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# SOME ASPECTS OF THE BREEDING BIOLOGY OF THE SNAIL KITE IN FLORIDA

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Abstract.—The breeding biology of the Snail Kite was studied in Florida from 1968–1977 and intermittently from 1978–1980. Breeding occurred every month, but not in the same year. Peak egg-laying occurred from February through April or generally about 81 d before the onset of the rainy season in mid- or late May. Courtship displays, copulation, and duration of copulation are described. Mean egg-laying interval was 2.2 d, and clutch size ranged from 1–6 eggs ($\bar{x}$ = 2.92). The frequency of large clutches (4–6 eggs) was significantly greater before 1940 than after. Incubation, which was shared by both sexes, lasted 24–30 d ($\bar{x}$ = 27.4). Egg length and breadth, eggshell thickness and weight, and whole egg volume and weight are presented. Hatching success was 57.5%. Mean hatching success for all clutches was 1.7 young or 2.3 per successful clutch. Hatching success of 2- and 3-egg clutches did not differ significantly. The nestling period averaged 28.7 d (range 23–34). The interval between fledging of the first and last nestling in 1 brood was up to 5 d. An average of 2.0 young were raised per successful nest, and 50.5% of the nests were successful. The mean percent of successful nests per year for the 11-yr period (excluding the drought year 1971 in which there was no nesting) was 56.5 (range 17.1–84.6/yr). Nestling mortality was 37% overall, but was less during favorable high water conditions. Twenty-two factors are identified as causing nesting failure in kites, principal among these was predation (44%).

**ASPECTOS DE LA REPRODUCCIÓN DE *ROSTRHAMUS SOCIABILIS PLUMBEUS* EN FLORIDA**

Sinopsis.—Desde 1968 a 1977 y luego de forma interrumpida de 1978 a 1980, se estudió la biología reproductiva de *Rostrhamus sociabilis plumbeus* en Florida. El ave aova en cualquier mes, pero no a traves del mismo año. El pico de la puesta de huevos ocurre de febrero a abril; por lo general 81 d previo al comienzo de la época de lluvia que ocurre en mayo. El intérvalo promedio entre la puesta de huevos resultó ser 2.2 d y la camada varió de 1–6 huevos ($\bar{x}$ = 2.92). La frecuencia de camadas grandes (4–6 huevos) resultó ser significativamente major previo a 1940, que después de esta fecha. La incubación llevada a cabo por ambos sexos, tomó de 24–30 d ($\bar{x}$ = 27.4). El 57% de los huevos eclosionaron. El éxito de eclosionamiento fue de 1.7 polluelos para todas las camadas y 2.3 por camada exitosa. El éxito de eclosionamiento de camadas de 2 o 3 huevos, no fue significativamente diferente. Los polluelos permanecieron en el nido de 23–34 d ($\bar{x}$ = 28.7). El intérvalo entre volar el primero y el último polluelo fue mayor de 5 d. El 50% de los nidos fueron exitosos y produjeron un promedio de 2 pichones. En 11 años de trabajo (excluyendo 1971 que fue un año extremadamente seco) el éxito de los nidos varió de 17.1 a 84.6% ($\bar{x}$ = 56.5%). La mortalidad de los polluelos fue de 37% aunque menor en años con niveles altos de agua. Se identificaron 24 factores de mortalidad, siendo el principal la depredación (44%).

The first nest of the Snail Kite (*Rostrhamus sociabilis plumbeus*) was found in Florida on 28 February 1870 near the headwaters of the Miami River (in what was then the Everglades and is now downtown Miami) by Charles J. Maynard (Baird et al. 1874, Maynard 1881). While much of the breeding biology of the Snail Kite has been described, many gaps persist (Bailey 1884; Baird et al. 1874; Bendire 1892; Bent 1937; Brown and Amadon 1968; Chandler and Anderson 1974; Haverschmidt 1970; Howell 1932; Maynard 1881; Nicholson 1926; Sprunt 1942, 1945, 1947; Stieglitz and Thompson 1967; Sykes 1979; Townsend 1927). This paper expands our knowledge of the breeding biology and presents an overview of the bird's reproduction to include: breeding season and its relationship to annual hydric cycles, courtship and mating behavior, clutch size, egg laying, incubation, egg characteristics, hatching, length of nestling period, reproductive success, and reasons for nesting failure.

## METHODS

I studied Snail Kites in Florida from 1968 through 1977 and intermittently from 1978 through 1980. The primary objective was to gather information pertinent to more effective management since the species is considered endangered within the United States (Committee on Rare and Endangered Wildlife Species 1966). Principal study areas were the headwaters of the St. Johns River, the Savannas, marshes on the west side of Lake Okeechobee, Loxahatchee National Wildlife Refuge, Conservation Area 2A (CA2A), and Conservation Area 3A (CA3A) (see Sykes 1979, 1983a, 1984).

Reproductive information was compiled from 427 nests and egg sets (museum material 148, this study 266, literature 13). Data from 1883 through 1967 were obtained from egg sets in collections at 25 institutions (Sykes 1984) and from the literature. The data span 1883 intermittently through 1967 and annually from 1968 through spring 1978. Breeding success was not determined for 1979 and 1980 in this study. Together with data from this study, egg sets provided information on locality, state of incubation, clutch size, and date of collection and were used to determine approximate dates of egg laying. I used extreme caution in treatment of the old egg data to avoid biases and mistakes by egg collectors. I was unable to determine which months egg laying began for several hundred clutches. Linear measurements of eggs were made with a vernier caliper to the nearest 0.1 mm. Eggshell thickness was measured by inserting a modified micrometer through the hole drilled by the collector at the equator of the shell. Three readings to the nearest 0.001 mm were taken of each egg and averaged. All measurements of eggshell thickness included the shell membrane.

