J. Field Ornithol., 60(2):216–223

NESTING BIOLOGY OF BLACK SKIMMERS, LARGE-BILLED TERNS, AND YELLOW-BILLED TERNS IN AMAZONIAN BRAZIL

PAM G. KRANNITZ[1]
Department of Botany
University of Guelph
Guelph, Ontario N1G 2W1, Canada

Abstract.—Nests of Black Skimmers (*Rynchops niger*) ($n = 37$), Large-billed Terns (*Phaetusa simplex*) ($n = 121$), and Yellow-billed Terns (*Sterna superciliaris*) ($n = 16$) on an exposed sandbar in the Trombetas River, Brazil, were monitored during incubation and hatching in 1982. The species were interspersed throughout the colony, though Black Skimmers nested closer to the river than the other two species. Black Skimmers had larger clutches (2.83 eggs/clutch) than Large-billed (2.30 eggs) and Yellow-billed (1.94 eggs) terns. Abandonment and flooding accounted for the majority of nest and egg losses during incubation for Large-billed Terns (22 of 27 nest failures) and Yellow-billed Terns (two failures, one due to flooding). Black Skimmers lost no eggs or nests to flooding, but abandoned three nests (seven eggs) and three clutches disappeared (11 eggs). Black Skimmer clutches hatched on averaged of 5 d earlier than Large-billed Tern clutches, and 2 d earlier than Yellow-billed Tern clutches. Estimated number of young leaving the nest for Black Skimmers was 1.66 young/nest, 1.08 for Large-billed Terns, and 1.04 for Yellow-billed Terns.

BIOLOGÍA DE LA REPRODUCCIÓN DE RYNCHOPS NIGER, *PHAETUSA SIMPLEX*, Y *STERNA SUPERCILIARIS* EN EL AMAZONAS BRAZILEÑO

Resumen.—Nidos de *Rynchops niger* ($n = 37$), *Phaetusa simplex* ($n = 121$), y *Sterna superciliaris* ($n = 16$) en una barrera de arena en el Rio Trombetas, Brazil, fueron monitoreados durante el periodo de incubación y eclosión en el 1982. Las especies se encontraban dispersas a través de la colonia, aunque *Rynchops niger* anidó más cercano al rio que las otras dos especies. *Rynchops niger* tenía camadas de huevos más grandes (2.83/camada) que *Phaetusa simplex* (2.30/camada) y *Sterna superciliaris* (1.94/camada). Abandono de nidos e inundaciones causaron la mayoría de perdidas de huevos y nidos durante la incubación para *Phaetusa simplex* (22 de 27 nidos fracasados) y *Sterna superciliaris* (1 nido inundado de 2 fracasos). *Rynchops niger* no perdió huevos o nidos por inundaciones, pero abandonaron 3 nidos (7 huevos) y 3 camadas de huevos desaparecieron (11 huevos). Las camadas de *Rynchops niger* eclosionaron, en promedio, 5 d antes que las camadas de *Phaetusa simplex* y 2 d antes que las camadas de *Sterna superciliaris*. El número estimado de volantones que abandonaron el nido para *Rynchops niger* fue 1.66 volantones/nido, 1.08 para *Phaetusa simplex*, y 1.04 para *Sterna superciliaris*.

In North America, Black Skimmers (*Rynchops niger*) nest in shallow scrapes on exposed beaches along the southeastern coastline from New York to Texas. In South America, Black Skimmers, along with Large-billed Terns (*Phaetusa simplex*) and Yellow-billed Terns (*Sterna superciliaris*) nest inland, in the Amazon and Parana river systems (Murphy 1936). Nest-sites become available during the dry season when water levels fall, exposing previously submerged sandbars (Murphy 1936, Pres-

[1] *Current address: Department of Biology, Queen's University, Kingston, Ontario K7L 3N6, Canada.*

ton 1962). Sandbars in the Trombetas River, a tributary of the Amazon, provide nesting sites for terns and skimmers. Few published data exist on the nesting biology of Large-billed Terns, Yellow-billed Terns, or Black Skimmers in South America. Therefore sandbars, such as those of the Trombetas River present an ideal opportunity for gathering data not only on general breeding biology, but also on how nest sites are segregated spatially among these three species. The objectives of this study were to: (1) describe the nesting biology of Black Skimmers, Large-billed Terns, and Yellow-billed Terns nesting on a sandbar in the Trombetas River, with respect to spatial distribution of nests, clutch size, hatching date, and hatching success, and (2) to compare and contrast the three species, in relation to the seasonal nature of their nesting habitat.

