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Cover Page Footnote

We thank the Arkansas Game and Fish Commission for permits for this project. We also thank Dr. David Bateman for support in procuring the game camera. Dr. Brett Serviss assisted with identification of vegetation.

Observations of an Alligator (*Alligator mississippiensis*) Nest and Behavior of Hatchlings in Clark County, with Anecdotal Observations of Other Alligator Nests in Arkansas

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Running Title: Observations of an Alligator nest in Arkansas

Historically, native populations of the American alligator (*Alligator mississippiensis)* extended throughout the southern portion of Arkansas (Trauth *et al*. 2004). By the early 1900s, populations range-wide had declined due to unregulated hunting, commercial exploitation, and habitat loss (McIlhenny 1935). In 1961, the Arkansas Game and Fish Commission (AGFC) implemented protection of this species, and in 1967 the U.S. Fish and Wildlife Service (USFWS) listed the alligator as an endangered species (USFWS 1967; Watt *et al*. 2002). The AGFC conducted a restocking program from 1972-1984, in which 2,841 alligators were released mostly in the southern portion of the state, and about 80% of the alligators were placed on private lands (Irwin and Wooding 2002). Some of the stock originated from Grassy Lake, a privately owned ~1200 hectare floodplain cypress swamp in Hempstead Co., Arkansas, but the majority came from Rockefeller Refuge and Sabine National Wildlife Refuge in Louisiana (Watt *et al*. 2002). The species made a full recovery throughout the historic range of Arkansas and was removed from the endangered list in 1987 (USFWS 1987).

Trauth *et al*. (2004) noted nesting or observation of young in Arkansas, Calhoun, Chicot, Hempstead, and Miller counties. In July of 2005, the first reported alligator nest was documented at the Red Slough Wildlife Management Area in McCurtain County, Oklahoma (Arbour and Bastarache 2006), though records of alligators in southeastern Oklahoma exist from the 1800s (Heck 2006). In northeast Texas, areas of the Sulphur River bottoms and Red River tributaries display healthy juvenile populations indicating nesting and breeding, and within the southern portion of Arkansas, alligators have confirmed breeding populations in Millwood Lake and Grassy Lake (Arbour and Bastarache 2006).

Still, little is known about reproductive biology and behavior of hatchling alligators in Arkansas. McCallum *et al*. (2003) reported a nest found on 7 August 2001 at Arkansas Post National Memorial, Arkansas Co., and reported seeing 22 hatchlings at the site 10 months later. In contrast, a second pod of hatchlings was found in the same area but were absent the following spring. Pods of hatchlings observed by Smith *et al*. (2016) in southern Arkansas were in vegetation near the shore (no other information about numbers of pods, nests, or specific localities were provided, as records were kept only for harvestable animals over 1.22 m (4 ft.) in length). A nest in nearby southeastern Oklahoma produced 19 hatchlings (Arbour and Bastarache 2006). Juvenile alligators were rarely observed during surveys in Arkansas habitats, perhaps because cold temperatures kill young alligators (Irwin and Wooding 2002), though smaller individuals also are more difficult to locate during surveys. These few observations demonstrate the need for better understanding of nesting success and post-hatching survival at the northern limit of the range of the species.

Most knowledge about alligator mating and reproductive behaviors that may relate to Arkansas are from studies conducted in Louisiana (Joanen 1969; Joanen and McNease 1970, 1971, 1975). Initiation of courtship typically begins with vocalizations and bellowing in early April. Male alligators have a 2-week peak of spermatogenesis, which decreases after mating, and by mid-June 90% of spermatogenic activity ceases (Joanen and McNease 1989). The female alligator develops mature ova during May-early June, and lays eggs about 3.5 weeks after ovulation (Joanen and McNease 1989).

Females attend and protect the nest. The average incubation period is 65 days, and through the period of 30-45 days, temperature of incubation determines the sex of the hatchlings (Lang and Andrews 1994), although incubation history can set this period a little earlier (McCoy *et al*. 2015). Nests can have varied temperatures, but eggs incubating experimentally at

31.5°C or less developed into females, while those incubating at 32-33.5°C produced all or mostly males and higher temperatures again produced females (Lang and Andrews 1994). As hatching begins, "peeping" vocalizations from the newborn alligators alert the mother to uncover the top of the nest. During this process, females may assist hatchlings and transport the young to the water (Hunt and Watanabe 1980).

