamensis* has been cited as declining due to a lack in juvenile recruitment (Dobie 1985). Thus, it is appropriate to establish a plan that improves both hatchling and adult survivorship. Only a combined approach is likely to offer continuing population stability. We propose implementing the following 4-step plan. 1) Construct a permanent barrier along the Causeway (US 90/98) to prevent female and hatchling mortality (see Dobie 1985). Known mortality of female *P. alabamensis* is greatest along the Causeway (Nelson 2003). Given the importance of reproductive females to turtle populations, road mortality is one of the most significant threats to the long-term survival of the Alabama red-bellied cooter. Successful wildlife barriers have been built in similar situations. For example, Aresco (2005) showed a 98% decrease in mortality after he erected a barrier on US 27 at Lake Jackson, Florida, USA. 2) Restrict major development along the Causeway because suitable nesting sites are scarce along the Causeway. Further development will limit nesting opportunities for *P. alabamensis*. Furthermore, the use of rip-rap to stabilize shoreline erosion should be avoided where turtles are known to nest. Turtles are known to become entangled in mats of rip rap and/or vegetation, which may cause injury and/or death (see Leary et al. 2008). 3) Prevent disturbance of levees and other elevations within the MTD. The USFWS/ADCNR has taken a step in the right direction by establishing a nesting beach on Gravine Island (Site A) as a restricted location for nesting Alabama red-bellied cooters. However, without enhanced law enforcement (at least during the nesting season) people will continue to ignore posted signs and disturb nesting turtles. For example, we witnessed several people wandering through the posted nesting area on Gravine Island during the summers of 2003 and 2004. 4) Establish a 1-year headstart program to introduce juvenile turtles into the environment. The use of predator excluders has been shown to be a minimally invasive hatchling collection technique (Siegel and Dodd 2000; this study), which should allow for the collection of hatchlings for a headstart program. Hatchlings could be maintained for 1–1.5 years, until they reach CL $>$ 65 mm, in a manner modeled after similar headstart programs (e.g., *Pseudemys rubriventris*; USFWS 1994; this study). The headstart program also would provide an opportunity to monitor long-term survivorship of released juveniles and confirm the effectiveness of this management tool within the genus *Pseudemys*.

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