Eggshells and whole eggs were weighed with a triple-beam balance to the nearest 0.1 g. Eggshell material collected after 1968 was air dried and weighed in an air conditioned room. Eggshell thicknesses and weights from pre- and post-DDT periods were compared. Whole egg volume was determined by the water displacement method in a graduated beaker and measured to the nearest cubic centimeter. Daily or alternate day observations were made at selected sites to determine start of courtship and nest building activities. Nests were located by systematic searching and watching adult behavior (i.e., carrying nesting materials, etc.). Activities at nests were observed from blinds placed 8–10 m from the nests and from a distance using a 30× spotting scope on an airboat or vehicle on dikes in the marshes. Nests ($N$ = 266) were checked at intervals of 4–8 d to determine nesting success and causes of failure, and selected others ($N$ = 21) were checked every 1–3 d to determine the lengths of incubation and nestling periods. Eggs at selected nests, from the time laid, were numbered with soft graphite pencil at each end for identification. The normal approximation to Chi-square (Steel and Torrie 1980) was used to test the difference ($Z$ value) in clutch sizes.

Rainfall and temperature data were adapted from Thomas (1974). Water levels are not shown for CA2A after 1971 as no nesting was recorded in that area after 1970 (Sykes 1979). Water level data were adapted from Monthly Report of Operations of the Central and Southern Florida Flood Control Project (U.S. Army Corps of Engineers 1968–1978).

## RESULTS AND DISCUSSION

### *Breeding Season*

Howell (1932) noted that breeding seasons began as early as January, but usually in late February, and extended to the middle of June. Bent (1937) listed egg dates from 15 February to 20 July ($N$ = 68), and Sprunt (1942) first reported fall nesting. From 1968 to 1976, breeding occurred every month (Table 1), but not in the same year. Egg laying generally began 10–30 d after the start of courtship and nest building activities.

Peak egg laying months (Table 1) were February, March, and April (67.4%; $N$ = 198 clutches), with substantial activity in January (11.6%) and May (8.2%). The least nesting activity occurred in July–September (1.3%). Breeding pairs at the same locality are asynchronous, therefore kites near each other may be building a nest, laying or incubating eggs, or caring for nestlings or fledgings. The start of breeding activities in Florida varied year to year. Peak egg laying generally occurred 81 d (95% CI = 61–101 d) before the rainy season began in mid to late May (Table 2, Fig. 1). In some years, autumn breeding began in the latter part of the rainy season in October or early November. Most breeding activity took place during the cooler months since higher temperatures and the rainy season occurred during late spring to mid fall (Thomas 1974). In Surinam the breeding season is January–July and coincides with the rainy season (Haverschmidt 1970).

### *Courtship and Mating*

Snail Kite courtship advertisement has been partly described (Bent 1937, Haverschmidt 1970, Stieglitz and Thompson 1967, Townsend 1927). Most displaying was by males. These displays took place throughout the day, in the air or at a perch, and close to the nesting site. Aerial displays frequently included stick carrying in the bill and vocalizations. The stick may be dry or with green leaves and several males may display

TABLE 1. Clutches begun by month.

| Month | This study | | Combined[a] | |
|---|---|---|---|---|
| | No. of clutches | % | No. of clutches | % |
| Jan | 26 | 16.7 | 34 | 11.6 |
| Feb | 35 | 22.4 | 67 | 22.8 |
| Mar | 36 | 23.1 | 66 | 22.5 |
| Apr | 21 | 13.5 | 65 | 22.1 |
| May | 10 | 6.4 | 24 | 8.2 |
| Jun | 5 | 3.2 | 12 | 4.1 |
| Jul | 1 | 0.6 | 1 | 0.3 |
| Aug | 2 | 1.3 | 2 | 0.7 |
| Sep | 1 | 0.6 | 1 | 0.3 |
| Oct | 5 | 3.2 | 5 | 1.7 |
| Nov | 9 | 5.8 | 11 | 3.7 |
| Dec | 5 | 3.2 | 6 | 2.0 |
| Total | 156 | 100 | 294 | 100 |

[a] Data from museum material (1881–1964) and this study.

simultaneously. Courtship flights occurred at heights up to 300 m, but were usually 100 m or less above the marsh. Most displays lasted 1–5 min, however, Stieglitz and Thompson (1967) reported one that lasted nearly an hour.

Six types of aerial displays were observed with some individual variation. Usually only one maneuver occurred per display but sometimes they were in combination (8%).

*Undulating flight.*—In undulating flight ($N$ = 346, 64% of displays), the bird flew upward from the horizontal at an angle of 40° or less, then partly folded the wings and dived at an angle less than 40°. The dive was checked abruptly, and the cycle repeated, often up to 6 times. The amplitude usually ranged from 10–30 m.

*Slow flight.*—Slow flight ($N$ = 109, 20%) was performed at a height of 30 m or less. In this display, wing beats were slowed, and the depth of the downstrokes was exaggerated with a slight hesitation at the lowest point of the stroke.

*Pendulum.*—The pendulum ($N$ = 36, 7%) was a shallow dive with some wing flapping followed by a tight turn and the process repeated.

*Mutual soaring.*—Mutual soaring ($N$ = 28, 5%) by a male and prospective mate consisted of the pair flying parallel close together, while executing dives, turns, rolls, etc.

*Tumbling.*—In tumbling ($N$ = 17, 3%), the bird dived with wings partly folded and turned completely over end-to-end several times before checking the descent and leveling off.

