J. Field Ornithol., 67(1):17–24

THE NESTING AND BREEDING BIOLOGY OF THE SOUTH AMERICAN TERN IN NORTHERN PATAGONIA

José Alejandro Scolaro, Sonia Laurenti, and Héctor Gallelli
CENPAT-CONICET and
Universidad Nacional de la Patagonia
9120 Puerto Madryn, Argentina

Abstract.—Clutch size, brood size, chick growth rates and population parameters of *Sterna hirundinacea* were studied at Punta Loma, Chubut, Argentina, during the 1992–1993 breeding season. There were two peaks of nesting activity: in early December and the first week of January. Nests of the earliest-laying couples were placed randomly in relation to each other, but at the end of the season the distribution of nests tended to be more uniform. Mean clutch size was 1.65 and mean incubation period was 21.5 d. Hatching success was 73.4% and the overall reproductive success was 35.1%. Highest chick mortality occurred during the first week after hatching. Increased chick mortality also occurred during molting of down feathers, and at the end of the rearing period. Predation, parental desertion or delays in feeding and starvation were the main causes of chick mortality. The growth rate of chick mass was similar in single and double broods, but second chicks attained a similar asymptotic mass if they survived the first 9 d after hatching.

NIDIFICACION Y BIOLOGIA DE LA REPRODUCCION DE *STERNA HIRUNDINACEA* EN PATAGONIA NORTE

Sinopsis.—Se estudió en *Sterna hirundinacea* el tamaño de nidada, tamaño de camada, tasas de crecimiento de los pichones y parámetros poblacionales durante la estación reproductiva 1992–1993, en Punta Loma, Chubut, Argentina. La actividad de nidificación tuvo dos picos: a principios de Diciembre y en la primer semana de Enero. Los nidos de las parejas nidificantes más tempranas fueron ubicados al azar en relación unos a otros, pero al final de la estación la distribución de los nidos tendió a ser más uniforme. El tamaño medio de la nidada fue 1.65 y el período medio de incubación fue 21.5 d. Los nacimientos exitosos promediaron 73.4% y el éxito reproductivo total fue 35.1%. La mayor mortalidad ocurrió durante la primer semana después de la eclosión. La mortalidad de pichones se incrementó durante la muda del plumón y hacia el final del período de crianza. La predación, las deserciones o demoras de los padres en la alimentación, y la inanición fueron las causas principales de mortalidad de los pichones. La tasa de crecimiento en masa de los pichones fue similar en camadas simples y dobles, pero el segundo pichón solamente logrará la misma masa asintótica si sobrevive los primeros 9 d luego del nacimiento.

The South American Tern (*Sterna hirundinacea*) has been reported from north of the Equator south to Cape Horn, on both the Atlantic and Pacific coasts (Harrison 1985). This species is migratory, with populations moving north at the end of the breeding season (March–April) and returning south the next spring (Harrison 1985, Olrog 1979). In successive breeding seasons, the birds tend to change colony sites, which are generally on small, isolated, offshore islands. This behavior hampers research.

Previous contributions have focused on the distribution of this species (Antas 1991, Contreras 1978, Croxall et al. 1984, Duffy et al. 1988, Olrog 1950, Schlatter 1984, Zapata 1967). Although some aspects of the breeding biology of the species have been reported (Daciuk 1973, De La Peña 1992, Escalante 1970, Humphrey et al. 1970, Philippi et al. 1954), most remain poorly documented.

In this paper we describe the breeding biology, population parameters and growth rates of chicks of the South American Tern, using data collected from a colony of some 1180 pairs.

STUDY AREA AND METHODS

We studied a population of South American Terns that nests irregularly at Punta Loma (42°49'S, 64°28'W), Chubut, Argentina, a Provincial Faunistic Reserve.

The colony site is on an eroded plateau of old marine deposits, with occasional patches of exposed soil and Patagonian shrub-steppe that terminates at the coast in sedimentary cliffs some 50-m high. The colony was situated at the top of the cliffs. The shape of the nesting colony followed the coastline.

