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REPRODUCTIVE VULNERABILITY: PARENTAL ATTENDANCE AROUND HATCHING IN ROSEATE (*STERNA DOUGALLII*) AND COMMON (*S. HIRUNDO*) TERNS[1]

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Abstract. Presence of one or both members of a pair at the nest site during the incubation and early chick stage reduces reproductive losses due to predation and weather stresses. We monitored the presence of pair members by the temporary removal of one member of several pairs of Roseate (*Sterna dougallii*) and Common (*Sterna hirundo*) Terns at nests at Cedar Beach, New York, to determine if vulnerability varies by reproductive stage, to compare species differences that might partially account for declines in Roseate Tern populations, and to examine their response to trapping. There were significant differences between species in the time to return to the nest following an initial disturbance, and Roseate Terns that were trapped and released took longer to return to the nest and resume incubating than did Common Terns. The nests of Roseate Terns were vulnerable (neither adult in attendance) for longer time than were the nests of Common Terns.

Key words: Roseate Tern; Sterna dougallii; *Common Tern;* S. hirundo; *nest vulnerability; trapping; colony; parental care; incubation; human disturbance; predation risk.*

INTRODUCTION

In seabirds, the efforts of both members of a pair are normally required for aquisition and maintenance of territories, incubation, and chick care (Lack 1968). Furthermore, in some seabirds, parents continue to provision the young long after chicks fledge (Burger 1980). The time parents can invest in these reproductive activities depends in part upon the time each parent devotes to maintenance activities such as foraging, preening, and sleeping. Parents not present at the nest site presumably are away foraging or are at 'loafing' sites. Individuals of a pair must balance present investment in reproductive units with the potential for investment in future offspring (Trivers 1972). In long-lived species of birds, such as seabirds, one of the highest priorities is to devote energy to self maintenance to prolong the potential for future reproduction, by minimizing the cost imposed by the present brood on physical condition and risk of predation.

Presumably breeding birds of all ages devote similar time and energy to sleeping and preening, even at different stages of the reproductive cycle. Moreover, both activities can be conducted at the nest site. However, time devoted to foraging depends on individual skill in locating food resources and capturing prey, and on the abundance and availability of prey. For example, younger birds have lower foraging success than older birds (Orians 1969, Searcy 1978, Burger 1987). Whereas seabirds that nest in burrows or that are very large may leave their nests unattended, most surface-nesting species usually have at least one parent in attendance to reduce losses due to predation or weather conditions.

In this paper we examine parental presence during the hatching period in Roseate (*Sterna dougallii*) and Common (*S. hirundo*) Terns. We were interested in determining how often both parents were present, and how soon a mate returned to the nest if one parent was removed temporarily. During the vulnerable stages (when there are eggs or young chicks), an incubating tern usually leaves the nest only when its mate returns. However, parents may leave to drink, defecate, obtain food, or engage in mobbing predators. Eggs and young chicks left unattended are vulnerable to predators and to heat or cold stress (Austin 1933, Kruuk 1964). Further, co-

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lonial birds that nest in coastal areas are frequently exposed to human disturbance, and their ability to respond appropriately affects their reproductive success (Burger and Gochfeld, in press). Habituation to human disturbance, including to investigators and banders, will reduce the time parents are away from vulnerable nests or young.

We use trapping as a method to determine "rapidity of return" following a disturbance (intrusion, setting the trap, and our presence near their nest). We recorded the presence of both mates before and after intrusion, and measured the time required for the second mate to return when the first was trapped and for the trapped bird to return following release. Thus we can examine vulnerability of eggs and chicks as a function of species and stage (eggs, or pipping eggs and young chicks). Trapped birds were color marked and held for 5 min. We also evaluate efficacy of trapping as a tool for examining population dynamics in terns. Nisbet (1981) examined the behavior of these two species following trapping at the Bird Island colony in Massachusetts. He reported that the median time for Common Terns to return was 24 min after release and for Roseate Terns it was 3 hr after release following trapping. We initiated the study partly to test our impression that nests of both species at the Cedar Beach colony on Western Long Island are less vulnerable (adults return more quickly after trapping) at our Western Long Island Colony compared to Bird Island.

Roseate Terns breed in colonies with Common Terns (Nisbet 1973, Gochfeld 1983, Gochfeld and Burger 1987, Burger and Gochfeld 1988). Although Roseate Terns have been decreasing historically, Common Tern populations are stable or increasing in the Northeastern United States (Burger and Gochfeld, in press). Recently the Roseate Tern population in the northeastern United States has been listed on the U.S. Endangered Species List. Here we compare vulnerability (nest attendance following disturbance) of Common and Roseate Terns nesting adjacent to one another.