STUDY SITE AND METHODS

This study took place from mid-October to early December, 1982, in the Trombetas River Biological Reserve 1°20'S, 56°45'W), in the municipality of Oriximiná, Pará, Brazil. The Trombetas River is a blackwater river flowing south into the Amazon and the seasonal variation in depth is about 10 meters (C. R. Alho and L. F. M. Pádua, pers. comm.). At lowest ebb the river was about 500 m wide at the study site. One colony of terns and skimmers nesting on a sandbar opposite the reserve headquarters was studied. The sandbar was about 4 km long, 1 km wide and up to 2 m high, and was exposed during the dry season (June to December). The sand was coarse (1–2 mm in diameter) and supported no plant growth. The nests were shallow depressions in the sand, about 30 cm in diameter (Table 1).

The site was visited daily either in the early morning or late afternoon to minimize the effect of heat on the chicks. The nesting season was under way when the study began; a few eggs hatched on the first day of observations, but a few nests were initiated that day. Most pairs were incubating. Nests were identified with numbered sticks and checked every 1–2 d. The number of eggs and chicks, dates of clutch initiation, and first day of hatching were recorded. The spatial distribution of nests and the distance from each nest to the river were estimated from a map of the colony.

Nest and hatching success was estimated by the Mayfield method (Mayfield 1961, 1975). This analysis considers the number of days nests were observed ("exposure") and is therefore a more accurate estimate for studies begun well into the incubation period. Rates of nest and egg survival through the incubation period for each species were calculated by taking the estimate of probability of daily survival to the jth power, j being the average incubation period for each species and was defined as the number of days between the first egg laid and the first egg hatched for each nest. Similarly, rates of nest and fledgling survival through the hatching period were calculated by taking the estimate of the daily survival probability during the hatching period to the kth power, k being the average hatching period for the average clutch size for each species.

TABLE 1. Median distance of nests from the river, mean (±SD) distance to the nearest nest of a conspecific, and mean nest diameter for Black Skimmers, Yellow-billed Terns and Large-billed Terns. Medians and means followed by different letters are significantly different at $P < 0.05$ (Median test and Fisher's Least-significant-difference Test respectively). Sample sizes are in parentheses.

	Black Skimmer	Yellow-billed Tern	Large-billed Tern
Distance from river (m)	42.25 a (36)	54.08 ab (13)	57.47 b (118)
Distance to nearest conspecific neighbor (m)	28.5 ± 18.8 a (13)	70.6 ± 49.3 b (10)	12.9 ± 7.0 c (13)
Nest diameter (cm)	36.5 ± 6.7 a (19)	21.1 ± 5.5 b (12)	37.2 ± 5.8 a (57)

Hatching period was defined as the number of days from the first egg hatched to the last egg hatched. The hatching period could not be ascertained for Yellow-billed Terns because of incomplete observations, but they did not lose nests or chicks during the hatching period and so the probability of survival was 1.00. Comparisons among daily probability estimates were made using Z-tests with estimated variance (Hensler and Nichols 1981).

RESULTS

A total of 173 nests were found on the sandbar, including 121 Large-billed Terns, 37 Black Skimmers and 16 Yellow-billed Terns. The species were interspersed, with Black Skimmer and Large-billed Tern nests randomly distributed with respect to each other ($P > 0.90$, nearest neighbor analysis, Pielou 1974). Nests from Yellow-billed Terns were not included in the test because of small sample sizes. The nests from all three species were on average 12.8 ± 10.93 (SD) apart (calculated from 35 randomly chosen nests). The distance between neighboring conspecific nests (Table 1) reflects relative abundance in the colony, with Large-billed Terns, the most abundant species, nesting closest together. Irrespective of species, the nests were clumped (Clark-Evans' Index of Aggregation = 0.86, $Z = 1.62$, $P = 0.053$, Clark and Evans 1954). Black Skimmers nested closer to the river than Large-billed Terns ($\chi^2 = 4.54$, $P < 0.05$) (Table 1).