From late November 1992 to March 1993 we investigated nesting chronology, egg laying, clutch size, reproductive success and chick growth rate for 57 tern nests. The nests were in an area of 43.7 m^2 surrounded by an enclosure 40-cm high to prevent chicks from escaping. Nests were marked with coded metallic stakes placed several centimeters away. Each egg was marked to determine clutch and incubation initiation, clutch size, and hatching success. During laying, nests were inspected twice daily (0630–0730 and 1930–2030 h). Later, during the rearing period, nests were periodically checked at intervals of 48–72 h. To minimize disturbance, observations during laying and incubation stages were made with 7×50 binoculars from a hide.

Chicks were identified by colored plastic leg bands bearing numbers. Using calipers, we took standard body measurements (to the nearest 0.1 mm), following Baldwin et al. (1931). Chicks were weighed (to the nearest 1 g) on a digital balance placed in a box to minimize wind. Chick growth rates were calculated using Rickelf's (1967) method (Langham 1983).

Nest distribution was assessed by using the nearest-neighbor-distance technique (Clark and Evans 1954). The R-ratio of observed to expected mean distances provides a measure of the distribution pattern and ranges from zero (maximum aggregation) to 2.5 when the distribution is completely regular. A value about 1.0 indicates that the distribution is random.

The probability that an individual chick, surviving at the beginning of an interval, would die within a particular interval was determined for successive 2-d periods using the hazard function or instantaneous death rate (Gross and Clark 1975). Data were tested for applicability before being subject to statistical tests (Sokal and Rohlf 1979).

RESULTS

Nests were built around an initial nucleus of pairs. These initial couples started the breeding cycle by selecting nest sites at random (Poisson $X^2 = 10.4$, df $= 6$, $n = 77$, $P > 0.10$) at the end of November. The number of breeding pairs increased until the third week of January, by which time the distribution of nests tended to be uniform (from minimum R $= 0.32$ to maximum R $= 1.80$).

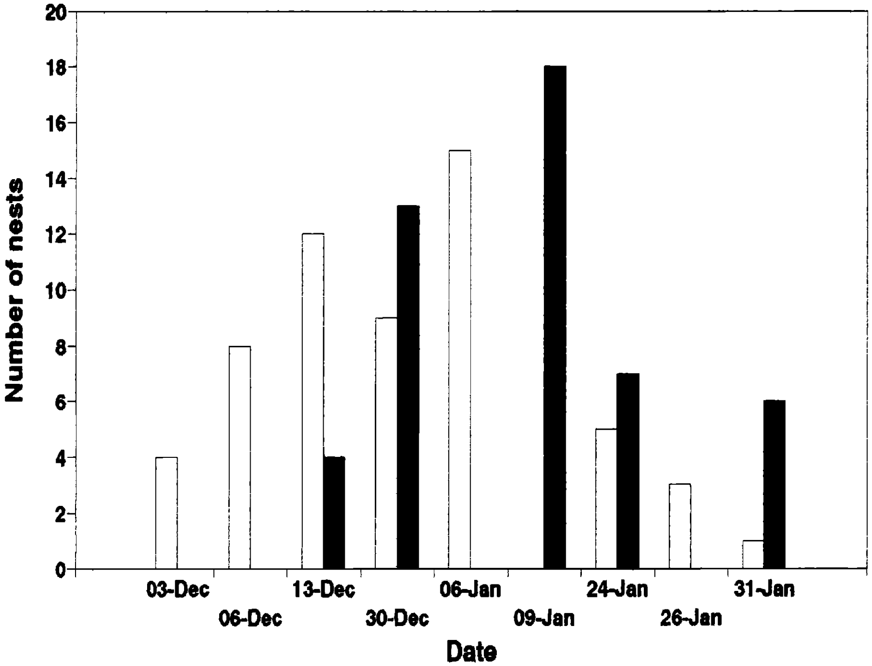

FIGURE 1. Nesting chronology of South American Terns during the 1992–1993 breeding season at Punta Loma, Argentina. Figures refer to absolute numbers of nests found within a specified subsection of the colony. Shaded bars indicate 2-egg clutches, empty bars 1-egg clutches. In cases where no bars are shown for specific dates, no data were taken.