*Grappling.*—In grappling flight ($N$ = 7, 1%), the kite rolled or turned its body to the side with the feet outstretched. This was performed by a lone male or a male with a prospective mate.

TABLE 2. Distribution of clutch sizes by month egg laying began.

| Clutch size | Number of clutches | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Total | % |
| 1 | 1 | | | | | 1 | | | | | | | 2 | 0.9 |
| 2 | 5 | 7 | 7 | 12 | 3 | 1 | | | | | | | 35 | 14.9 |
| 3 | 24 | 45 | 42 | 39 | 13 | 7 | | | | | | 2 | 172 | 73.2 |
| 4 | 1 | 3 | 6 | 3 | 3 | | | | | | | | 16 | 6.8 |
| 5 | | 1 | 5 | 1 | 2 | | | | | | | | 9 | 3.8 |
| 6 | | | | | 1 | | | | | | | | 1 | 0.4 |
| Total | 31 | 56 | 60 | 55 | 22 | 9 | | | | | | 2 | 235 | 100 |
| % | 13.2 | 23.8 | 25.6 | 23.4 | 9.3 | 3.8 | | | | | | 0.9 | 100 | — |

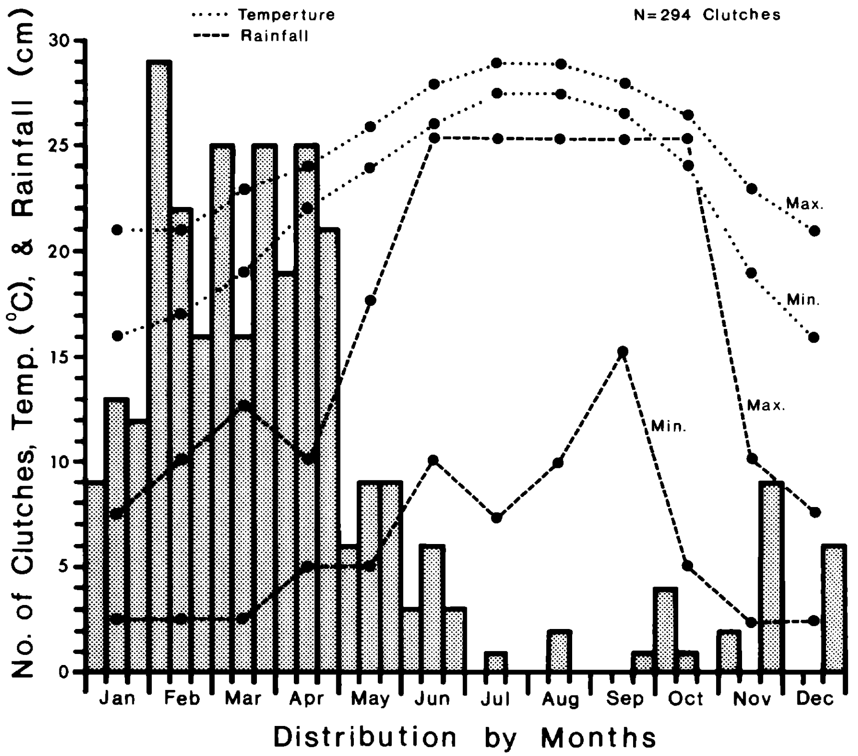


FIGURE 1. The onset of egg laying for the Snail Kite by months in relation to range of mean monthly rainfall and temperature in South Florida.

In non-aerial displays ($N$ = 41) the male flew from perch to perch with a stick in his bill close to a female and occasionally perched beside her. Posturing and vocalizations frequently occurred between male and female.

Once the pair bond was established, mating activity ensued. The receptive female perched in a tree, bush, on an exposed dead snag, or at the nest. Greeting calls sometimes were exchanged. Male pre-copulatory behavior included courtship feeding of an extracted apple snail (*Pomacea paludosa*) or presenting a small twig. In mating, the female crouched with tail tilted slightly to one side. The male mounted from the rear while holding onto her back feathers with his talons. He positioned the rear of his body and tail at a downward angle, at which time copulation took place. Copulation lasted 3–30 s ($\bar{x}$ = 17, SE = 4.0, $N$ = 22), after which the male generally flew away. I do not know if brief copulations were successful or how many copulations were required to fertilize a full clutch of eggs. Copulations were observed from the early stages of nest construction through laying of eggs.

Copulation took place during early incubation if the clutch was not yet completed. This was observed at 1112 h on 8 February 1974 in a nest containing 2 eggs (the full clutch for this nest was 4 eggs). Copulation by the pair was repeated at 1236, 1559, and 1834 h.

*Clutch Size*

Clutch size in Florida is 1–6, with 3 eggs being the most frequent (Bendire 1892, Howell 1932, Maynard 1881). The clutch size is reported to be 2 and 3 in Argentina (Bendire 1892) and Surinam (Haverschmidt 1970) respectively. Mean clutch size in this study was 2.92 (Table 3). The number of 1-egg clutches (3%) may be low because some pre-1968 egg sets had insufficient data to determine whether the clutch was 1-egg or simply incomplete; these questionable clutches were not used.

Large clutches (4, 5, and 6 eggs; $N = 26$) were significantly more frequent ($Z = 3.37$, $P < 0.001$) for the pre-1940 period (Table 3). Although 4 and 5-egg clutches were once fairly common, I found only one 4-egg clutch in my study and know of one other (R. Chandler, pers. comm.) among 266 clutches. This post-1940 reduction is probably related to habitat decline (Sykes 1983a).

