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NESTING SUCCESS IN TWO WOOD STORK COLONIES IN VENEZUELA

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Abstract.—I studied the reproductive success of the Wood Stork (*Mycteria americana*) in a seasonally inundated savanna in the southern Ilanos of Venezuela. Two breeding colonies were occupied by Wood Storks during the 1989–1990 nesting season. Storks arrived at the colonies in October, and most of the clutches were laid during the second half of November. The nesting period extended to mid-March. Of the 840 Wood Stork nests counted, 30.9% produced at least one chick of fledging age. One of the colonies was abandoned during the incubation period, whereas the other produced 435 fledglings (0.66 per nest). Predation by Crested Caracaras (*Polyborus plancus*) and eggs falling from the nest during early stages were the main causes of nesting failure. The entry of humans into Wood Stork colonies during early stages of nesting (October–November) increased egg/chick predation by Crested Caracaras, while parents were off their nests. Limited visits when young were half grown (after late January) did not result in large disturbance effects. As Wood Stork colonies in the study area are managed for ecotourism and receive heavy human visitation, measures to minimize human disturbance of colonies are proposed.

ÉXITO REPRODUCTIVO EN DOS COLONIAS DE GABANES EN VENEZUELA

Sinopsis.—Se estudió el éxito reproductivo del Gabán (*Mycteria americana*) en una sabana estacionalmente inundable en los Ilanos meridionales de Venezuela. Dos colonias reproductivas fueron ocupadas por los gabanes durante la temporada de 1989–1990. Los gabanes comenzaron a llegar a las colonias en octubre y la mayor parte de las puestas tuvieron lugar en la segunda quincena de noviembre. El período de cría se extendió hasta mediados de marzo. De los 840 nidos estudiados, el 30.9% lograron sacar adelante al menos un pichón. Una de las colonias fue abandonada durante el período de incubación, mientras que la otra produjo 435 volantones (0.66/nido). La depredación por parte d *Polyborus plancus* y la caída de huevos del nido durante estadíos tempranos fueron las principales causas de fracaso reproductivo. La entrada de personas a las colonias de gabanes durante los estadíos tempranos de cría (octubre–noviembre) facilitó la de predación de huevos/pichones por parte de los *P. plancus*, mientras los padres estaban fuera del nido. Visitas restringidas realizadas cuando los pichones se encontraban a medio crecimiento (a partir de finales de enero) no produjeron grandes molestias a las aves. Dado que las colonias de gabanes en el área de estudio son manejadas con fines de ecoturismo y reciben numerosas visitas, se proponen medidas para minimizar el impacto humano.

The Wood Stork (*Mycteria americana*) ranges from southern United States to northern Argentina, east of the Andes (Blake 1977). Many studies have been conducted in recent decades on various aspects of its biology in the southeastern U.S. (e.g., Kahl 1964, Kushlan et al. 1975, Ogden et al. 1976). In the Ilanos (tropical wet savanna) of Venezuela, however, information about this species is scarce (Hancock et al. 1992), although some general data on its status and ecology are available (Morales et al. 1981, Thomas 1985, González 1997). No published studies report on the breeding biology and nesting success of the species in the Ilanos.

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Throughout its range, the Wood Stork is often threatened by human disturbance at nesting sites (Hancock et al. 1992). The effects of human disturbance are of particular interest to researchers, because activity associated with the study of nesting may bias estimates of the reproductive parameters recorded (Frederick and Collopy 1989a). In the case of ciconiiforms, it seems that human disturbance during and before egg-laying may strongly affect reproductive parameters, and visits initiated late in incubation may not (Dusi and Dusi 1968, Tremblay and Ellison 1979). However, reproductive responses vary greatly with species, timing, type of disturbance, and the degree of previous exposure to human activities (Frederick and Collopy 1989a).

Predation is another important factor affecting reproductive success in colonial birds (Burger 1982). The colonial habit makes wading birds especially susceptible to predation during the breeding season, because once the colony is located predation may continue for many days and may result in the complete failure of the colony (Parnell et al. 1988). Opportunities for egg or chick predation are often enhanced by human disturbance (Milstein et al. 1970, Shields and Parnell 1986).