Egg laying began early in December (earliest egg laid on 3 Dec. 1992) and showed two peaks (13 Dec. 1992 and 6 Jan. 1993, Fig. 1). The latest clutches were laid on 30 Jan.

Clutch size averaged 1.65 (n = 57, range = 1–3, SD = 0.64). At the end of the incubation period we found the percentages of 1-egg, 2-egg and 3-egg clutches to be 43.8%, 47.4% and 8.8%, respectively. The mean interval between laying the first and second egg was 54.7 h (n = 27, range = 24–72, SD = 13.7). The mean incubation period was 21.5 d (n = 72, range = 21–23, SD = 1.3). The interval between the hatching of the first and second chick was, on average, 53.8 h (n = 25, range = 24–96, SD = 26.2). On average, 73.4% (n = 94) of the eggs hatched successfully. Hatching failure resulted from predation (12.6%) and desertion (14%). Overall reproductive success (from laying to the end of fledging) averaged 35.1%, or 0.58 chicks/pair. Chick mortality during the rearing period was 52.2%.

We found no significant difference in hatching success between 1-egg and 2-egg clutches ($X^2 = 1.7$, df = 1, $P > 0.25$) nor between early (before 18 January) and late clutches ($X^2 = 0.2$, df = 1, $P > 0.65$). No correlation

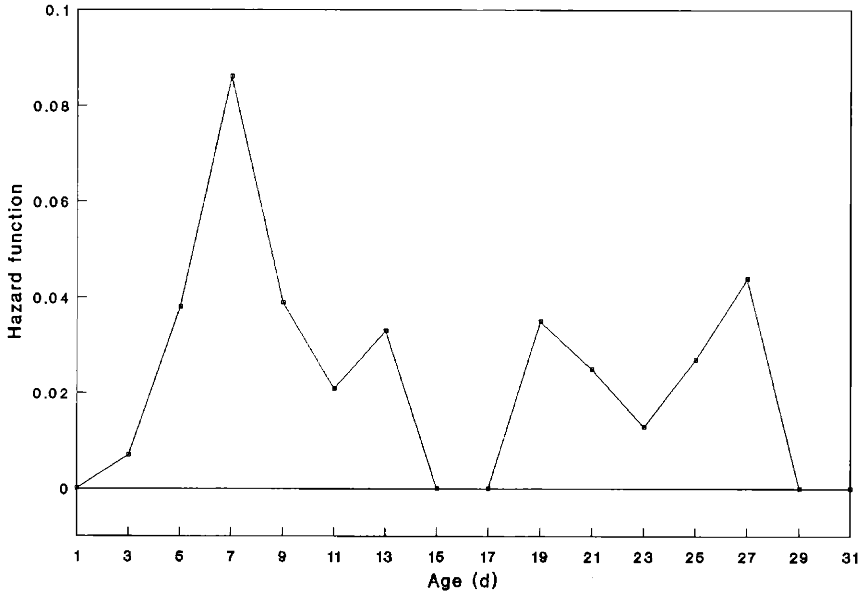

FIGURE 2. Hazard function for a sample of South American Tern chicks showing the probability that an individual chick surviving to the beginning of each 2-d interval will die within that interval.

was found between egg mass and mass of the chick at hatching ($r^2 = 0.42$, $n = 17$, $P > 0.10$).

Fledging success was greater for 2-egg clutches ($n = 27$) than for 1-egg clutches ($n = 25$) but the difference was not significant ($X^2 = 0.19$, df = 1, $P > 0.65$). Five pairs (18.5% of 2-egg clutches, 8.8% of all clutches) successfully reared two chicks.

The overall duration of the breeding season was 86 d. The mean breeding season for successful pairs lasted 50 d (SD = 2; incubation = 21–23 d, rearing = 26–29 d).