Since the study started during the nesting season, incubation periods were determined for only seven nests: Yellow-billed Tern = 22 d; Large-billed Tern = 23, 25, 25 and 26 d; Black Skimmer = 20 and 20 d. Chicks were semi-precocious and left the nest 1–3 d after hatching. The hatching period for Black Skimmers was 3.8 ± 0.84 d ($n = 5$) for clutches of three eggs and 3 d ($n = 1$) for clutches of two eggs. For clutches of three eggs of Large-billed Terns, hatching period was 3.71 ± 0.95 d ($n = 7$) and for clutches of three eggs it was 3.13 ± 0.83 d ($n = 8$).

Overall, Black Skimmers had the largest clutches (Table 2) and their eggs hatched 5 d earlier than those of Large-billed Terns (Fig. 1) ($\chi^2 =$

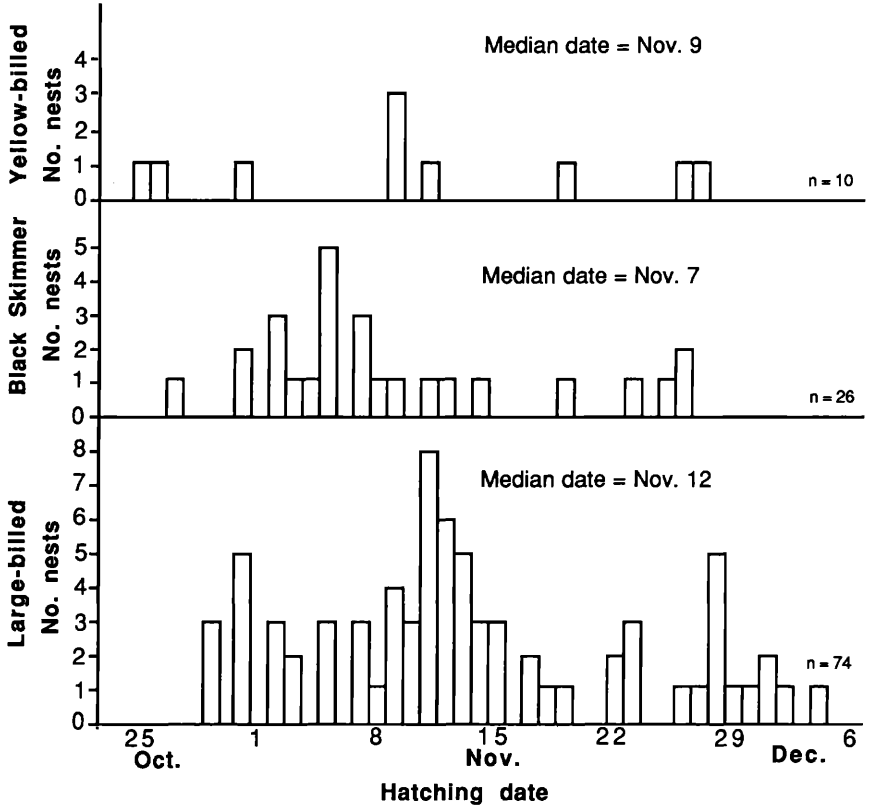

FIGURE 1. Frequency distribution for date of first egg hatched in individual nests of Black Skimmers, Large-billed Terns, and Yellow-billed Terns.

4.16, df = 1, $P < 0.05$, median test, Siegel 1956), but not significantly earlier than eggs of Yellow-billed Terns ($\chi^2 = 1.76$, df = 1, $P > 0.05$, median test, Siegel 1956).

Nest abandonment accounted for most egg losses among Large-billed

TABLE 2. Clutch size distributions and means for Black Skimmers, Yellow-billed Terns, and Large-billed Terns.

Species	*n*	Number of eggs				Mean[a]
		1	2	3	4	
Black Skimmer	37	1	9	25	2	2.83 a
Yellow-billed Tern	16	5	7	4	0	1.94 b
Large-billed Tern	121	12	61	48	0	2.30 b

[a] Distributions of clutch size that are significantly different (Chi-square, overall $P \leq 0.05$) are followed by different letters. Clutches 1 and 2, and 3 and 4 were combined for analysis because of small sample sizes.