*Egg Laying*

Eggs usually are laid between dawn and 1000 h based on 5 clutches. Eighteen 3-egg clutches (January–June) had a mean laying interval of 2.2 d (SE = 0.08) and a range of 2–3 d. The laying interval was the same within a single clutch. Chandler and Anderson (1974) reported laying intervals of 2–4 d for kites with 3-egg clutches at Lake Okeechobee.

*Incubation*

Both sexes shared incubation duties. The changeover of such duties took place on or near the nest. On occasion, the incubating bird left the nest before its mate arrived, leaving the eggs unattended for 1–3 min. The usual call at the changeover was a soft, "ku-wak," given once or twice by one or both members of the pair. The female sometimes gave a low short series of "kaa-kaa-kaa."

Both males and females frequently brought a dry stick, a green twig with leaves, or other material to the nest. Nesting material was given to the mate to arrange on the nest or placed on the structure by the incoming bird. Males often fed extracted apple snails to incubating females. The presentation of gifts usually accompanied changeover of incubating duties. Stick-giving behavior by the male has also been reported in Surinam (Haverschmidt 1970). During the changeover of incubating duties or upon arrival of the male with nesting material, the female on occasion nibbled the base of the male's bill, head, or neck feathers. The presentation of gifts and nibbling behavior may have helped reinforce the pair bond.

TABLE 3. Clutch size by decades.

| Decade | $N$ | $\bar{x}$ | SE | Range in clutch size |
|---|---|---|---|---|
| 1881–1890 | 2 | 3.00 | 1.00 | 2–4 |
| 1891–1900 | 21 | 3.24 | 0.26 | 1–5 |
| 1901–1910 | 12 | 3.33 | 0.59 | 2–5 |
| 1911–1920 | 43 | 3.23 | 0.12 | 1–5 |
| 1921–1930 | 47 | 3.00 | 0.10 | 2–6 |
| 1931–1940 | 8 | 2.88 | 0.68 | 2–4 |
| 1941–1950 | 3 | 2.67 | 1.49 | 2–3 |
| 1951–1960 | 6 | 2.67 | 0.56 | 2–3 |
| 1961–1970 | 31 | 2.87 | 0.11 | 2–3 |
| 1971–1980 | 140 | 2.75 | 0.04 | 2–4 |
| Total | 313 | 2.92 | 0.04 | 1–6 |

One member of a pair incubated through the night while the other slept nearby or at a communal roost (pers. obs.). The female tended to assume the night shift ($N$ = 200+ observations), but at 3 nests on 8 occasions males were found incubating through the night. Incubation at night by the male is known for only a few raptors (Brown and Amadon 1968). The first changeover of incubating duty for the day took place within an hour after dawn and the relieved bird flew off to hunt (pers. obs.). The mean diurnal incubation interval was 58 min (range 3–299 min, $N$ = 57). There was no significant difference ($P > 0.5$) in the incubation interval between members of a pair ($N$ = 3); males incubated for an average of 60 min (SE = 12.5, $N$ = 28) and females for 55 min (SE = 8.5, $N$ = 29). During diurnal incubation, the attending individual slept, rearranged nesting materials, preened, called, watched birds and aircraft flying over, turned eggs, or changed incubating position. Incubating posture was with the head erect, head lowered with tail higher than head, or head lowered with the chin resting on rim of the nest. The number of changes ($N$ = 50) in incubating position was 1–25 per incubating interval and averaged 5.3 (SE = 0.7). Incubating position changes averaged every 11.5 min (SE = 0.76, range 1–100, $N$ = 262). Incubating birds faced in any compass direction with the orientation independent of wind direction.

Eggs were turned 1–3 times per day ($N$ = 16 observations); females turned eggs more frequently (87.5%, $N$ = 14, 3 pairs) than males. Egg turning was accomplished in 1–3 min and usually occurred before noon (93%).

Incubation averaged 27.4 d (SE = 0.1, range 24–30 d, $N$ = 21 nests). The incubation period at Lake Okeechobee was 26–28 d (Chandler and Anderson 1974), whereas for captive *R. s. sociablis* from Argentina at Patuxent Wildlife Research Center, Laurel, Maryland, it ranged from 24–26 d (G. F. Gee, pers. comm.). Incubation started anytime after the first egg was laid but generally after the second was deposited.

### *Egg Characteristics*

The eggs are usually oblong oval in shape, although some tend to be elliptical. The shell surface is smooth and dull, and the ground color is dull white with variable markings (Fig. 2, also see Bent 1937). Intensity of brown pigments varied between and within clutches.

Bent (1937) listed an average length of eggs of 44.2 mm and breadth of 36.2 mm ($N$ = 65). These measurements correspond closely with my larger sample ($N$ = 317, Table 4). Eggshell thickness is variable in the same egg and between eggs. Shell weight is perhaps a better indicator of any biological problem (Anderson and Hickey 1972, Hickey and Anderson 1968, Porter and Wiemeyer 1969, Ratcliffe 1967). No significant difference was found for eggshell weights ($t = 0.53$, $P > 0.6$) for the pre- (1944 and earlier) and post-DDT (1945 and later) periods.

The mean fresh egg weight was 31.7 g ($N$ = 23). The mean loss of egg weight (primarily water loss) during incubation was 16.3%, similar to most birds (Rahn and Ar 1974). The nests were built over water and the nest bowls lined with green materials which insured a more uniform high relative humidity and probably helped minimize water loss from the eggs.

### *Hatching*

Hatching was asynchronous. The interval between hatching of successive eggs within a clutch ranged from less than a day up to 6 d. The nestling can be heard calling within the egg 24–48 h prior to hatching and emerges 6–14 h ($\bar{x}$ = 8.2, SE = 1.0, $N$ = 9 eggs, 8 clutches) after the egg is first pipped.