Chick survival.—Chick mortality data showed that the highest probability of death (15.9% of all deaths) occurred during the first week after hatching (Fig. 2). Chick mortality in this period was caused by predation (4.8%, $n = 3$) and parental desertion or delays in returning to the nest (11.1%, $n = 7$). The risk of chick death decreased towards the end of the rearing period, showing three small peaks when the chicks shed their first down and acquired yearling plumage (13–17 d).

The risk of death increased again when the chicks were 26–28 d old and the rearing period ended. The main causes of death (8.3%, $n = 3$) were parental desertion and changes in the frequency of parental visits to the chicks. The critical age of survival (when 75% of the chicks were still alive) was calculated to be 8.6 d ($n = 69$). The median for 50% survival of the analyzed cohort occurred when chicks were 27 d of age.

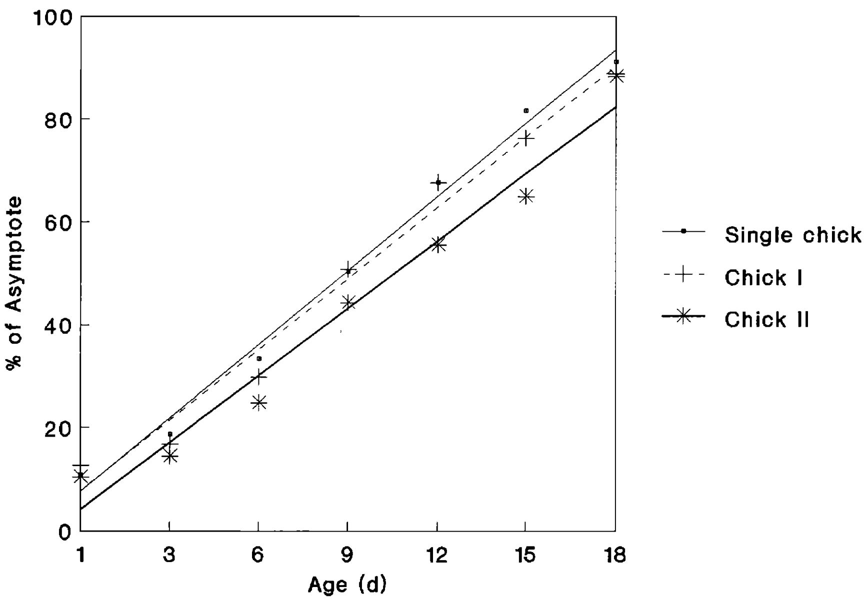

FIGURE 3. Increase in body mass of South American Tern chicks as a percentage of the asymptote.

Growth rate.—The chick growth curves fitted closely to a logistic equation ($r^2 = 0.98$, $n = 30$, $F_{3,7} = 501.8$, $P < 0.001$) where the increase in body mass (W) was defined by:

$$W = 181.02/(1 - 8.39e^{-0.24T})$$

where T = age (days).

Examination of the growth rates in broods by means of calculated logistic factors of conversion (K, Ricklefs 1967) showed that single chicks (K = 0.246) and chicks in 2-chick broods (K = 0.225) showed similar average growth rates, reaching similar asymptotic masses at fledging (Fig. 3). The growth rates were similar in the first (K = 0.225) and second (K = 0.222) chicks in 2-chick broods. Second chicks showed a marked change in growth rate, however, after 9 d of age. The first part of the fitted curve has a very low growth constant (K = 0.176), which suggests that the second chick experienced a shortage of food during that period. The second part of the fitted curve followed a different slope, giving a growth constant of K = 0.304, which was higher than in the first chick. Although the data on second chicks in 2-chick broods were based on relatively few chicks ($n = 7$), they suggest that if chicks survived the first 9 d (33% of rearing period) they would attain a similar growth constant to that shown by first and single chicks over the whole period.

Data on tarsus growth fitted a logistic equation ($r^2 = 0.99$), but the

TABLE 1. Summary of breeding parameters and chick growth in different tern species. With the exception of the South American Tern, all data are from Langham (1983).

