Alligator Nesting Ecology in Two Habitats in Southern Georgia

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Abstract: Alligator (*Alligator mississippiensis*) nest characteristics from 2 different habitats in southern Georgia were compared. Nest and egg measurements varied somewhat between Silver Lake, an open freshwater habitat, and Rhetts Island, a brackish marsh habitat. However, except for the distance nests were found from water, none of the differences between study areas were significant. Mean clutch size for the Silver Lake study area was 38.0 while that of Rhetts Island was 40.7. Fertility rate of eggs on Silver Lake was 92.1%. Of 29 nests containing eggs on the Silver Lake area, 14 (48.3%) were successful, with 55.1% of the eggs in successful nests hatching. Predators destroyed 37.9% of the Silver Lake nests. Fertility rate of eggs on Rhetts Island was 92.7%. Twenty-three (74.2%) of 31 nests containing eggs were successful, with 44.7% of the eggs in successful nests hatching. Six nests (19.4%) were destroyed by predators. Hatching of eggs appeared to begin about 1 week earlier on Silver Lake, but on both areas the peak of hatching occurred during the first week of September.

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Estimates (Ruckel, 1982, unpubl. rep.) indicate that alligator populations in Georgia are increasing in portions of their geographic range and are stable throughout the remainder. The number of nuisance alligator complaints investigated in recent years, as well as observations of Georgia Department of Natural Resources (DNR) field personnel, tends to support the idea that alligator populations have rebounded significantly from the lows experienced in the 1960s.

Intelligent management of this valuable resource becomes necessary as its population grows. Baseline reproductive data are essential if alligator populations are to be managed scientifically. Hunt (1976) and Metzen (1977)

studied nesting ecology of alligators in the Okefenokee National Wildlife Refuge and provided reproductive data representative of freshwater swamp/marsh habitat. Very little other literature about alligator nesting characteristics in Georgia was found. Joanen (1969) in Louisiana, Bara (1976) in South Carolina, Goodwin and Marion (1978), and Deitz and Hines (1980) in Florida have studied alligator nesting ecology, but considerable variation in some nesting parameters between these geographic regions and their associated habitats suggests the need to collect baseline reproductive data within the geographic area to be managed. This study was designed to quantify and compare certain characteristics of alligator nests from 2 study areas representing 2 major habitat types in southern Georgia.

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Methods

Study Areas

The Silver Lake study area encompasses a 1,400-ha portion of IP's Southlands Experiment Forest in Decatur County, Georgia. This upper coastal plain site has, as its focal point, Silver Lake, a 120-ha shallow freshwater reservoir with weed-choked coves and standing, flooded timber. This area was chosen to represent typical open, freshwater alligator habitat. Numerous permanently and seasonally flooded ponds are found scattered over the study area. Principal aquatic plant species include water shield (*Brasenia schreberi*), fanwort (*Cabomba caroliniana*), and scented pond lily (*Nymphaea odorata*).

Buttonbush (*Cephalanthus occidentalis*) and wax myrtle (*Myrica cerifera*), predominant species near water's edge, give way to uplands of open stands of longleaf pine (*Pinus palustris*) that are maintained by winter burning. Ground vegetation on upland sites is mainly comprised of bracken fern (*Pteridium aquilinum*), wiregrass (*Aristida stricta*), and running oak (*Quercus pumila*).

Average annual rainfall is 127 cm, 40% of which normally falls during the summer months. Mean maximum daily temperature for the summer is 32° C and elevation ranges from 24 to 31 m above sea level. A more complete description of the study area is given by Landers et al. (1980).

A small percentage of the nests included in this study were found on Lake

Seminole WMA, an area of similar habitat located less than 6 km from the primary study site.

Rhetts Island and 3 smaller nearby islands make up the second study area. Rhetts Island (931 ha) is located at the mouth of the Altamaha River in McIntosh County, Georgia, on the Atlantic coast. The island consists of 3 brackish impoundments surrounded by a main dike and divided by 2 cross dikes. The 3 impoundments are identified by number, with Pools 1 (the westernmost) through 3 containing approximately 324 ha, 202 ha, and 219 ha, respectively, for a total of 745 ha. The remaining 186 ha is comprised of undiked marsh that varies from approximately 25 to 400 m in width between the perimeter dike and the river. A 7.6 m wide ditch that ranges in depth from 1.4 to 2.0 m is found along the interior side of the dikes. The 3 impoundments remain flooded all year and the water salinity varies. Samples taken in July 1983 showed the following salinities: Pool 1 = 5.4 ppt, Pool 2 = 5.9 ppt, and Pool 3 = 11.3 ppt.