The purpose of this paper is to report on nesting success in two Wood Storks colonies in the southern Ilanos of Venezuela, and to quantify the influence of predation and human disturbance in the reproductive parameters. As Wood Stork (and other wading bird) colonies in the study area are managed for ecotourism and receive heavy human visitation, I also evaluated the need for measures to minimize the impact of humans on colonies.

STUDY AREA AND METHODS

I conducted the field work on Hato El Frío, a 78,000-ha private cattle ranch located in the state of Apure, between the villages of El Samán and Mantecal, Venezuela (7°35′–7°55′N, 68°50′–69°00′W). The study area is a tropical wet savanna with a highly seasonal distribution of rainfall. Mean annual rainfall is 1653 mm (n = 20 yr), most (>80%) falling between May and October, when most of the land becomes flooded (rainy season). Rainfall is scarce between November and April, when much of the land is dry and water is restricted to a few streams, lagoons, ponds, and deep marshes (dry season). The climate is tropical and mean monthly temperature is reasonably uniform throughout the year, with a maximum in March (28.6 C) and a minimum in July (25.4 C). Most of the area is covered by herbaceous savanna vegetation and bodies of water, with less than 20% occupied by forests (*matas* and gallery forests). Landscape and vegetation communities of the ranch are described exhaustively in Ayarzagüena et al. (1981) and Castroviejo and López (1985).

During the breeding season of 1989–1990, I monitored weekly two colonies of Wood Storks located at Macanillal River, approximately 8 km northwest of El Frío Biological Station. The colonies were separated by 500 m of river. A detailed description of the characteristics of these col-

onies is in González (1993). Between November 1989 and February 1990, I conducted weekly censuses from a 4-m high blind located 50 m from the middle of colony B; I also used the top of a four-wheel drive vehicle to census colony A and some parts of colony B not visible from the blind. The total number of adults was counted, and a bird/nest ratio was established to arrive at a total nest estimate (King 1978). Both colonies were observed weekly during continuous periods of 6–8 h for predation attempts. All censuses and observations were made from outside the colonies using 12× binoculars. Data were recorded on a tape recorder or transcribed directly to notes. Other data collection and occasional observations were made during the 1988–1989 and 1990–1991 breeding seasons.

Nine visits to colony B were made from late January–March 1989, when most of the chicks were more than 1-mo old, to collect regurgitation samples (González 1997). To determine the possible effect of the researcher inside the colony during early stages of nesting, a limited section covering about 15% of colony B was chosen. A team of two persons entered this part of the colony once in November 1989 and checked the contents of 61 Wood Stork nests using a mirror on an extendable pole. We spent 20 min inside the colony, while another two persons observed from the top of the vehicle and from the blind. The time spent inside the colony and the 30 min following our visit were considered the "disturbed" period (observations continued during this length of time).

To document the possible effect of tourism on Wood Stork reproduction, I accompanied several groups of tourists to colony B at different times during the breeding season, taking notes on the behavior of local guides and tourists and the responses of Wood Storks.

RESULTS

Breeding dates.—The Wood Stork nesting period in the study area began in October and extended to mid-March (dry season). In the 1989–1990 breeding season, the first storks arrived at the colony during the last week of October. The maximum number of nesting pairs was reached in late November. The first clutches were observed in the second week of November, but most of the clutches were laid during the second half of that month. The laying period, including possible replacement clutches, extended to early January. The first chicks were observed on 12 December. The latest fledglings left the colony during the second fortnight of March.

Observations during the 1990–1991 breeding season showed a 3–4 wk advance relative to the previous nesting season. In 1990, all the storks arrived at the colonies in early October. A total of 40 nests was being incubated as early as 16 October. Unfortunately, I could only monitor the colonies until mid-December 1990.

Nest site and structure.—Most nests (91.5%) were built on *Coccoloba* sp., the dominant tree (>80% of total) in the colony. The height of trees that supported Wood Stork nests averaged 3.8 m (range: 2.9–6.0; $n = 18$).