	Tern species						
Parameters	South American	Common	Sandwich	Arctic	Crested	White-capped Noddy	Sooty
Clutch size (egg/nest)	1.65	2.45	1.23	1.82	1.01	1.00	1.00
Incubation (d)	21.5	23	23	22	28–30	35	30
Fledging (d)	27	22	25	19	35–41	51–53	60
Asymptotic weight (g)	181	128	189	115	279–318	117	205
Adult weight (g)	194	126	230	110	350	115	175
Age 90% asymptote (d)	18.3	14.1	26.6	14.5	38–40	28.9	—
Age 50% asymptote (d)	9.0	7.6	7.8	7.5	16–19.6	10.6	—

values derived from Ricklef's method (1967) showed a very low growth constant (K = 0.080).

DISCUSSION

During our study, the population of South American Terns nesting at Punta Loma followed a pattern of nest establishment similar to that of other temperate tern species (Langham 1983), whereby initial randomly nesting pairs attracted other nesters until a dense colony was formed.

The reproductive parameters of semi-nidifugous tern species are highly variable and dependent on breeding season, clutch size and geographic location (Langham 1983). Our population, located at about the latitudinal midpoint of the South American Tern's extensive Atlantic distribution, showed similarities to tern species from both tropical and temperate regions. Table 1 shows, for purposes of comparison, the reproductive parameters for several tern species. Our data for the South American Tern are from only one breeding season, however, and are thus inadequate for a more extensive comparison. Other data on this species are scarce (Humphrey et al. 1970, Philippi et al. 1954).

High egg and chick losses with a consequent low reproductive success, the laying of equal numbers of 1-egg and 2-egg clutches, high chick-growth constants and daily growth rates, as well as growth-rate differences between siblings of 2-chick clutches, are features of temperate tern species (Langham 1983). Aspects of chick survival are comparable to those in some populations of Common and Sandwich Terns (Dunn 1979, Langham 1983); both the survival likelihood (Gross and Clark 1975) and the growth curve (Ricklefs 1967) of chicks indicates that there was a critical period during the first 9 d after hatching. Parental desertions could result from a shortage of food during that period. After this period, the survival of chicks increased, particularly that of the second chick in 2-chick broods.

The slow growth rate of the tarsus compared to other body structures could be related to the limited mobility of the chicks within the nesting area. As Ricklefs (1979) has pointed out, mobility may be important in dense colonies, in which emphasis is on rapid development of legs followed by slow growth of other body structures. Slower tarsus growth is also found in Crested (*S. bergii*) and Sandwich terns (*S. sandvicensis*) (Langham 1983). This rate is in contrast to other inshore feeders whose chicks move out of the nesting area soon after hatching. South American Tern chicks are sedentary until fledging, and nesting near to cliff ledges would seem to necessitate little chick mobility. These features, together with an extended rearing period, resemble some of the breeding strategies reported for tropical tern species (Langham 1983), such as the White-capped Noddy (*Anous tenuirostris*) and the Sooty Tern (*S. fuscata*). In such offshore species, slow chick growth is considered a strategy to prevent chick starvation during fluctuating food supplies. Although the South American Tern is an inshore temperate species, which experiences more predictable food supplies, it seems to be capable of withstanding long periods of scarce food or prolonged bad weather.

ACKNOWLEDGMENTS

We thank R. P. Wilson and D. C. Duffy for their suggestions and criticism and two anonymous reviewers whose comments improved an earlier draft of this paper. We are also grateful to J. A. Upton, C. Beloso and T. Poretti for assistance in the field. The authors acknowledge specially to Dirección de Turismo de la Municipalidad de Puerto Madryn for the appropiate permission for our study in the Faunistic Reserve. The authors are members of the Carrera del Investigador y Personal de Apoyo a la Investigación del CONICET, Argentina.