STUDY AREAS AND METHODS

We studied Roseate and Common Terns at Cedar Beach, New York in 1988. Cedar Beach (13 ha) is about 250 km West of Bird Island, Massachusetts. About 100 pairs of Roseates and 5,000 pairs of Common Terns nested there in 1988. The colony is situated between artificially stabilized low dunes and has about 40–50% vegetation cover. A further description of the colony and nest sites can be found in Gochfeld and Burger (1987) and in Burger and Gochfeld (1988, in press).

Before setting traps we observed nests to determine if one or both parents were present. We placed traps (treadle-activated, sliding door) on nests from 7 days before hatching to 7 days after hatching, usually trapping twice on different days to obtain both members of a pair. We usually placed traps on one to four nests at once. When a trap was placed at a nest site, we recorded species, nest number, and contents. From a concealed position 30–40 m away, we observed nests with binoculars, recording for each nest: time for the first bird to return, time for the second bird to return, time for one bird to enter the trap, time for the second bird to return and commence incubation after the first bird trapped was removed, and time for the first bird to return to the nest following release. Due to vegetation we usually were able to observe only one to four nests at a time. In our discussion Bird A refers to the first mate trapped which was almost always the first bird to return following the disturbance (setting of the trap), and B refers to its mate. Prior to release, all birds were banded (1 incolloy and 3 colorbands) and an identifying color was placed on the breast with a magic marker (such marks lasted only 2–3 days). All birds were weighed and their bills and wings were measured.

Comparisons among species were made with Kruskal-Wallis χ^2 tests, and we give means $\pm$ one standard error unless otherwise noted.

RESULTS

SPECIES COMPARISONS

The behavior of Common and Roseate Terns differed with respect to all factors associated with disturbance and trapping, with Roseates taking longer to return and to incubate following disturbance (Table 1). For Common Terns, the average return time for Bird A was less than 2 min, while Roseate Terns returned in 2.3 min. However, Common Terns entered the traps in 5–6 min while Roseate Terns entered took an average of 15 min. Common Terns often returned, entered the trap, and began to incubate. If left undisturbed, they remained incubating until their mate returned. Similarly, when released after

TABLE 1. Comparison of Common and Roseate Tern behavior at Cedar Beach. Given are means ± 1 SE.

Behavior	Common Tern	Roseate Tern	χ^2 (*P*)[c]
Number of Nests trapped on	46	107	
Time for Bird A to return (min)[a]	1.7 ± 0.6	2.3 ± 0.4	13.2 (0.0003)
Percent of nests where both mates returned	50%	34%	(NS)
Time for Bird A to enter trap (min)[a]	5.6 ± 1.4	15.2 ± 2.2	19.3 (0.0001)
Percent of Bird A's to return within one hour	100%	89%	(NS)
Mean time for Bird A to return after release (min)	5.4 ± 1.6	12.9 ± 1.6	21.1 (0.0001)
Median time for Bird A to return after release (min)	3.5	7.0	—
Time for Bird B to return to nest when initially present (min)[b]	0.6 ± 0.01	2.1 ± 0.5	15.4 (0.0001)
Time for Bird B to begin incubating or brooding (min)[b]	2.2 ± 0.2	6.4 ± 1.2	12.7 (0.0004)
Vulnerability Time (time when nest was unattended) for all nests (min)	2.2 ± 0.8	10.5 ± 2.3	19.4 (0.0001)

[a] From time trap was set up.
[b] After Bird A was removed from trap and trap was removed.
[c] NS = not significant based on Kruskal-Wallis Test.

banding, many Common Terns returned within 5 min whereas Roseate Terns did not return for at least 12 min (Table 1).

Prior to setting the traps we observed both members of the pair at 12% of Common and 40% of Roseate Tern nests. However, once the trap was set we observed that both members returned at some point for 50% of Common and 34% of Roseate Nests. Thus when one parent was removed, its mate was present a third to half of the time. Mates may have been present more often, but they were not close enough to the nest site to be identified. When mates were visible beforehand, they usually returned to the nest within a few minutes of when the first bird was removed from the trap. These mates immediately took over guarding the nest. Even when no mate was apparent, a mate turned up half of the time for both species. These birds may have been visually in contact with the nest (but not visible to us) or just returning from foraging trips. Such birds returned within 2 or 3 min (Common Tern) or within 10 min (Roseate Tern, Table 1). These mates usually began to incubate (no trap present) within 2 or 3 min (Common) or 6 min (Roseate).