TABLE 1. Characteristics of Wood Stork nests in the study area on Hato El Frío, Venezuela (measures were taken shortly after fledging of nestlings).

	Mean	Range	*n*
Supporting tree height (m)	3.8	2.9–6.0	18
Nest height (m)	2.8	1.9–5.1	74
Nest diameter (cm)	70.3	61–91	34
Lined area diameter (cm)	28.4	22–36	33
Nest thickness (cm)	16.2	12–20	18
Distance to center[a] (m)	1.1	0–2.1	39
Supporting branch thickness (cm)	3.6	3–5.5	28
Number of nests per tree	5.9	1–14	35

[a] Measured as the horizontal distance from the center of the nest to the central axis of the supporting tree.

Nests were placed on forks of large limbs, or more usually in places where 3–4 branches crossed. The average height of Wood Stork nests was 2.8 m (range: 1.9–5.1; $n = 74$). The mean number of nests per tree was 5.9 (range: 1–14; $n = 35$ trees).

Wood Stork nests were circular to slightly elliptical structures composed of sticks up to 120-cm long and 2.5-cm thick, with a central area lined with green plant material. The diameter of 34 nests measured shortly after fledging averaged 70.3 cm, with a central lined area of 28.4 cm. Nest thickness ranged between 12 and 20 cm (Table 1). Most of the Wood Storks used the same nest sites that had been used previously by Great Egrets between July and October (Ayarzagüena et al. 1981); the residual nests left by Great Egrets were in a poor condition and had to be repaired almost completely by storks.

Clutch size and eggs.—The eggs of the Wood Stork were ovate to subelliptical. Coloration was dull white but became dirty with the passage of time. Eight infertile eggs collected from eight different nests averaged 68.6 × 46.6 mm (length: 65.6–72.1; width: 45.8–48.5), with a mean mass of 65 g (range: 63–68).

Five completed clutches counted from the blind averaged 3.2 eggs/nest, with two nests of three eggs, two nests of four eggs and one nest of two eggs. During our survey of colony B in November 1989, 46 clutches were counted; another 12 nests were empty and three nests (not considered) had one recently laid egg. Average clutch size was 2.8 eggs (range: 2–4), with three eggs the modal clutch size (61% of the clutches). Although most of the nests in the entered area had been in incubation for more than a week when visited, we were not certain that these clutches were complete.

Nesting success.—The estimated number of breeding pairs in the study area varied between seasons. In 1988–1989 the number of breeding pairs was 550, but data from this season were only partial and do not represent the maximum number of nests, because counts began late in the nesting cycle (January 1989). The number of Wood Storks nesting in the study

area during 1989–1990 (840 pairs) was much lower than any other year, which was confirmed by local inhabitants. The maximum number of nests was found in the 1990–1991 breeding season (1780 pairs).

Complete data on nesting success were only available for the 1989–1990 breeding season. Colony A was abandoned over a 1-wk interval, when most of the 180 Wood Stork nests in it contained eggs. Colony B produced a total of 435 fledglings (0.66/nest). Mean number of fledglings per successful nest was 1.67 (range: 1–3). Of the 840 Wood Stork nests located in the study area, only 260 produced at least one chick to fledging age (30.9% of successful nests).

Mortality and predation.—Several causes contributed to nesting failure, but it is difficult to assess the relative importance of each. During my entrance into colony B, I found seven crushed eggs on the ground under their nests. Poor construction of nests, and fights for nest-sites and materials between adults, were the main reasons of these egg-fallings.

Crested Caracaras (*Polyborus plancus*) appeared to be the main predators of Wood Stork eggs at the studied colonies. During nine days of observation, I recorded a total of 24 predation events, 20 of which involved Crested Caracaras. Eight of these events occurred in just one hour of observation, and were probably induced by a group of local horsemen that passed close to colony A; as a result, many adult birds flew away from their nests, leaving eggs unprotected. Crested Caracaras preyed upon nests that were temporarily abandoned by adults. In some cases the Wood Storks came back to the nest while the caracara was still in it; in these instances the storks expelled the predator with a forward threat. However, Wood Storks as a group did not exhibit any antipredator defense towards Crested Caracaras. Predation events were more common during incubation and early stages of nesting, but predation was not limited to eggs. Three times I observed Crested Caracaras carrying a Wood Stork nestling in its claws; nestlings were taken to the ground, 200–300 m away from the colony, and then eaten.