LITERATURE CITED

ANTAS, P. DE T. Z. 1991. Status and conservation of seabirds breeding in Brazilian waters. Pp. 141–158, *in* J. P. Croxall, ed. Seabird status and conservation: a supplement. ICBP Tech. Pub. 11. Cambridge, United Kingdom.

BALDWIN, S. P., H. C. HOBERHOLSER, AND L. G. WORLEY. 1931. Measurements of birds. Sci. Pub. Cleveland Mus. Nat. Hist. 2:1–165.

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

CONTRERAS, J. R. 1978. Ecologia de la avifauna de la región de Puerto Lobos, Provincias de Río Negro y Chubut. Ecosur 5(10):169–181.

CROXALL, J. P., S. MCINNES, AND P. A. PRINCE. 1984. The status and conservation of seabirds at the Falkland Islands. Pp. 271–291, *in* J. P. Croxall, P. G. H. Evans and R. W. Schreiber, eds. Status and conservation of the world's seabirds. ICBP Tech. Pub. 2. Cambridge, United Kingdom.

DACIUK, J. 1973. Notas faunísticas y bioecológicas de Península Valdes y Patagonia. IX. Colonia de nidificación del Gaviotín Brasileño en Caleta Valdes (Chubut) y sugerencias para su protección. Physis 32(84c):71–82.

DE LA PEÑA, M. R. 1992. Guía de aves argentinas. 2a. ed. LOLA Literature of Latin America, Buenos Aires, Argentina. Vol. 2. 180 pp.

DUFFY, D. C., P. G. RYAN, R. P. WILSON, AND M. P. WILSON. 1988. Spring seabird distribution in the Strait of Magellan. Cormorant 16:98–102.

DUNN, E. H. 1979. Nesting biology and development of young Ontario black terns. Can. Field Nat. 93:276–281.

ESCALANTE, R. 1970. Aves marinas del Río de la Plata y aguas vecinas del oceano Atlántico. Barreiro y Ramos S. A., Montevideo, Uruguay. 199 pp.

GROSS, A. F., AND V. A. CLARK. 1975. Survival distributions: reliability applications in the biomedical sciences. John Wiley and Sons, New York.

HARRISON, P. 1985. Seabirds: an identification guide. Croom Helm Ltd., London, United Kingdom. 448 pp.

HUMPHREY, P. S., D. BRIDGE, P. W. REYNOLDS, AND R. T. PETERSON. 1970. Birds of Isla Grande (Tierra del Fuego). Preliminary Smithsonian Manual, Smithsonian Institution, Washington, D.C. 411 pp.

LANGHAM, N. P. 1983. Growth strategies in marine terns. Stud. Avian Biol. 8:73–83.

OLROG, C. C. 1950. Notas sobre mamíferos y aves del Archipiélago de Cabo de Hornos. Acta Zoologica Lilloana 9:505–532.

———. 1979. Nueva lista de la avifauna argentina. Opera Lilloana 27:1–324.

PHILIPPI, R. A., A. W. JOHNSON, J. D. GOODALL, AND F. BEHN. 1954. Notas sobre aves de Magallanes y Tierra del Fuego. Bol. Mus. Nac. Hist. Nat. Chile 26(3):1–65.

RICKLEFS, R. E. 1967. A graphical method of fitting equations to growth curves. Ecology 48: 978–983.

———. 1979. Adaptation, constraint, and compromise in avian postnatal development. Biol. Rev. 54:269–290.

SCHLATTER, R. P. 1984. The status and conservation of seabirds in Chile. Pp. 261–269, *in* J. P. Croxall, P. G. H. Evans, and R. W. Schreiber, eds. Status and conservation of the world's seabirds. ICBP Tech. Pub. 2. Cambridge, United Kingdom.

SOKAL, R. R., AND F. J. ROHLF. 1979. Biometría. Blume ed., Madrid, España. 832 pp.

ZAPATA, A. R. P. 1967. Observaciones sobre aves de Puerto Deseado, Provincia de Santa Cruz. El Hornero 10(4):351–381.

Received 3 Nov. 1994; accepted 29 Dec. 1994.