The paddling activity causes the amplexed pair of frogs to surge forward, and it is clear that any longer sequence of this efficient swimming motion would draw the pair away from the spawn clump. Hence truncation is essential for the creation of a foam nest in Australian leptodactylids laying eggs in water. Conceivably a different technique is employed by the Australian species that create foam nests on land: species of *Heleioporus*, *Kyarranus* and *Philoria*, and it will be interesting to discover whether they resemble the South American foam nest constructors.

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USE OF AMERICAN ALLIGATOR NESTS BY NESTING TURTLES

Nest site selection by North American freshwater turtles has recently come under increasing study (e.g., Burger & Montevecchi, 1975; Plummer, 1976). These investigations have examined the importance of slope, vegetation and elevation as factors influencing the selection of nest sites by turtles that nest in sandy substrates. During our studies of reproduction of *Alligator mississippiensis* and several species of turtles in north Florida from 1974 to 1977, we noted extensive use of alligator nest mounds by nesting turtles. The presence of *Chrysemys nelsoni* eggs in alligator nest mounds has been reported by other workers (Carr, 1967; Goodwin and Marion, 1977); we extend these observations to *Trionyx ferox* and *Kinosternon subrubrum*, and provide data on frequency of occurrence.

A. mississippiensis nest mounds examined were located on Payne's Prairie State Preserve and on Orange and Lochloosa Lakes, Alachua Co., Florida. They were not extensively excavated by us to search for turtle eggs, and many were not opened at all (see Deitz and Hines, MS, for methods). Turtle nests in unopened nest mounds were usually noted only after exposure by predators; rarely did we actually observe nesting turtles. Consequently, we believe the incidences of turtle eggs presented in Table 1 to be substantial underestimates. This is underscored by observations of one nest which we did completely excavate after raccoons, *Procyon lotor*, had eaten or de-

TABLE 1. Incidence of turtle eggs in alligator nests.

Locality	Turtle Eggs Present			
	Nests opened by investigators		All Nests	
Payne's Prairie	18/41	(43.9%)	24/54	(44.4%)
Orange-Lochloosa Lakes	10/30	(33.3%)	16/58	(27.5%)
Total	28/71	(39.4%)	40/112	(35.7%)

stroyed the alligator eggs (Fig. 1); at least 216 turtle eggs, representing 15 clutches of *Chrysemys nelsoni* and one of *Trionyx ferox*, were deposited in this mound during a period of less than 4 weeks. The location and composition of this alligator nest did not appear unique in any respect. Multiple clutches were noted in several additional nest mounds, and the presence of numerous holes dug by raccoons after preying on other alligator nests also suggested that usage by turtles was extensive. We identified the turtle species in 22 of the 40 alligator nests containing turtle eggs. *C. nelsoni* eggs were present in 20 mounds (90.9%), *T. ferox* eggs in 3 (13.6%), and *Kinosternon subrubrum* eggs in one (4.5%). Adult female *K. subrubrum*, presumably nesting, were found in several other alligator nests but no associated eggs were found.
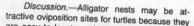

FIGURE 1. Top view of an alligator nest mound (Payne's Prairie, Florida); raccoons have exposed the alligator eggs (left center) and removed most of them. Further removal of the surface material by the authors revealed eight clutches of turtle eggs around the periphery of the mound. Four clutches had previously been removed from this mound by raccoons, and four more were later deposited. Length of the alligator eggs is approximately 75 mm.

Discussion.—Alligator nests may be attractive oviposition sites for turtles because they are easy to locate and once found provide adequate nesting material. Turtles following a path of least resistance from the water might be expected to use alligator trails frequently. These often lead to nests or basking areas, which are generally higher above water than other locations in a marsh. *A. mississippiensis* nests maintain a constant temperature of 29°–31°C, as high or higher than mean air and soil temperatures, and a constant high humidity (Chabreck, 1973, 1975); these conditions are highly favorable for incubation of *C. nelsoni* and *T. ferox* eggs as well as alligator eggs (D. Jackson, unpublished manuscript). The decaying vegetation of the nest mound is more easily excavated than the surrounding substrate. This may decrease the time necessary for nesting, thereby reducing the time of exposure of the female to terrestrial predators. On several occasions females of all three species were found completely buried in the alligator nest material. Deep burial of eggs would increase the effectiveness of the nest mound as an insulator. We noted that some turtles constructed nests in the substrate even when in the vicinity of an alligator nest. This was especially true of *Trionyx*, whose relatively low incidence of alligator nest utilization may reflect a preference for sandy soils.

Deitz and Hines (MS) have suggested that the presence of turtle eggs may increase raccoon predation on *A. mississippiensis* nests, perhaps by providing additional olfactory cues. Other predators may also be attracted. We observed an otter, *Lutra canadensis*, eating turtle eggs at one nest, and short-tailed shrews, *Blarina brevicauda*, eating eggs at another. Disturbance of the mound by turtles may occasionally have more direct negative effects; in one instance a nesting female *C. nelsoni* broke several alligator eggs and smeared yolk over the nest material. Female alligators may not always be tolerant of turtle intrusion. We recorded three instances of alligators driving *C. nelsoni* away from nests, and found dead adult female *C. nelsoni* (one gravid) by two other nests.