On 3 April 2018, we observed an approximately 2 m long alligator on the western side of a small pond near Arkadelphia, Clark Co. The pond is approximately 14 meters off a 2-lane road and is surrounded on the other three sides by lowland forest, briars, and brushy vegetation. Aquatic vegetation in the pond was sparse and occurred primarily around the banks. At the western end of the pond is a small island approximately 7 m long x 5 m wide. Approximately 50 m southeast of the pond is a creek that runs beneath a bridge and allows wildlife to access farmland and other marshy areas, including Clear Lake.

Daily visits revealed that the alligator typically stayed on or near the island but occasionally occupied the middle of the pond. On 18 April, we observed a second alligator, approximately 2.5 m. in length, swimming near the smaller one. We continued observations between April and October. Although we never observed courtship behaviors, vocalizations, or mating, we noticed possible mate-guarding behavior as the larger alligator consistently positioned itself between the smaller alligator and us. Both alligators remained together until 18 May, after which the larger alligator was no longer seen.

Throughout June, sightings of the smaller alligator were unremarkable. On 31 July 2018, we took a canoe into the pond and found no evidence of alligators, although they could have been present and hidden on the banks. However, we discovered an alligator nest on 7 August, in an area on the eastern bank of the pond where a patch of ground had been cleared of vegetation. Most of the rest of the pond was surrounded by a more wooded landscape, and there we observed signs of heavy use by feral pigs *(Sus scrofa*). As egg predators (McIhenny 1935; Elsey *et al*. 2012), activity of pigs might have destroyed the nest had it been constructed on that side of the pond, but we have no evidence that nest site selection was based on predator avoidance.

Most of the vegetation surrounding the nest site was Roundleaf green briars (*Smilax rotundifolia* L.). A heap of sticks and dead plant material were mounded on top of a higher part of the bank, producing a structure 1.6 m long x 1.3 m across and 43-56 cm in height (Fig. 1). A slide of bare ground extended from the mound to the water. A nest described in southeastern Oklahoma was slightly larger, at 2 m wide x 1.8 m long, and about 60 cm tall, and was comprised of bulrush (*Scirpus* sp.) (Arbour and Bastarache 2006).

Figure 1. An alligator (*Alligator mississippiensis*) nest in Clark County, 15 August 2018. Photo by RT.

Upon our approach to the mound, the smaller alligator, presumed to be the nesting female, appeared in the water near the bank approximately 1 meter from the nest. Alligators reach sexual maturity at about 2 m (Joanen and McNease 1975), so this was possibly her first nesting attempt. We set up a Spypoint Link-S infrared game camera to monitor nest activity.

On 11 September, we heard "peeping" coming from the nest, and the unhatched alligators responded to vibration when we tapped the sticks on top of the mound. Five days later at 22:14 h, the game camera captured the female alligator on top of the mound. This was the only time the game camera captured female attendance directly on the nest (Fig. 2). We inspected the nest the next day, and although we found no alterations, peeping still could be heard.

From 21-25 September, Arkadelphia received approximately 10.2 cm (4 in.) of rain, and a significant drop in daily air temperature from 35.6°C (96.1°F) to 17.8°C (64.0°F), with prediction of lows in the 50s later in the week (it did reach 14.4°C (57.9°F); (www.usclimatedata.com/climate/arkadelphia/arkansas/united-states/usar0016/2018/9). We were concerned about the effect of appreciable temperature change, as the effect of thermal shock to a clutch of unhatched alligators is not understood. Lang and Andrews (1994) noted that embryos tolerate temperatures 1-3°C different from their viable range for 1-2 days.

Survival of alligators at the northern limit of the

Figure 2. The female alligator checking her nest at 2214 hr on 16 September 2018, caught by a game camera

range is limited by chilling temperatures. Partial freezing of ponds may trap smaller alligators under ice and cause them to suffocate, and the smallest individuals may die due either to lesser physiological tolerance to thermal shock or lesser ability than larger individuals to withstand lower temperatures (Spotila *et al*. 1972; Brandt and Mazzotti 1990; Lee *et al*. 1997). Spotila *et al*. (1972) noted that alligators enter water to avoid thermal stress induced by warmer or colder air temperatures.