TABLE 3. Fate of eggs for nests of Black Skimmers, Yellow-billed Terns, and Large-billed Terns.

	Black Skimmer	Yellow-billed Tern	Large-billed Tern
Number nests	37	16	121
Eggs laid	102	31	278
Disappeared	11	3	8
Cracked open	0	0	1
Abandoned	7	0	41
Flooded	0	2	10
Did not hatch	5	2	16
Unknown	11	4	25
Eggs hatched	67	20	177
Chicks died while hatching	0	0	8
Chicks died post hatching	1	0	2

Terns (17 of 27 nest failures, Table 3), whereas Black Skimmers abandoned three nests and had three disappear (more eggs were in the nests that disappeared), and Yellow-billed Terns had one nest disappear. Disappearance of eggs occurred at the end of October and may have been due to human visitation. Only Large-billed Terns lost chicks during hatching (i.e., between pipping and hatching), whereas both they and Black Skimmers lost chicks in the short period between hatching and leaving the nest (Table 3).

The daily probability of nest survival during incubation was not significantly different among the species (Black Skimmers = 0.9830, Yellow-billed Terns = 0.9791, Large-billed Terns = 0.9825, $Z = 0.069 - 0.379$, $P = 0.47$–0.36). However, nest success through the incubation period (Table 4, column A) appears different among the three species, because of differences in the incubation periods. Hatching success of eggs in successful nests (Table 4, column C) was again similar among the species, but given other differences in incubation time and chick survival, estimated overall egg success, from laying to a chick leaving the nest (Table 4, column AXBXCXD), is lower for Large-billed Terns than for the other

TABLE 4. Nest success, egg success and estimated number of young leaving nests of Black Skimmers, Large-billed Terns and Yellow-billed Terns.[a]

Species	No. nests	Nest success		
		Incub. (A)	Hatch. (B)	A × B
Black Skimmer	37	0.710	1.000	0.710
Large-billed Tern	121	0.644	0.968	0.623
Yellow-billed Tern	16	0.629	1.000	0.629

[a] Based on days of nest and egg exposure (Mayfield 1961, 1975).

two species. Since chicks left the nests well before fledging, this is not an estimate of fledging success.

Because nest failure from disappearance is probably not a reflection of ineffective parental care, but is probably a reflection of human disturbance, the values in Table 4 were recalculated with nest failures due only to abandonment and flooding. Daily probability of nest success was less similar (Black Skimmer = 0.9913, Large-billed Tern = 0.9853, Yellow-billed Tern = 0.9892), but still non-significant (Z = 0.179–0.832, P = 0.43–0.21). Overall egg success (A × B × C × D) was 0.696 for Black Skimmers, 0.502 for Large-billed Terns, and 0.669 for Yellow-billed Terns, and the estimated number of young leaving the nest was 1.97, 1.15, and 1.30 respectively.

DISCUSSION

This study describes the breeding biology of Black Skimmers, Large-billed Terns and Yellow-billed Terns in a mixed nesting colony. Black Skimmers nest in association with Common Terns in North America (Gochfield 1977) where they are defended from predators by the more antagonistic Common Terns (Erwin 1979). Whether Black Skimmers garner the same from Large-billed Terns is not known. However, the terns were certainly more aggressive than the skimmers, dive-bombing incessantly and occasionally striking observers on the head. Furthermore, skimmers nested amongst the terns, though on average closer to the river.

Of the three species in this study, Black Skimmers had the largest clutches. Black Skimmer clutches were smaller in this study (2.83 eggs/clutch) than in Virginia, (3.55 eggs, Erwin 1977) or in most populations in Texas (3.44 eggs, Custer and Mitchell 1987; 2.7–3.5 eggs, King and Krynitsky 1986; 2.8–3.5 eggs, White et al. 1984).

Black Skimmer eggs hatched on average 5 d earlier than eggs of Large-billed Terns and 2 d earlier than Yellow-billed Terns. The earlier hatching dates of skimmers may be a result of their comparatively short incubation period. My measures of the incubation period for Black Skimmers (20 d from first egg laid to first egg hatched) compares well with other reports (19 d from first egg laid to first egg pipped, Custer and Mitchell 1987; 22.9 ± 2.2 d, Erwin 1977).