The restricted nesting season (late May through early September) of the American alligator dictates that only those species of turtles whose reproductive cycles coincide or overlap extensively with that of *A. mississippiensis* may utilize this strategy of nest site selection; in north Florida almost all nesting by *C. nelsoni* and *T. ferox* does coincide. In contrast, the nesting seasons of several other species that are locally sympatric with alligators (e.g., *Chrysemys floridana*, *C. scripta*, and *Deirochelys reticularia*) are primarily fall, winter, or spring (D. Jackson, unpublished manuscript). For the nesting turtle, an alligator nest mound is available principally from its time of construction to the time of its partial destruction by the attending alligator at hatching. Deterioration of the nest mound following the alligator hatch usually occurs fairly rapidly (before winter), leaving a residual

mound which is probably inferior in insulative and other protective qualities for turtle eggs. Old mounds may nonetheless serve as nest sites the following year (Carr, 1967). The marked temperature fluctuations (including probable freezing) of an exposed, above-ground nesting site during the winter would not be appropriate for turtles which utilize a winter nesting strategy (D. Jackson, unpublished manuscript). Because of the risk of destruction during nest-opening activities of the female alligator, the survivorship of turtle eggs laid in a nest mound late in the summer is presumably lower than that of eggs laid earlier. In this respect it is interesting to note that eggs of *C. nelsoni*, the most frequent user of alligator nests, may complete incubation in one of the shortest periods of any turtle—less than 50 days at 30°C (D. Jackson, unpublished manuscript).

Also found in alligator nests were eggs of *Farancia abacura* and *Anolis carolinensis* (once each), as well as several specimens of *Seminatrix pygaea* and *Nerodea cyclopion*.

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REPRODUCTION EGGS: FACTORS ASSOCIATED WITH INCUBATION AND HATCHING AND SUGGESTION FOR LABORATORY REARING.

Introduction.—The successful hatching of reptilian eggs depends upon many numerous factors. Ignorance or neglect of these factors permitting normal development of the embryos will result in mortality of the embryos. Because of such hatching failures, I have attempted to analyze the factors associated with incubation and hatching to improve laboratory incubation.

Three external factors affect incubation: temperature, moisture, and air circulation. Successful incubation requires a narrow range of temperature. If the temperature rise too high or fall too low, the embryo dies.

The range of acceptable moisture levels—both air and substrate—is some what broader, but the extremes are also lethal to the embryo, either through drowning or dehydration. The developing embryo require a continuous diffusion of air to avoid asphyxiation.

During incubation the leathery reptilian egg actually enlarges and gains weight. If the embryo dies, this process stops.

Structure of the Egg.—An egg is composed of a shell surrounding a reservoir of albumen, an air pocket, and the embryo and its yolk Fig. 1. Under natural conditions the reptilian egg is commonly placed in a substrate with a 6–8 percent moisture level and of sufficient porosity to permit air diffusion.

Shell.—The shell is a keratinous structure containing a reinforcement of approximately 35 percent calcium carbonate crystals. Towards the end of development, the embryo extracts the calcium carbonate from the shell to form bone. Thus the thickness of the shell decreases and its flexibility increases.

Albumen.—The egg albumen is a protein solution composed largely of albumins and globulines. At 25°C, the albumen has a specific weight of 1.192 g/cm^3. The albumen serves as a water attractant through vapor pressure and osmotic gradients.

According to the law of Raoult, the vapor pressure of a liquid is lowered relative to concentration of the solute(s):

$$\frac{\Delta P}{P_0} = \frac{P_0 - P_1}{P_0} = \delta_B$$

where Δp is the difference in vapor pressure, P_0 vapor pressure of pure solvent, P_1 vapor pressure of solution, and δ_B molarity of solution. Because P_0 and P_1 are temperature dependent, vapor pressure reduction is also temperature dependent. The water in the surrounding substrate contains fewer solutes, hence has a higher vapor pressure. The differential between the outside and the inside of the egg results in an inward flow of water vapor, controlled by the Maxwell and Boltzimann laws of diffusion:

$$m = \frac{K.A}{n} \cdot \Delta P$$

where m is the amount of diffused material, k diffusion coefficient, A surface area, and n molecular weight of solute. The diffusion of oxygen and water vapor is govern by these laws. The egg albumen also is responsible for the inward flow of liquid water by osmosis, since water will flow from an area of high water concentration to an area of low concentration. This water movement is controlled by the Van't Hoff law:

$$\pi V = nRT$$

where π is osmotic pressure, V volume of solution, R universal gas constant of solute, and T absolute temperature. For a generalized reptilian egg:

$$\pi = \frac{nRT}{V} = \frac{44000 * 8.314 * 298 * (98 * 10^{-6})}{5.07} = 2107 \text{ g/cm}^3$$

or approximately 30 PSI. Thus if an egg is exposed to excess moisture it will explode since the shell cannot withstand such a high pressure.

Yolk.—The yolk contains nearly all the fats and carbohydrates required for embryonic development. The embryo obtains water and oxygen from outside and releases carbon dioxide through respiration. The diffusion into and out of the egg are governed by the laws of diffusion and the diffusion pathway is through the albumen, air bubble, and shell. If air circulation around the egg is minimal or stopped, carbon dioxide becomes concentrated within and outside of the egg and oxygen diffusion slows and eventually stops resulting in the death of the embryo. Table 1 shows the concentration of CO_2 in natural nest.

Air bubble.—The air bubble controls the exchange of oxygen and carbon dioxide. It also acts as a pressure regulator, since gas is compressible but not liquids.

TABLE 1.

	Normal Air	Air in the Soil	Air in the Soil but Around the Nest
Carbonic acid	0.033 ± 0.001	0.12 ± 0.02	2.24 ± 0.06
Oxygen	20.946 ± 0.002	20.63 ± 0.03	18.40 ± 0.06
Nitrogen	79.021 ± 0.004	79.25 ± 0.05	79.36 ± 0.12