Predominant vegetation in each impoundment differs somewhat in relation to the different salinities, but mainly includes giant cut-grass (*Zizaniopsis miliacea*), giant cordgrass (*Spartina cynosuroides*), cattail (*Typha* spp.), needlerush (*Juncus roemerianus*), and bulrush (*Scirpus robustus*). Vegetation on the dikes is primarily wax myrtle, blackberry (*Rubus* spp.), and pokeweed (*Phytolacca americana*). Giant cordgrass is the dominant species in the marsh outside of the impoundment and on the 3 smaller nearby islands.

Elevations on the study area range from sea level to 2.8 m on top of the dikes. Annual rainfall in 1981 on nearby Sapelo Island was 112 cm with 44% of that falling in the summer months. Mean maximum daily temperature in July was 27.8° C.

Data Collection

Alligator nests were initially located on the Rhetts Island study area by observation from a Bell Jet Ranger helicopter flown at approximately 100 m altitude in a circular pattern which covered the entire study area. Aerial searches were conducted during the last 2 weeks of July in 1982 and 1983, when all nests were expected to be completed. Nest locations were marked on a map and large, weighted fishing floats were dropped near each nest to aid ground searchers. As soon as possible thereafter, all nests that could be located from the ground were visited, and data were collected.

Due to overstory vegetation at the Silver Lake study area, all nest searches were conducted on foot by 2-man teams walking approximately 25 m apart around the perimeters of Silver Lake and all nearby ponds during the last 2 weeks of July in 1981, 1982, and 1983.

During the initial visit to each nest, maximum nest height and maximum nest diameter at the base were recorded. Nests were then opened from the top and the distance from the top of the nest to the top of the egg clutch was measured. Eggs were removed and placed to the side, carefully avoiding ro-

tating the eggs. Fertile eggs were identified by the presence of white circular bands as described by Deitz and Hines (1980) and the numbers of fertile and infertile eggs were recorded. Ten eggs from each nest were chosen at random, and length and diameter at the greatest points were measured by caliper. Eggs were then returned to the nest cavity and covered to the original depth. Other information collected at each nest included: 1) distance from the nearest permanent water; 2) predominant vegetation around nest; 3) major materials used in nest construction; 4) evidence of an alligator den near the nest; 5) presence, size, and behavior of female at the nest; and 6) an estimate of the amount of shade at the nest at 1200.

Each nest was subsequently checked at approximately 1-week intervals to document nest disturbance by predators, until the third week of August, when nest checks were increased to 3 per week in order to pinpoint hatching dates and attempt to accurately determine hatching success. Nests were not reopened during checks unless predator interference was obvious. The number of eggs that hatched from successful nests was determined by counting hatchlings. If hatchlings were not observed, egg membranes and unhatched eggs were counted to determine the number hatched.

Data collected in different years on each study area were compared and if no significant differences between years were found, data for all years were pooled for each study area. Pooled data from the 2 study areas were then compared by *F*-test for significant differences at the $P < 0.05$ level.

Results and Discussion

Alligator nests were highly visible from the air on the Rhetts Island study area. Thirty-seven nests were found and all but 5 nests, which could not be found by ground search, were checked on the ground and followed through hatching. Thirty nests were found on the Silver Lake study area. Alligator nest characteristics on the 2 study areas are compared in Table 1.

Nest Characteristics

Alligator nests were dome-shaped and varied in size. Nests on the Silver Lake study area averaged 49.7 cm in height and 191.7 cm in diameter while Rhetts Island nests had a mean height of 51.4 cm and a mean diameter of 174.5 cm. Nest height and diameter were not significantly different ($P > 0.05$) between the 2 study areas. These measurements are slightly greater than similar nest measurements in Florida (Goodwin and Marion 1978) but very close to nest measurements reported from South Carolina (Bara 1976).

The distance from the top of the nest to the top of the egg cavity, a measurement of the depth the eggs were covered by nesting materials, averaged 25.5 cm on the Silver Lake area and 19.5 cm on the Rhetts Island area. This difference was not significant ($P > 0.05$). Goodwin and Marion (1978) noted a mean depth to egg cavity of 20.9 cm in Florida.

Table 1. Alligator nest characteristics from Silver Lake study area, Decatur County, Georgia, 1981–83, and Rhetts Island study area, McIntosh County, Georgia, 1982–83.