In Florida from 1968 through 1978, hatching success was 57.5% (Table 5). Chandler and Anderson (1974) reported hatching success of 53.7% for kites at Lake Okeechobee. Kites averaged 2.3 chicks per nest at hatching in clutches where one or more eggs hatched, but 39 of 127 nests failed. Where at least one egg hatched, 2% hatched 1 egg, 13% 2 eggs, and 85% 3 eggs. In the only 4-egg clutch I observed, 3 eggs hatched.

Hatching success by clutch size and month is summarized in Table 6. There was no significant difference ($P > 0.4$) in hatching success between 2- and 3-egg clutches. Other clutch sizes were too few for comparison. The months with the largest number of successful hatches were March (31%), April (23%), and February (19%).

### *Nestling Period*

The nestling period as used in this paper is the period extending from hatching to fledging. Nestling periods ranged from 23–34 d with a mean of 28.7 d. In the same brood, the interval between fledging of the first and last nestling was up to 5 d ($\bar{x}$ = 2.3, SE = 0.2, $N$ = 20) and may have been longer in a few cases. The interval between fledging of siblings appears to be independent of brood size. The attentiveness of individual pairs in care of young varied widely.

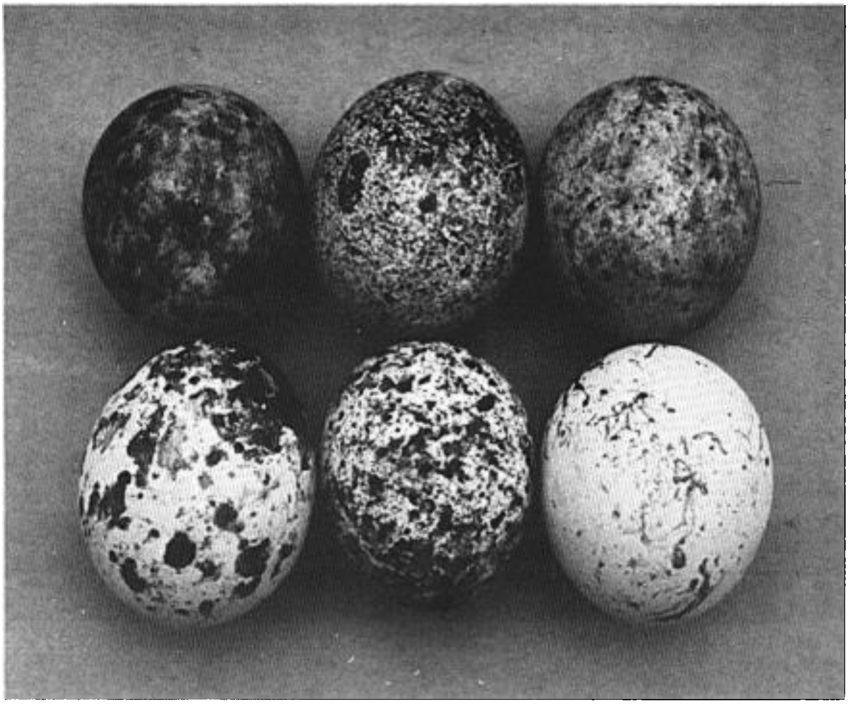

FIGURE 2. Snail Kite eggs from Florida showing variation in markings.

*Breeding Success*

From 1968–1978, 50.0% of the nests (102 of 204) were successful, and fledged 201 young or 2.0 (range 1.4–2.5) young per successful nest or 0.99 young for all nests in which one or more eggs were laid. In a smaller more limited study at Lake Okeechobee 1966–1973, 82 eggs were laid, 44 hatched (53.7%), and 31 young fledged (37.8%) (Chandler and Anderson 1974). Mean annual nesting success for the 11-yr period, excluding the drought year of 1971 when no breeding was recorded, was 56.5% (range 17.1–84.6).

Brown and Amadon (1968) and Newton (1979) showed that breeding success is usually less than 50% among Falconiformes but varies widely. The range of success rates for the Snail Kite in Florida was within this norm. The year-to-year variation appears to be due to environmental variability. Breeding success was lowest in the dryer years (Fig. 3; also see Sykes 1983b) and highest during wetter times when food was more abundant and predation lower (Sykes 1987, unpubl. data). A breeding success between 40–50% (see Table 7) is probably adequate to maintain the species in Florida. Nestling mortality from 1968–1978 was 37%. The kite population increased significantly from 81 to 651 birds ($r = 0.981$, $P < 0.001$) between 1974 and 1980 under favorable habitat conditions

TABLE 4. Measurements of Snail Kite eggs from Florida.

| Parameter | *N* | No. of clutches | x̄ | SE | Range: For total sample Max. | Range: For total sample Min. | Range: Within same clutch Max. | Range: Within same clutch Min. |
|---|---|---|---|---|---|---|---|---|
| Length (mm) | 317 | 117 | 44.6 | 0.087 | 50.5 | 40.2 | 49.2 | 44.1 |
| Breadth (mm) | 317 | 117 | 36.1 | 0.060 | 38.7 | 33.0 | 38.0 | 34.2 |
| Eggshell thickness (mm) | 193 | 77 | 0.267 | 0.002 | 0.360 | 0.210 | 0.340 | 0.250 |
| Pre-1945 | 151 | 50 | 0.264 | 0.003 | 0.360 | 0.210 | 0.340 | 0.250 |
| 1945 and later | 42 | 27 | 0.276 | 0.004 | 0.323 | 0.213 | 0.280 | 0.220 |
| Eggshell weight (g) | 84 | 37 | 2.3 | 0.024 | 3.0 | 1.9 | 3.0 | 2.2 |
| Pre-1945 | 61 | 20 | 2.3 | 0.032 | 3.0 | 1.9 | 3.0 | 2.2 |
| 1945 and later | 23 | 17 | 2.3 | 0.027 | 2.5 | 1.9 | 2.4 | 2.2 |
| Whole egg weight (g) | | | | | | | | |
| Fresh or incubation just begun | 23 | 8 | 31.7 | 0.357 | 35.6 | 26.8 | 31.6 | 26.8 |
| Incubation half complete or more | 16 | 7 | 28.6 | 0.276 | 31.4 | 26.0 | 29.0 | 26.0 |
| Near hatching | 9 | 5 | 26.5 | 0.443 | 28.8 | 24.4 | 28.5 | 25.7 |
| Whole egg volume (cc) | 14 | 11 | 31.6 | 0.522 | 36 | 29 | 36 | 32 |