Four other avian predators were observed preying upon Wood Stork eggs or chicks in the study area. The Yellow-headed Caracara (*Milvago chimachima*) was observed on one occasion with a group of Crested Caracaras preying upon Wood Stork eggs. A Harris' Hawk (*Parabuteo unicinctus*) was observed eating a 6-wk-old Wood Stork chick. A Great Black-Hawk (*Buteogallus urubitinga*) was observed preying upon two Wood Stork nests that contained eggs or recently hatched chicks. Black Vultures (*Coragyps atratus*) scavenged eggs and chicks abandoned by adults and also ate the remains left by Crested Caracaras in depredated nests.

Human disturbance.—In late November 1989, we entered a section of colony B during early stages of nesting (see Methods). All the birds nesting in the entered area took flight, leaving their nests temporarily unattended. No predation was observed while we were checking the nests, but many Crested Caracaras concentrated in the area. After leaving the colony, caracaras began to prey upon unattended nests. The first adult Wood Storks returned to their nests 10 min after we left the colony, but many

other storks had not returned when we left the site 30 min later. During this time, 11 Crested Caracaras and one Yellow-headed Caracara depredated 23 Wood Stork nests. Because only 49 of the 61 disturbed nests contained eggs, researcher disturbance caused the failure of 46.9% of the nests in the entered section of the colony. Nevertheless, two weeks after the entry, this part of the colony was completely reoccupied by new breeding pairs. During the visits made from late January–March 1989 (chicks >1-mo old) to collect regurgitation samples, no case of predation or falling was observed, although older chicks escaped from their nests and moved through the nearby branches when we climbed the trees.

Colony B was frequently visited by tourists and photographers (2–4 visits/wk). Tourist visits to this colony were made on a four-wheel drive vehicle driven by a local guide. A small trail that passes along the southern part of the colony, 50–80 m from the nearest Wood Stork nests, was used in these visits. The presence of the vehicle caused no disturbation to the colony. When tourists descended from the car, the nearest Wood Storks appeared stressed, although they never took flight. On just one occasion I observed a group of visitors approach the colony by walking. This caused a significant disturbance and resulted in the temporary abandonment of many nests by adults. The event occurred late in the nesting season and did not cause failure, but it must be assumed that if this had happened during early stages of nesting, the loss of eggs could have been significant.

DISCUSSION

Breeding dates of the Wood Stork in the study area are consistent with data from other regions, considering that the timing of the dry season differs in various parts of the Wood Stork's range (Hancock et al. 1992). In Florida, Wood Storks begin nesting mostly at the begining of the dry season in November–January, although some nesting may occur until May (Kahl 1964, Kushlan et al. 1975). In Surinam, egg-laying began in late September and continued through October, coinciding with the local long dry season (Spaans 1975). In the Yucatan peninsula of Mexico, Wood Stork colonies are occupied in February, also during the local dry season (Ramo and Busto 1992). In Honduras and Nicaragua several Wood Stork colonies with eggs or chicks were observed in February–March (Frederick et al. 1997).

There is considerable variabiliaty in breeding success throughout the range of Wood Storks. Kahl (1964) reported that the mean number of fledglings per active nest ranged between 1.34 and 2.92 during 1958–1961 in Florida. Ogden et al. (1987) report significant differences in nesting success between Wood Stork colonies of north and south Florida; the percentage of successful nests varied between 0% and 59% in the north, and between 45% and 88% in the south (period: 1977–1985). Rodgers and Schwikert (1997) found that the mean annual fledging rates in eight colonies of north and central Florida ranged from 0 (colony failed) to 2.66 fledglings/nest. In my study area, 30.9% of the nests were successful; one of the studied colonies failed, whereas the other produced 0.66

young/nest. There are no other data on nesting success from the same region for comparison.