Characteristic	Mean ± SD (*N*)	
	Silver Lake	Rhetts Island
Nest height (cm)	49.7 ± 9.85 (30)	51.4 ± 13.71 (28)
Nest diameter (cm)	191.7 ± 31.60 (30)	174.5 ± 22.30 (29)
Distance nest from water (m)	11.5 ± 12.01 (30)	2.1[a] ± 3.70 (34)
Distance from top of nest to top of eggs (cm)	25.5 ± 6.78 (28)	19.5 ± 5.76 (27)
Number of eggs per nest	38.0 ± 7.74 (29)	40.7 ± 7.95 (25)
Egg diameter (mm)	44.2 ± 1.61 (29)	42.0 ± 1.56 (15)
Egg length (mm)	75.3 ± 2.92 (29)	75.6 ± 3.35 (15)
Fertility rate of eggs (%)	92.1 ± 10.00 (25)	92.7 ± 12.65 (21)
Hatching rate (%)	55.1 ± 25.01 (11)	44.7 ± 23.56 (17)

[a] Significantly different from Silver Lake study area at $P < 0.01$ level.

The distance alligator nests were found from permanent water was significantly different ($P < 0.01$) between years on each study area. This finding was not surprising considering weather conditions on the Silver Lake area. An early summer drought in 1981 brought on rapidly falling water levels shortly after nest construction, leaving nests a greater distance from water by the time nest searches were conducted. Water levels were considered normal to slightly above normal in 1982 and 1983.

Distances of nests from water likewise varied significantly ($P < 0.01$) between 1982 and 1983 on Rhetts Island. Pool 1 had been partially drained prior to the 1982 nesting season. This allowed alligators to nest on "dry" spots within the impoundment and probably resulted in a greater mean distance from water. During 1983 Pool 1 was at its normal water level.

Pooled data from all years on each study area disclosed that the distance from alligator nests to permanent water at Silver Lake ($\bar{x} = 11.5$ m) was considerably greater ($P < 0.01$) than at Rhetts Island ($\bar{x} = 2.1$ m). Part of this difference may be accounted for by the variation between years. Confirmation of actual differences in distance of nests from water between the 2 study areas will require more long-term data collection.

Of the 37 nests discovered on the Rhetts Island study area, 17 (46%) were in flooded impoundments; 12 (32%) were either on dikes or the outside apron of dikes; and 8 (22%) were on nearby undiked islands. Nests on the Silver Lake area exhibited no predictable pattern of location. They were found in a variety of habitat types, mostly above the normal water level.

As reported by Joanen (1969), Metzen (1977), Goodwin and Marion (1978) and Deitz and Hines (1980), alligators apparently utilize the nearest available materials for nest construction. The results from this study support these findings. The typical nest on the Silver Lake area was comprised of a mixture of soil, pine straw, dead twigs, and whatever other dead or living

vegetation was nearby. Rhetts Island nests were constructed primarily of cordgrass or cutgrass.

Shade itself did not seem to be a determining factor in nest location. Nests on the Silver Lake area were built in locations with varying amounts of shade, from almost totally shaded to totally open. Little or no shade was present at most Rhetts Island nest sites.

Adult alligators were not observed at the nest site on the Rhetts Island area. However, 1 adult alligator exhibited what was perceived to be aggressive behavior toward the helicopter as it hovered at low altitude over a nest during aerial nest searches in 1983. On 2 occasions, large alligators were observed at nest sites on the Silver Lake area. One swam back and forth approximately 30 m from the nest as it was being checked, and the other, a 1.8 m adult, actively defended a nest located 45 m from the water. Aggressive behavior and nest attendance by adult females was likewise low in other studies (Joanen 1969, Goodwin and Marion 1978, Deitz and Hines 1980). Metzen (1977), however, reported fairly constant nest attendance during nest checks but a low incidence of aggressive behavior. Only 30% of the Silver Lake nests and 16% of the Rhetts Island nests showed evidence of an active alligator den nearby.

Egg and Clutch Characteristics

Alligator eggs from the Silver Lake study area averaged 44.2 mm in diameter and 75.3 mm in length. Those from the Rhetts Island area had a mean diameter of 42.0 mm and a mean length of 76.5 mm. Differences between study areas were not significant ($P > 0.05$). These measurements are similar to those reported in north-central Florida (Goodwin and Marion 1978).