We were particularly interested in the vulnerability time for nests. We defined vulnerability as the time the nest was not attended by a parent that could defend it. Thus, we did not consider the nest vulnerable (to predators) if at least one parent was standing nearby. For the Cedar Beach terns, nests were unattended for a total of only about 2 min (Common) or 10 min (Roseate). Another species difference occurred with respect to the effect of trapping and banding on subsequent trapping (Table 2). Common Terns previously trapped (and released) did not take longer to trap than untrapped birds, whereas once a Roseate Tern was trapped, it became trap-shy.

TEMPORAL PATTERNS

Since newly hatched chicks are more vulnerable to cold stress and predation than eggs, we examined parental behavior just prior to hatching, and when pairs had pipping eggs and small chicks (less than seven days old, Table 3). There were

TABLE 2. Trapping times for Common and Roseate Terns. All previously banded birds had been trapped in 1987 or 1988 using the same type of treadle trap.

	Common	Roseate	χ^2 (*P*)
Number of nests	46	107	—
Time to enter traps (min):			
Unbanded birds	6.1 ± 1.5	9.4 ± 3.1	2.7 (NS)
Birds banded in previous year	4.2 ± 1.1	18.2 ± 4.1	17.3 (0.0001)
Birds banded in present year	—	21.1 ± 5.2	
Percent of nests where no bird entered traps (after 20 min)	17%	27%	1.1 (NS)

TABLE 3. Comparison of behavior of Roseate Terns with eggs or pipping eggs versus chicks. Given are mean ± standard error in minutes (NS = Not Significant).

	Eggs	Chicks	Kruskal-Wallis χ^2 (*P*)
Time for A to return	3.1 ± 1.1	1.2 ± 0.2	2.04 (NS)
Time for A to enter trap	18.9 ± 4.3	14.9 ± 3.9	1.12 (NS)
Time for B to return after A removed from trap	1.7 ± 0.4	5.0 ± 1.7	0.94 (NS)
Time for B to begin incubation or brooding (after A removed)	2.5 ± 0.5	7.2 ± 1.9	2.25 (NS)
Time for A to return after being banded and released	20.6 ± 4.2	8.0 ± 1.4	4.84 (0.02)
Vulnerability time (time when nest was unattended, min)	16.7 ± 4.6	4.3 ± 0.8	29.6 (0.0001)

no significant differences except for the time for a released bird to return to the nest after being trapped. Roseate Terns with chicks returned in significantly less time than those with only eggs.

DISCUSSION

SPECIES DIFFERENCES

With respect to almost all measures, Common Terns returned sooner, began to incubate sooner, entered traps sooner, and returned after being released sooner than Roseate Terns. This suggests that Roseate Terns, when disturbed by trapping, banding or by other causes, do not settle as fast as Common Terns, and their eggs or chicks are thus vulnerable for more time. This was true for each measure, as well as for vulnerability time (the time the nest was not closely guarded following the disturbance). There were also temporal differences in when the untrapped mates returned, suggesting that disturbance per se, rather than trapping is important.

COLONY DIFFERENCES

Our data for both species differ from Nisbet's (1981) results for Bird Island, Massachusetts. Nisbet found that the median time to return after banding and release was 24 min for Common (compared to 5 min at Cedar Beach), and 3 hr (compared to 15 min at Cedar Beach) for Roseate Terns. These differences are quite dramatic and suggest major differences in behavior.

At Cedar Beach birds of both species that we released usually flew out over the ocean, bathed, and flew back to the colony to land near the nest. They usually did not land on the beach, nor did they leave directly on foraging trips. When they returned to the nest site they preened briefly, or went right back on the nest to incubate.

In contrast, Nisbet (1981) reported that the terns he observed usually settled on the shore and preened for 10–20 min before they flew to the nest. He reported that Roseate Terns often left their nest uncovered for 1–2 hr following trapping. This was not the case at Cedar Beach. A higher proportion of mates may be present at Cedar Beach, and these birds quickly take over incubation. But even when mates were not present, the trapped bird quickly returned and resumed incubation. Time of day clearly can affect their behavior, so we trapped both species concurrently.

The lower percentage of mates regularly near the nest, and the rapid return of mates where none were visible, may indicate that foraging is less difficult at Cedar Beach than Bird Island, at least during the time of our study, resulting in birds being able to spend less time foraging and more time at the colony.

Foraging difficulties may relate either to food availability or the distance to foraging sites. Safina (1990) examined foraging in these two species and found that Cedar Beach has a greater variety of foraging habitats than are available in the waters surrounding two other large Roseate and Common Tern colonies (Falkner Island, Connecticut, and Great Gull Island, New York), suggesting that Cedar Beach may have greater foraging habitat diversity than Bird Island.