Many of the flooded nests of Large-billed Terns had been abandoned previously, but the projected hatching date of those nearest the water's

TABLE 4. Extended.

Hatch suc. (C)	Chick suc. (D)	Total egg suc. A × B × C × D	Mean clutch size (E)	Est. no. yg. leaving nest A × D × C × D × E
0.849	0.976	0.588	2.83	1.66
0.822	0.914	0.468	2.30	1.08
0.849	1.000	0.534	1.94	1.04

edge was after the date when flooding occurred. Whether such flooding would have a significant effect on the nesting success of Large-billed Terns every year is unknown.

This study's estimate of the daily probability of nest survival during incubation for Black Skimmers (0.983) was almost identical to that estimated for skimmers in Texas (0.98486, Custer and Mitchell 1987). In addition, the estimate of total egg success (0.587) was also similar to percent overall success through incubation and hatching (68.3 × 78.4% = 53.55%, Custer and Mitchell 1987). The estimate of total hatching success in this study, including eggs from completely unsuccessful nests (i.e., $A \times B \times C = 0.603$), fell within the range of some Black Skimmer populations in Texas (10–91%, King and Krynitsky 1986), but was higher than hatching success recorded for other populations (45%, White et al. 1984).

These are the first published data on nesting success in Large-billed and Yellow-billed terns. Their generality can only be ascertained when additional studies of these species are completed in other parts of South America.

ACKNOWLEDGMENTS

I am grateful to the Instituto Brasileiro de Desenvolvimento Florestal in Brazil, and to C. R. Alho and L. F. M. Pádua who arranged for me to work in the Trombetas River Biological Reserve. I thank A. G. Carvalho, the superintendent of the reserve, and associated personnel for technical assistance and support. E. and G. Krannitz provided financial assistance and moral support. Suggestions from F. Cuthbert, T. Arnold, T. Custer and I. Jamieson greatly improved the manuscript.

LITERATURE CITED

CLARK, P. J., AND F. C. EVANS. 1954. Distance to nearest neighbour as a measure of spatial relationships in populations. Ecology 35:445–453.

CUSTER, T. W., AND C. A. MITCHELL. 1987. Organo-chlorine contaminants and reproductive success of Black Skimmers in south Texas, 1984. J. Field Ornithol. 58:480–489.

ERWIN, R. M. 1977. Black Skimmer breeding colonies and behavior. Auk 94:709–717.

———. 1979. Species interactions in a mixed colony of Common Terns (*Sterna hirundo*) and Black Skimmers (*Rynchops niger*). Anim. Behav. 27:1054–1062.

GOCHFIELD, M. 1977. Colony and nest site selection by Black Skimmers on Long Island, New York. Pp. 78–90, *in* W. E. Southern, ed. Proceedings 1977 Conference of the Colonial Waterbird Group. Northern Illinois University Press, Dekalb, Illinois.

HENSLER, G., AND J. D. NICHOLS. 1981. The Mayfield method of estimating nesting success: a model, estimators and simulation results. Wilson Bull. 93:42–53.

KING, K. A., AND A. J. KRYNITSKY. 1986. Population trends, reproductive success, and organochlorine chemical contaminants in waterbirds nesting in Galveston Bay, Texas. Arch. Environ. Contam. Toxicol. 15:367–376.

MAYFIELD, H. F. 1961. Nesting success calculated from exposure. Wilson Bull. 73:255–261.

———. 1975. Suggestions for calculating nest success. Wilson Bull. 87:456–466.

MURPHY, R. C. 1936. Oceanic birds of South America, vol. 2. MacMillan Co., New York.

PIELOU, E. C. 1974. Population and community ecology: principles and methods. Gordon and Breach, New York.

PRESTON, F. W. 1962. A nesting of Amazonian terns and skimmers. Wilson Bull. 74: 286–287.

SIEGEL, S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., New York.

WHITE, D. H., C. A. MITCHELL, AND D. M. SWINEFORD. 1984. Reproductive success of Black Skimmers in Texas relative to environmental pollutants. J. Field Ornithol. 55: 18–30.

Received 14 Mar. 1988; accepted 24 Sep. 1988.