Clutch size ranged from 27 to 51 ($\bar{x} = 38.0$) on the Silver Lake area and from 21 to 55 ($\bar{x} = 40.7$) on the Rhetts Island area. Mean clutch size compared favorably to the 38.9 (Joanen 1969) reported in Louisiana and the 37.5 (Deitz and Hines 1980) found in Florida but is higher than the 30.0 reported by Metzen (1977) in Georgia and the 30.3 noted by Goodwin and Marion (1978) in Florida. Mean fertility rates of eggs were 92.1% and 92.7%, respectively, for the Silver Lake and Rhetts Island areas and were very similar to the results of a Florida study (Deitz and Hines 1980). Neither clutch size nor fertility rate was significantly different ($P > 0.05$) between the 2 study areas. Two nests on the Silver Lake study area and 1 nest on the Rhetts Island area contained no eggs. Cracked eggs were present in 58.6% of the Silver Lake nests and 19.4% of the Rhetts Island nests.

Hatching rates (the percentage of eggs that hatch in successful nests) averaged 55.1% ($N = 11$) on the Silver Lake area and 44.7% ($N = 17$) on the Rhetts Island area. These rates were not significantly different ($P > 0.05$). Joanen (1969) reported a 58.2% hatching rate in Louisiana; Goodwin and Marion (1978), a 45% rate in Florida; and Deitz and Hines (1980), a 50.6% rate in Florida; all of which were considerably lower than the 70% rate reported from the Okefenokee Swamp in Georgia (Metzen 1977). It is sus-

pected that hatching rates in this study are conservative due to the high probability of not observing all hatchlings or finding all egg membranes at a successful nest site.

Nesting Success

Of 29 nests containing eggs on the Silver Lake area, 14 (48.3%) produced young which reached the water. One additional nest hatched, but the female never returned to open it. The hatchlings were eventually liberated by the authors but the nest was considered unsuccessful because, without human interference, no young would have escaped the nest.

Twenty-three (74.2%) of the 31 nests containing eggs on the Rhetts Island study area were successful. Nests located within the impoundment had a success rate of 80% ($N = 15$); those located on nearby islands had a 100% ($N = 5$) success rate; and only 36% ($N = 11$) of those built on dikes or the outside apron of dikes were successful. Although the sample size is small, it appears that nests located in areas less accessible to predators are more successful.

Nest Losses

Eleven (37.9%) of 29 nests that contained eggs on the Silver Lake study area were destroyed by mammalian predators. Some were known to have been destroyed by raccoons (*Procyon lotor*) due to presence of identifiable tracks at the nest, and raccoons were assumed responsible for others destroyed because of the abundant raccoon population in the vicinity and because no evidence identified any other predator. One nest was partially destroyed by raccoons, after which the female repaired the nest and the remainder hatched. Six eggs from another nest were dug out and eaten by a raccoon. The remaining eggs were covered up by the investigator and this nest also eventually hatched. These 2 observations appear to be exceptions because all other preyed upon nests ended in complete destruction after predators discovered eggs within the nest. In most instances, predation at a nest continued for several days until all eggs were gone.

Six (19.4%) of the 31 nests that contained eggs on the Rhetts Island area were totally destroyed by predators. Four were lost to feral hogs (*Sus scrofa*), 1 to raccoons, and 1 to an unidentified predator. Five (83.3%) of the 6 preyed upon nests were located on dikes. All but 5 eggs were eaten in another nest by a combination of raccoons and feral hogs. A great blue heron (*Ardea herodias*) was seen at 1 nest which had hatched the day before. Although predation on the newly hatched alligators was not observed, it was suspected.

Joanen (1969) and Goodwin and Marion (1978) reported that most predation of alligator nests occurred after the seventh week of incubation when the egg shells began to crack. However, Metzen (1977) found that black bear (*Ursus americanus*) predation on Georgia nests occurred early in the incuba-

tion. No such pattern of predation was apparent in this study, as nest destruction occurred throughout the incubation period. It is believed that, in some instances in this study, opening the nest during the initial nest check led to predation soon afterward. This seemed especially true at Silver Lake during the 1981 drought when no rain fell for several days after nest opening. In 1982, when the predation rate was only 12.5% at Silver Lake, afternoon rains during the initial nest opening period were thought to have washed away most of the scent associated with nest opening and may have contributed to the lower overall predation rate. Fleming et al. (1976) noted higher predation rates on alligator nests by raccoons in coastal marshes during dry years, a fact they attributed to less favorable food conditions and a resultant change in raccoon foraging habits.