TABLE 5. Hatching success (number and percentage) for the Snail Kite in Florida.

| Category | Clutch size | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 egg | | 2 egg | | 3 egg | | 4 egg | | | |
| | # | % | # | % | # | % | # | % | # | % |
| Nests | | | | | | | | | | |
| Sample total | 2 | 1.6 | 23 | 18.1 | 101 | 79.5 | 1 | 0.8 | 127 | 100 |
| Number successful | 2 | 100 | 11 | 48 | 74 | 73 | 1 | 100 | 88 | 69 |
| Number in which no eggs hatched | 0 | 0 | 12 | 52 | 27 | 27 | 0 | 0 | 39 | 31 |
| Number in which 1 egg hatched | 2 | 100 | 1 | 4 | 10 | 10 | 0 | 0 | 13 | 10 |
| Number in which 2 eggs hatched | | | 10 | 43 | 24 | 24 | 0 | 0 | 34 | 27 |
| Number in which 3 eggs hatched | | | | | 40 | 40 | 1 | 100 | 41 | 32 |
| Number in which 4 eggs hatched | | | | | | | 0 | 0 | 0 | 0 |
| Eggs | | | | | | | | | | |
| Number laid | 2 | 0.6 | 46 | 13 | 303 | 85.3 | 4 | 1.1 | 355 | 100 |
| Number that hatched | 2 | 100 | 21 | 46 | 178 | 59 | 3 | 75 | 204 | 57.5 |
| Mean that hatched for all nests | 1.0 | | 0.9 | | 1.8 | | 3.0 | | 1.7 | |
| Mean that hatched per successful nest | 1.0 | | 1.9 | | 2.4 | | 3.0 | | 2.3 | |

TABLE 6. Hatching success by clutch size and month of hatching for the Snail Kite in Florida.[a]

| Mo of hatching[b] | Clutch size[c]: 1 | | 2 | | 3 | | 4 | | 6 | | Unknown | | Total successful clutches | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | S | U | S | U | S | U | S | U | S | U | S | U | # | % |
| Jan | | | | | 4 | | | | | | 4 | | 8 | 6 |
| Feb | | | 2 | | 16 | 4 | | | | | 5 | | 23 | 19 |
| Mar | 1 | | 6 | 2 | 22 | 4 | 1 | | | | 8 | 2 | 38 | 31 |
| Apr | | | 2 | 1 | 20 | 5 | | | | | 7 | | 29 | 23 |
| May | 1 | | | 3 | 6 | 9 | | | | 1 | 4 | 1 | 11 | 9 |
| Jun | | | 1 | | 7 | 2 | | | | | 1 | 2 | 9 | 7 |
| Jul | | | | | | | | | | | | 1 | 0 | 0 |
| Sep | | | | | | | | | | | 1 | | 1 | 1 |
| Oct | | | | | | | | | | | 1 | | 1 | 1 |
| Nov | | | | | | | | | | | 2 | | 2 | 2 |
| Dec | | | | | 1 | | | | | | | | 1 | 1 |
| Total | 2 | 0 | 11 | 6 | 76 | 24 | 1 | 0 | 0 | 1 | 33 | 6 | 123 | 100 |
| % within clutch size | 100 | 0 | 65 | 35 | 76 | 24 | 100 | 0 | 0 | 100 | 85 | 15 | 77 | — |
| % overall | 1 | 0 | 7 | 4 | 47 | 15 | 1 | 0 | 0 | 1 | 20 | 4 | — | 100 |

[a] A successful clutch(es) has one or more hatched eggs. U = unsuccessful clutches.
[b] No data for hatching in August.
[c] No data for clutch size of 5.