The main reason for nesting failure reported in the literature is the rising of water levels on the feeding grounds (either caused by artificial water management of by an unusual rainfall pattern), leading to chick starvation and colony abandonment (Kahl 1964, Kushlan et al. 1975, Ramo and Busto 1992). Rainfall between November 1989 and March 1990 in my study area was slightly lower than the normal pattern (González 1993), so the complete failure of colony A cannot be attributed to a severe increase in water level. Furthermore, colonies A and B were close from each other, and just one of them was abandoned, which is inconsistent with a climate-induced failure. Human disturbance may have influenced this rapid colony desertion, as a trail passes close to colony A and Wood Storks are hunted by local people (Thomas 1987, pers. obs.). However, no evidence of human interference (footprints, tracks) was observed in the colony.

The main causes of mortality at colony B were predation and egg-falling. The increase in the number of failed eggs and chicks caused by the activities of other individuals is one of the most severe costs associated to colonial nesting (Wittenberger and Hunt 1985). Predation has been reported to play an important role in the reproductive success of many colonial waterbirds (Dusi and Dusi 1968, Ellison and Cleary 1978, Frederick and Collopy 1989b). The Crested Caracara is the most common avian predator/scavenger of wading bird nests in the study area; in most cases it remains unclear if predation is the primary cause of failure or if it is precipitated by other factors such as parental desertion (González 1996). Crested Caracaras are not capable of displacing adult Wood Storks from their nests, so opportunities to prey upon eggs or nestlings are likely to be limited to periods of absence by both members of the pair. Consequently, the effect of Crested Caracaras on nest success of Wood Storks may become especially important during major colony disturbances, such as by human observers.

Several mammals and snakes have been mentioned as important predators on colonial wading bird nests (Dusi and Dusi 1968, Thomas 1984, Pratt and Winkler 1985). Predation by mammals usually is reported from colonies at which the protective moat of water has dried during the course of nesting (Rodgers 1987, Frederick and Collopy 1989b). This was the case in colony B during the 1989–1990 breeding season, when artificial water management left some parts of the colony without water protection. During colony formation in 1989, water depth in the middle of the colony was only 90 cm, compared with 230 cm in 1988 and 220 cm in 1990. Despite of this, we did not find any evidence of mammalian or reptile predation.

Human activities are a major factor in the disturbance of colonial waterbirds (Ellison and Cleary 1978, Frederick and Collopy 1989a). When disturbed, adult birds fly away from their nests, leaving eggs or young nestlings unprotected and exposed to predators (Shields and Parnell

1986). Short disturbances permit the birds to return to their nests rapidly, but lengthy disturbances may keep them from their nests for a longer period. Birds may not abandon a site because of frequent human disturbance, but reproduction may be impaired (Parnell et al. 1988). In my study area, the entry of humans into Wood Stork colonies during early stages of nesting greatly enhances opportunities for egg and chick predation by Crested Caracaras and other avian predators, while parental birds are off their nests; limited visits when young are half grown do not result in large disturbance effects. The existence of an early-nesting sensitive period has been reported for several species of wading birds (Dusi and Dusi 1968, Tremblay and Ellison 1979, Frederick and Collopy 1989a).

Kury and Gochfeld (1975) have recommended that colonies managed for tourism should be visited only late in the nesting cycle. Rodgers and Smith (1995) reported that Wood Storks exhibited an average flush distance of 21.6 m (SD = 8.2) in Florida colonies, which was the shortest of all wading birds at their study sites. To minimize disturbance, I propose that visitors on foot and local horsemen be kept 100 m away from the nearest Wood Stork nests between October and March, and recommend that this conservative distance must be marked with signs placed at 50-m intervals around the colony perimeter (Erwin 1989). Colony B may be approached to 50 m by vehicle, using the existing trail, only if visitors are accompanied by a local guide and remain inside the car, which serves as a mobile hide.

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