Nonetheless, the foraging difficulties not withstanding, there are still behavioral differences. One obvious explanation is the presence of people at Cedar Beach. The colony at Cedar Beach is in an interdune area that parallels a beach with high recreational use. In most summers there are almost always people walking, swimming, or playing on the beach adjacent to the colony. In general, the terns do not rest singly on the beach. Thus, a disturbed tern returns to stand in the

colony itself, rather than on the beach, and thus usually returns to its nest. It may be that once the tern is near its nest, the presence of the uncovered eggs stimulates it to incubate.

Additionally, both Roseate and Common Terns have been banded at Cedar Beach since 1970 (Gochfeld 1976), and have experienced researchers in the colony on many days during the breeding season since that time. As researchers, we spent time in all parts of the colony, so most birds would be habituated to our presence. In addition to experience, age of the adults could also affect our results.

The differences in behavior between Cedar Beach and Bird Island Terns should be examined in the same year, and we hope to initiate such a comparison among the terns at Cedar Beach, Falkner Island, and Bird Island.

DIFFERENCES AS A FUNCTION OF REPRODUCTIVE STAGE FOR ROSEATE TERN

We found few differences in behavior as a function of reproductive stage, perhaps because we restricted activity to late incubation and early chick phase. However, parents with chicks returned to the nest significantly sooner after being trapped than those with eggs. This may relate to the relative vulnerability of the reproductive units. Small chicks are more vulnerable to heat stress (Austin 1933) or chilling, and to predators (Burger and Gochfeld, in press) than are eggs that are partly cryptic. Andersson et al. (1980) proposed that parental defense of offspring should be most intense when the offspring are most vulnerable. This contrasts with Trivers' (1972) hypothesis that parental defense should increase with increasing investment (i.e., as age of the nest and chick increases through the season). Our data support Andersson et al.'s (1980) hypothesis.

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LITERATURE CITED

ANDERSSON, M., C. C. WILKLUND, AND H. RUNDOREN. 1980. Parental defense of offspring: a model and an example. Animal Behav. 28:536–542.

AUSTIN, O. L., JR. 1933. The status of Cape Cod Terns in 1933. Bird-Band. 4:190–198.

BURGER, J. 1980. The transition to independence and post-fledging parental care in seabirds, p. 367–448. *In* J. Burger, B. L. Olla and H. E. Winn [eds.], Behavior of marine animals. Vol. 4: marine birds Plenum Press, New York.

BURGER, J. 1987. Foraging efficiency in gulls: a congeneric comparison of age differences in efficiency and age of maturity. Studies in Avian Biology 10: 83–90.

BURGER, J., AND M. GOCHFELD. 1988. Nest site selection and temporal patterns in habitat use of Roseate and Common Terns. Auk 105:433–438.

BURGER, J., AND M. GOCHFELD. In press. Breeding biology and behavior of the Common Tern. Columbia Univ. Press, New York.

GOCHFELD, M. 1976. Waterbird colonies of Long Island, New York 3. Cedar Beach Ternery. Kingbird 26:62–80.

GOCHFELD, M. 1983. World status and distribution of the Roseate Tern, a threatened species. Biol. Conserv. 25:103–125.

GOCHFELD, M., AND J. BURGER. 1987. Nest site selection: comparison of Roseate and Common Terns (*sterna dougallii* and *S. hirundo*) in a Long Island, New York Colony, Bird Behav. 7:58–66.

KRUUK, H. 1964. Predators and anti-predator behavior of the Black-headed Gull (*Larus ridibundus* L.). Behaviour Suppl. 11.

LACK, D. 1968. Ecological adaptations for breeding in birds. Methuen and Co., London.

NISBET, I.C.T. 1973. Terns in Massachusetts: present numbers and historical changes. Bird-Banding 44: 27–55.

NISBET, I.C.T. 1981. Behavior of Common and Roseate Terns after trapping. Colonial Waterbirds 4: 44–46.

ORIANS, G. H. 1969. Age and hunting success in the Brown Pelican *Pelecanus occidentalis*. Anim. Behav. 17:316–319.

SAFINA, C. 1990. Foraging habitat partitioning in Roseate and Common Terns. Auk 107:351–358.

SEARCY, W. A. 1978. Foraging success in three age classes of Glaucous-winged Gulls. Auk 95:587–588.

TRIVERS, R. L. 1972. Parental investment and sexual selection, p. 136–179. *In* B. Campbell [ed.], Sexual selection and descent of man. Aldene, Chicago.