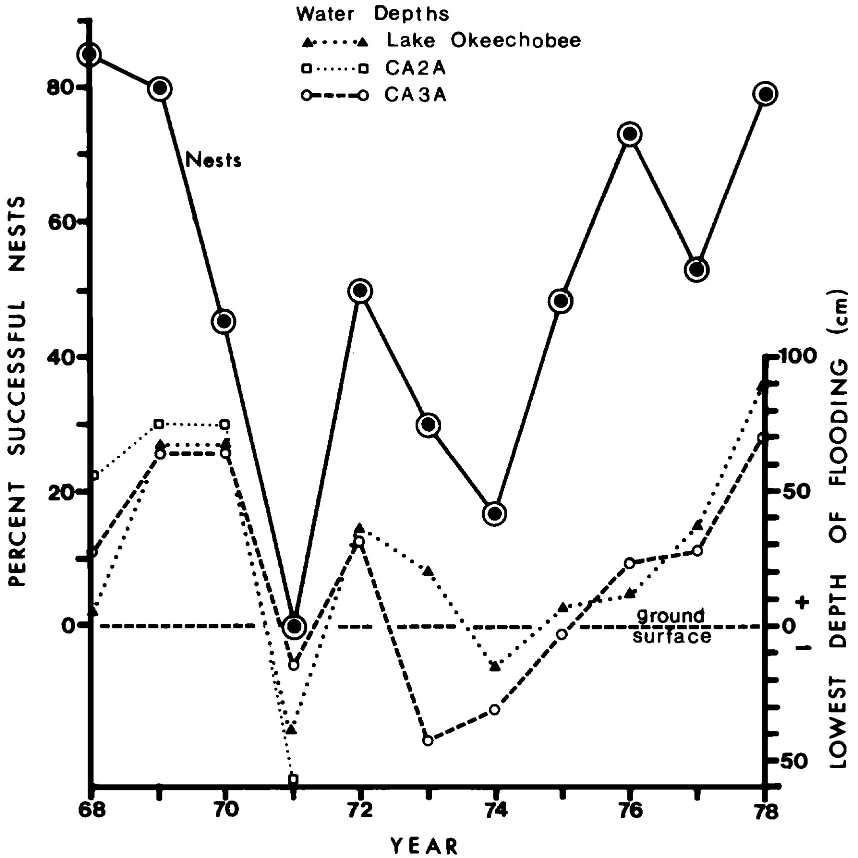


FIGURE 3. Relationship of successful nesting (%) by the Snail Kite in Florida per year with the lowest depth of marsh flooding at the end of the annual dry season, late April–early May, at three principal breeding areas.

of high water levels at Lake Okeechobee and in CA3A (Sykes 1983b). The greater abundance of snails during this period of favorable conditions was probably the reason for the lower nestling mortality.

The kite's breeding season was timed to take advantage of increasing seasonal water levels in Florida's marshes and avoid the period of intense local summer storms with heavy rains and strong winds. Most young had fledged when the rainy season commenced in May and water levels began to rise. Apple snail activity and abundance increased to a high level in April and continued through summer and early fall (Hanning 1978, pers. obs.). Thus, the kite's prey was more active, widespread, and available at the time when most juvenile kites are learning to hunt and become self-sufficient.

TABLE 7. Breeding success of the Snail Kite in Florida 1968–1978.[a]

| | Nests | | Young | |
|---|---|---|---|---|
| Year | Successful | Percent successful | Total number fledged | Fledged per successful nest[b] |
| 1968 | 11 | 84.6 | 24 | 2.2 |
| 1969 | 8 | 80.0 | 13 | 1.6 |
| 1970 | 8 | 44.4 | 12 | 1.5 |
| 1971[c] | — | — | 0 | — |
| 1972 | 3 | 50.0 | 7 | 2.3 |
| 1973 | 12 | 35.3 | 29 | 2.4 |
| 1974 | 6 | 17.1 | 11 | 1.8 |
| 1975 | 14 | 48.3 | 35 | 2.5 |
| 1976 | 22 | 73.3 | 30 | 1.4 |
| 1977 | 8 | 53.3 | 20 | 2.5 |
| 1978 | 11 | 78.6 | 20 | 1.8 |
| Total | 103 | 50.5 | 201 | 2.0 |

[a] Incorporates 1968–1976 data (Sykes 1979) but excludes nests placed in nesting structures at Lake Okeechobee (Sykes and Chandler 1974, Roderick Chandler pers. comm.).
[b] Only those nests in which the exact number of young fledged was known were used to derive these figures.
[c] Severe drought conditions throughout peninsular Florida; no nesting attempts observed.

*Reasons for Nesting Failure*

Nesting failure resulted from predation, adverse weather, weak nesting substrate, human disturbance, and miscellaneous causes (Table 8). Between 1968 and 1978, 14 false starts (4% of the nesting attempts observed) were recorded (not included in Table 8). In 13 cases, nests were never completed and in one, the nest was completed but no eggs laid. Only 4 cases of nest desertion were observed, all contained eggs. The reasons for desertion were not determined. For the documented nesting failures ($N$ = 81), 67% contained eggs and 33% nestlings. If the nest failed, particularly during the egg stage or early in the nesting season ($N$ = 9), the birds usually renested. This was determined from color banded individuals and recognition of a few unmarked birds by plumage characteristics.

Most predation (58%) was not traceable to specific predators, but I suspect that the Everglades rat snake (*Elaphe obsoleta rossalleni*) was responsible for many of the losses (Table 8). Snakes will on occasion attempt to ingest nestlings that are too large for them to swallow. In two such cases, the nestlings probably suffocated, as the feathers of the head and neck were matted with mucous from the snake's mouth while the remainder of the plumage was in the normal dry condition. The Everglades rat snake is widespread in southern Florida (Carr and Goin 1959), highly arboreal, and one of the most common snakes in the nesting habitats of the kite (pers. obs.).