The nest provides insulation whether or not it contains decaying vegetation. Because eggs and hatchlings still in a nest cannot access water, they may be more susceptible to changes in air temperatures they cannot escape, especially if the nest is not lined with a lot of decaying vegetation, whose decomposition incubates the eggs (McIlhenny 1935; Chabreck 1973). In Louisiana, maximum and minimum temperatures taken at the position of the eggs in a successful nest ranged from 38.9-28.9°C (102-84°F), with the highs occurring in very early development (McIlhenny 1935). The embryo does not survive past developmental stage 18 if temperatures remain above 36°C (96.8°F; Lang and Andrews 1994). In another study, mean temperatures taken in nests during late August averaged between 26.6-31.7°C (79.9-89.1°F) over 3 years (Chabreck 1973). Thus, we were concerned about effects of our lowering temperatures in late September.

Further, hatching occurs between late August and early September in Louisiana (Joanen and McNease 1975), and in eastern Texas most nests hatched in the first week of September (the latest date of hatching was 21 September; Saalfeld 2010). We excavated our nest on 27 September at 1630 h because the shift in temperatures, increased precipitation, presence of a second adult alligator in the pond, and the delayed hatching caused concern. We observed behaviors of hatchling alligators at the time of hatching from a wild nest, and later the development of feeding behaviors in the lab.

During collection of eggs and hatchlings, we observed neither of the adult alligators in the pond. We gently brushed the surface material, comprised mostly of small sticks and dirt, from the top of the nest and encountered eggs at a depth of approximately 15 cm. By use of a VWR® handheld digital thermometer, we determined the temperature of the nest to be a cool 24.2°C (75.6°F).

The nest contained 33 eggs. In Louisiana, clutch sizes averaged 38.9 eggs (Joanen 1969). Without changing their orientation (to prevent possible damage, see Ferguson 1985; Woodward *et al*. 1989), unhatched eggs were moved carefully to a plastic container lined with original nesting material and were transported to the vertebrate lab at Henderson State University, and were incubated in original nesting material at a temperature of 30°C. We continued incubation for 6 days to see if any other eggs would hatch.

Only those eggs in the process of hatching in the nest had survived. Eight were hatched within the nest at the time of opening, and 4 others were in the process of hatching. We measured (mm) the 21 unhatched eggs (mean ± STD, minimum-maximum): length was 60.5 ± 2.1, 57-65, and width was 37.3 ± 5.0, 33-38. Trauth *et al*. (2004) noted that alligator eggs are usually about 75 x 45 mm, and McIlhenny (1935) recorded usual measurements of 66 x 41 mm, so ours appear to be smaller than normal; possibly due to being from one of the first nests constructed by a young female.

We opened the dead eggs to determine developmental status of each. Eight eggs contained almost fully developed embryos, which we suspect may have died due to the rapid changes in temperature experienced a few days before we opened the nest. Nest temperature at the time of collection had dropped well below the tolerance suggested by Lang and Andrews (1994). McIlhenny (1935) similarly described a nest opened in late September, in which most of the young were dead due to lack of heat in the nest. Alternatively, Joanen (1969) observed a nest no longer attended by the female, in which half of the young had managed to hatch and liberate themselves whereas the other half were matured but died in the egg.

Three additional eggs from our nest showed development to the point of some bone and scale, but these had died early in incubation. The remaining 10 eggs appeared to have been infertile.

One day after hatching, we measured total length

(TL), snout-vent length (SVL), and mass of each of the 12 hatchlings. Mean ± STD, and minimum-maximum measurements were: TL (mm) 213.4 ± 5.1 (205-222); SVL (mm) 97.0 ± 3.0 (90-102); and mass (g) 25.4 ± 2.8 (20.9-29.6). In Louisiana, McIlhenny (1935) noted that hatchlings usually measure 9 in. (229 mm) or more, so ours may be a little small, consistent with the smaller eggs.

During hatching in the nest, hatchlings were aggressive and bit debris and each other while exiting their shells. Biting and wiggling helped the emerging alligators get their front legs free from the shell so they could pull themselves from, and shake off, their housing (Fig. 3). Only the snout protruded from 1 hatching egg brought to the lab, but the alligator did not exit overnight. The next morning, RT touched the snout of this baby with his finger, eliciting a biting response. The alligator was allowed to bite, and it held on while wriggling free from its eggshell. The aggressive biting behavior of the new hatchlings diminished within a few hours, and we observed little antagonistic interaction afterwards although all 12 hatchlings were kept in constant contact.