Losses of alligator nests due to flooding, as reported by Metzen (1977), Goodwin and Marion (1978), and Deitz and Hines (1980), were $\leq 8\%$. In this study, no nests were lost to flooding on the Silver Lake area and 2 (6.4%) were destroyed by high water on the Rhetts Island area.

Egg Deposition and Hatching Times

Time of egg laying was not determined by actual observation at any nest during this study, but by assuming an incubation period of 65 days (Joanen 1969, Bara 1976), egg deposition time was calculated from known hatching times. The earliest egg laying occurred approximately 15 June and the latest about 16 July. Egg laying appeared to begin about 1 week earlier on the Silver Lake area than the Rhetts Island area, but the peak for both areas occurred during the last week of June and the first week of July. Thus, the peak of egg laying was similar to that reported in South Carolina (Bara 1976) and the Okefenokee Swamp (Metzen 1977) but slightly later than egg laying in Louisiana (Joanen 1969) and Florida (Deitz and Hines 1980).

The percentage of nests hatching each week on each study area is shown in Figure 1. The earliest hatching date for the Silver Lake area was 16 August and for the Rhetts Island area, 29 August. Latest hatching dates for the respective areas were 19 September and 23 September. During the 5 weeks in which hatching occurred, 80% of the Silver Lake nests hatched during the first 3 weeks, while 91% of the Rhetts Island nests hatched during the last 3 weeks of the period. Peak of hatching occurred during the first week of September on both areas.

Most successful nests showed evidence of the female alligator opening the nest to liberate the hatchlings. Two nests on the Silver Lake area were unsuccessful because the females failed to open the nests at hatching time.

In summary, there were no significant differences in nesting parameters between the 2 study areas, except for the distance nests were found from water. Predators destroyed a higher percentage of nests on Silver Lake, and the predation rate varied considerably from year to year on that study area. Nest initiation and hatching of eggs began approximately 1 week earlier at

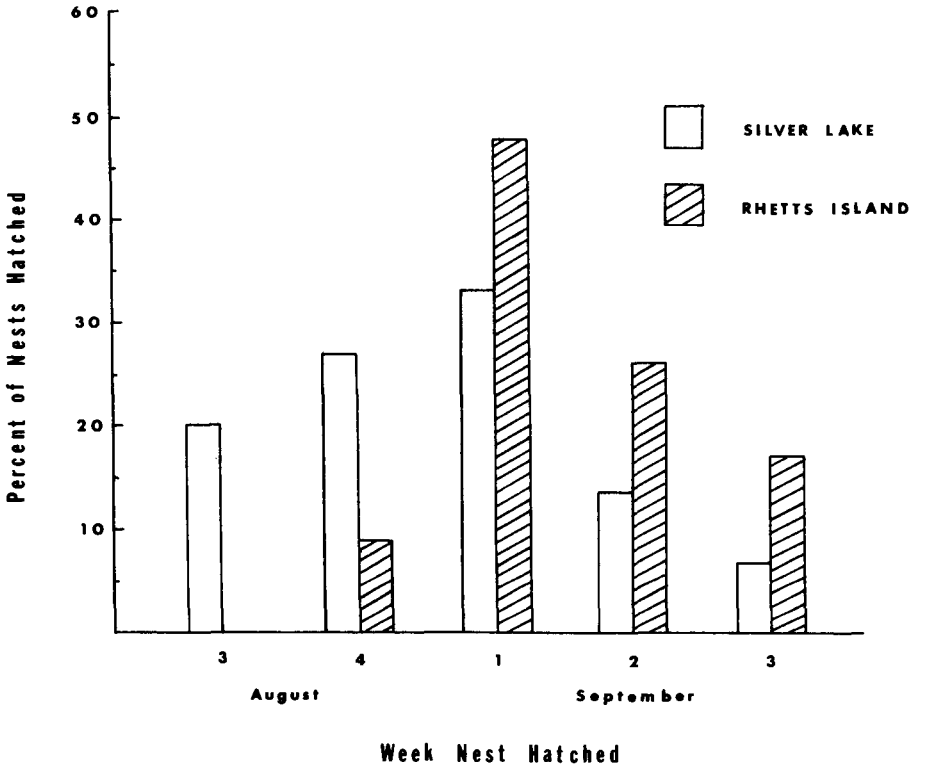

Figure 1. Percent of alligator nests hatched each week on the Silver Lake study area ($N = 15$), Decatur County, Georgia, 1981–83, and the Rhetts Island study area ($N = 23$), McIntosh County, Georgia, 1982–83.

Silver Lake, but the peak of hatching occurred during the first week of September on both areas.

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