Nestlings at two nests at Loxahatchee National Wildlife Refuge may

TABLE 8. Factors responsible for nesting failure.

| Decimating factor | % of total mortality | % of mortality within category | Number of nests: Contents at time of failure: Eggs | Number of nests: Contents at time of failure: Young | Number of nests: Contents at time of failure: Eggs or young | Number of nests: Total |
|---|---|---|---|---|---|---|
| Predation | 44 | | | | | 36 |
| Unknown predator | | 58 | 18 | 3 | | 21 |
| Everglades rat snake (*Elaphe obsoleta*) | | 17 | 3 | 3 | | 6 |
| Probably Everglades rat snake | | 8 | 2 | 1 | | 3 |
| Fish Crow (*Corvus ossifragus*) | | 5 | 5 | | | 2 |
| Crow, species undetermined | | 3 | 1 | | | 1 |
| Cottonmouth moccasin (*Agkistrodon piscivorus*) | | 3 | 1 | | | 1 |
| Probably cottonmouth mocassin | | 3 | 1 | | | 1 |
| Ant (*Crematogaster atkinsoni*)[a] | | 3 | 1 | | | 1 |
| Adverse weather | 22 | | | | | 18 |
| Strong winds without rain | | 55 | 7 | 3 | | 10 |
| Long period of heavy rain | | 22 | 1 | 3 | | 4 |
| Low temperatures | | 11 | 2 | | | 2 |
| Heavy rain with hail | | 6 | | 1 | | 1 |
| Heavy rain with strong winds | | 6 | | 1 | | 1 |
| Weak nesting substrate | 16 | | | | | 13 |
| Nest fell down | | 100 | 10 | 3 | | 13 |
| Human disturbance | 9 | | | | | 7 |
| Fire set by humans | | 57 | | 3 | 1 | 4 |
| Airboats | | 29 | 2 | | | 2 |
| Activity near nests | | 14 | 1 | | | 1 |
| Eggs did not hatch | 4 | | | | | 3 |
| Eggs probably infertile | | 67 | 2 | | | 2 |
| Eggs infertile | | 33 | 1 | | | 1 |
| Ectoparasites | 3 | | | | | 2 |
| Heavy mite infestation | | 100 | | 2 | | 2 |
| Disease | 1 | | | | | 1 |
| Pneumonia[b] | | 100 | | 2 | | 2 |
| Accident | 1 | | | 1 | | 1 |
| Nestling fell from nest | | 100 | | 1 | | 1 |
| Total | | — | 54 | 27 | 1 | 82 |
| Percent | | — | 66 | 33 | 1 | 100 |

[a] Sykes and Chandler (1974).

[b] Diagnosis of dead nestlings was made by the National Fish and Wildlife Health Laboratory, Madison, Wisconsin.

have been taken by a Great Horned Owl (*Bubo virginianus*). Both nests were highly visible and within the territory of a pair of nesting owls. The young kites were too large to have been swallowed by a snake, and they disappeared overnight. There was no evidence of struggle at the nest or immediate surroundings and during that period no corvids were observed in that area of the refuge. These two losses are included under unknown predator in Table 8.

Crows (*Corvus* spp.) were reported to occasionally rob kite nests of eggs on the eastern edge of the Everglades in the late 1800s (Bailey 1884). During my study the Fish Crow (*C. ossifragus*) took eggs at two nests on the headwaters of the St. Johns River. Reservoirs in which the kites nested on the St. Johns are small and close to upland habitats (Sykes 1983a, 1984). Common (*C. brachyrhynchos*) and Fish Crows are now uncommon in the extensive marshes of the Everglades, except for Common Crows along the Tamiami Trail (U.S. Hwy. 41), and are usually restricted to upland margins or cypress and mangrove forests. With few exceptions, kites nest away from such areas.

Circumstantial evidence suggests that kite eggs were destroyed by a Boat-tailed Grackle (*Quiscalus major*) in 1956 at Lake Okeechobee (Wachenfeld 1956). More recently, 9 clutches were reported lost to grackle predation (Chandler and Anderson 1974). On several occasions I have watched Boat-tailed Grackles show no interest in Snail Kite eggs, although they were within less than 5 m of unattended nests with eggs in view. If grackles do take kite eggs, it may be localized behavior.

During long periods of rain (i.e., up to 3 d) some nestlings die from exposure or from a secondary agent. Two nestlings that died from pneumonia (Table 8) were probably soaked first by rain and then contracted the disease. Also, rainy weather makes hunting more difficult for adults (pers. obs.) and nestlings already stressed from being wet may not survive if feeding is reduced.

All kite nests were built over water and those placed in cattails (*Typha angustifolia* and *T. domingensis*) were frequently lost (Sykes and Chandler 1974). The leaves of cattails are not rigid enough to support nests in strong winds (>24 km/h) during storms or prolonged windy periods. Cattail leaves were further weakened as nesting substrates when water levels were lowered. Also, nests built in cattails settled, some as much as a meter, and often tipped, dumping their contents into the water. Twelve of the 13 nests that failed because the nest fell or tipped were in cattails and the remaining nest was placed on a rotten tree stub that broke.

Human-caused fires often sweep through kite nesting habitats in Florida during the dry season, November–April (Hofstetter 1974, Robertson 1953, Sykes 1979), and usually were more severe than natural fires from lightning that occurred during the wet season, May–October (Hofstetter 1974, Robertson 1953). Nicholson (1926) reported several nests on the headwaters of the St. Johns River destroyed by fire. In my study 4 nests were lost to fires.

Human disturbances to nesting kites probably were not overt acts. From my observations, people either did not know a nest was present or failed to recognize the behavior of nesting adults. Incubating birds near frequently used boat trails were repeatedly flushed. Also, nests may be blown down from the prop wash of an airboat propeller or run over.

Such was much more likely to occur with frog hunters who operate at night.

Unhatched eggs presumed to be infertile have been reported in Florida (Chandler and Anderson 1974, Sprunt 1945, Stieglitz and Thompson 1967). In my study, one nest had and two others were suspected to have infertile eggs (full term incubation with no trace of embryonic development).

Additional factors may be responsible for nesting failure in the Snail Kite in Florida. One nestling fell from its nest, became lodged by the neck in the forked stem of a small tree, and died when it could not free itself; and ectoparasitic mites (*Ornithonyssus bursa*) were responsible for the death of young at two nests (Sykes and Forrester 1983).

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