We placed hatchlings in a dry holding tank for 3 days until their umbilici were closed (to decrease chances of infection). Then, they were transferred to a 90 cm X 44 cm glass tank filled with dechlorinated water to a depth of 3 cm. On 3 October, 6 days after collection from the nest, we began attempts at feeding. Because smallest alligators feed largely on invertebrates and small fishes (McIlhenny 1935, Delaney 1990), our hatchlings were fed aquatic insects and worms collected locally, as well as commercial crickets and small shiners. Video of feeding behaviors was recorded by use of cell phones.

Figure 3. A hatchling alligator with only its head free from the eggshell often bit debris or siblings to help get its front legs out of the shell, Clark Co., 27 September 2018. Photo by RT.

We first offered earthworms and crickets, and the hatchlings attempted capture usually by sideways thrusts of their heads as potential prey came within reach. Within a few days, the hatchlings pursued cricket prey by taking a few steps in the direction of nearby prey, and attempted capture by use of side thrusts of the head. When we introduced earthworms to the tank, foraging behavior consisted of an individual placing its snout against the bottom of the tank and walking while moving the head side-to-side, at a rate of checking both sides about each second. When worms were caught, hatchlings were inept at prey handling and mostly repetitiously bit the prey, with the earthworm either escaping or being broken apart. Within a few days, capture of worms became aggressive and the hatchling shook the worm vigorously and began forward head thrusts to move the worm toward the back of the throat for ingestion.

Occasionally, two alligators grabbed the same earthworm, and attempted to pull it from each other. On 9 October, 12 days after recovery from the nest, we first observed the spin motion characteristic of crocodilians that attempt to separate meat from a prey item. More aggressive foraging behavior had developed along with this behavior, including pursuit and shaking of captured prey.

We introduced Golden Shiners (*Notemigonus chrysoleucas*) as prey on 8 October. Alligators initially had difficulty catching this more elusive prey, and pursued more vigorously and with more misses than with previous prey. When prey were caught, alligators had difficulty swallowing. Some individuals carried the catch in their mouths for some time, and eventually began pressing their heads against the aquarium glass to push the prey further into their mouths for consumption. As foraging skills improved, capture was more successful but competition became apparent as individuals commonly grabbed prey held in the mouths of siblings. Rolling behavior had improved and was employed more quickly and efficiently as the alligators had developed strength and agility, and most captured shiners were sheared and quickly became partial meals of 2 alligators.

After strong feeding behaviors had developed, we transferred the hatchlings to the alligator farm at Hot Springs on 16 November 2018.

Anecdotal Observations of Other Alligator Nests

Successful nests in eastern Texas had larger

circumferences, were closer to water but farther from trees, and had less canopy cover, and the primary causes of failure were predation and flooding (Saalfeld 2010). The nest we report was at the bank of a pond on the opposite side from activity of feral pigs, which reduced the chances of predation. McCallum *et al*. (2003) and Trauth *et al*. (2004) noted a nest at Arkansas Post National Memorial that appeared to have been comprised of herbaceous vegetation and constructed at the base of a tree.

Grassy Lake, in Hempstead Co., contains a population of alligators representing the original stock of native alligators in Arkansas (Irwin and Wooding 2002). During 2003, 5 nests were located in the area. Two of the nests were built at the base of bald cypress (*Taxodium disticum*) trees and had incorporated Redvine (*Brunnichia ovata*) material in the construction of the nest, and 2 were found with females attending the nest. Nests were constructed away from nearby human activity, and wallows were present. Four of these nests were constructed with heavy reliance on woody debris ranging from sticks to branches, 50-100 mm wide (Fig. 4). In southern Louisiana, where herbaceous marsh plants are more available, alligators used branches torn from bushes of larger diameter (such as alders 64-76 mm, 2.5-3.0 in.) for use in building nests, but discarded the trunks (McIlhenny 1935). Nests in the more wooded areas around Grassy Lake incorporated such materials, however.

Figure 4. An alligator nest near Grassy Lake, Hempstead Co., comprised of larger sticks and branches mounded with other debris and dirt at the base of a bald cypress (*Taxodium distichum*), 30 August 2003. Photo by Lisa K. Irwin.

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