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HATCHING SUCCESS IN ROOF AND GROUND COLONIES OF LEAST TERNS[1]

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Key words: Least Tern; Sterna antillarum; *hatching success; roof-nesting; Florida.*

Least Terns (*Sterna antillarum*) were first reported nesting on gravel-covered roofs in Florida more than 30 years ago (Goodnight 1957). Roof-nesting colonies have since become increasingly common in the southeastern United States (Fisk 1975, 1978; Jackson and Jackson 1985), and in some areas of Florida Least Terns nesting on roofs outnumber those on the ground (Hovis and Robson 1989; Gore, unpubl. data). Despite the increasing proportion of Least Terns nesting on roofs, little is known about the productivity of roof colonies relative to those on the ground. Here we compare hatching success in ground and roof colonies of Least Terns and discuss the importance of roof-nesting to local populations and to the conservation of Least Terns.

STUDY AREA

We studied eight colonies of Least Terns in northwest Florida in 1989; four were on roofs and four on the ground (Table 1). Five colonies were located in Bay County, in or near Panama City. The East Pass colony was located in Okaloosa County 75 km west of Panama City; the Phipps colony was approximately 115 km east, at the tip of Alligator Point, in Franklin County; and the Publix colony was 135 km northwest in Tallahasee, Leon County. For logistical reasons, study colonies were not randomly selected from all available Least Tern colonies in northwest Florida. However, the study colonies represent about 20% of the region's colonies and are found across >75% of the range of nesting habitat in the area (Gore, unpubl. data). Thus, we believe the study colonies are likely to be representative of Least Tern colonies in northwest Florida.

Each site supported nesting terns in 1988 and most had been active each year since 1985. Of the four colonies nesting on the ground, three were within 100 m of the Gulf of Mexico and either on the beach in front of the dunes or, in the case of the East Pass colony, some nests were upon or behind high open dunes. The Highway 98 colony was located 800 m north of the beach, on a barren site that was cleared for construction several years ago. To deter people from entering the colonies on the ground, we posted signs and surrounded each site with string and colored flagging.

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TABLE 1. Productivity of Least Tern nests in four roof and four ground colonies in northwest Florida in 1989.

Colony type and name	Nests	Eggs	Chicks	% eggs hatched	Chicks/nest
Ground					
St. Andrews	54	105	4	3.8	0.07
Highway 98	29	40	3	7.5	0.10
East Pass	36	63	9	14.3	0.25
Phipps	27	52	10	19.2	0.37
Total	146	260	26		
$\bar{x}$ (95% CI)[a]				10.4 (2.1–23.9)	0.19 (2.7–43.9)
Roof					
Navy 319	38	67	5	7.5	0.13
Walmart	282	452	137	30.3	0.49
Publix	34	61	21	34.4	0.62
Navy 110	16	25	13	52.0	0.81
Total	370	605	176		
$\bar{x}$ (95% CI)[a]				29.4 (4.9–63.5)	0.51 (8.2–92.6)

[a] Proportions were arcsine-transformed for statistical analysis. Means (and confidence intervals) presented here are back-transformed values and may be slightly biased from those calculated from raw scores.

The four roofs that supported study colonies ranged in size from 0.1 to 0.4 ha and all were less than 25 m above ground. The Publix colony was located >35 km inland, but the other roof colonies were near the gulf. Human activity on the roofs was limited to the observers and, on a few occasions, building maintenance workers.

METHODS

With few exceptions, observers visited colonies before 09:00 or after 16:00 and restricted visits to <30 min in order to minimize disturbance. All observers were trained to our specific methods so as to standardize data collection.

During each visit, nests, eggs, and unfledged chicks were counted and nests were sorted by clutch size and status. The location of each nest was marked with short wooden rods, but only nests at the Publix, Phipps, and East Pass colonies were identified individually. The number of nests, eggs, and chicks produced in a colony during the season was determined by summing the increases in each between counts. If nests, eggs, or chicks produced between counts were offset by unobserved losses, no net increase was detected. Thus, our data represent the minimum number of nests, eggs, and chicks produced.

Birds were not banded but it was usually possible to determine whether a chick was new to the census based upon clutch size, time since last count, and the chick's size and presence in or out of the nest. When the choice was unclear, we assumed the chick was present previously. We did not attempt to estimate the number of young that were fledged from the colonies.

All colonies were not observed on the same days; dates of first visit ranged from 1–18 May (median = 9 May). Colonies were visited on average every 4.5 days (range among colonies was from 3.9 to 5.2 days) and observation periods lasted from 51–94 days, depending upon how long a colony contained active nests.

For each colony, we summarized hatching success as a percentage and chicks per nest as a proportion. Data were normally distributed after arcsine transformations, and differences between group means were tested with t-tests.

RESULTS

All colonies had some nests with eggs when we first visited and four colonies had one or two, apparently infertile, eggs on our last visit. The roof colonies represented a wider range of nest numbers than the ground colonies (Table 1). The number of active nests in ground colonies declined steadily after reaching a peak in May, but roof colonies had a more protracted nesting season, including a small second wave of nesting in July. Although we visited sites at irregular intervals, the mean number of days between visits to a site was not highly correlated with hatching success (Pearson r = 0.142) or the number of chicks produced per nest (Pearson r = 0.139).

When nest data from all colonies were pooled by colony type, the proportion of eggs that hatched in roof colonies (29.1 %) was significantly higher than in ground colonies (10.0 %; χ^2 = 37.03, df = 1, $P < 0.001$). The proportion of nests that produced a chick was also higher on roofs (47.6 % versus 17.8 %; χ^2 = 38.9, df = 1, $P < 0.001$). Nest success, however, is probably not independent among all nests. When productivity of colonies, not individual nests, was compared, differences between roof and ground colony means were not statistically significant, at the 0.05 level, for hatching success ($t = -1.97$, df = 6, $P = 0.10$) or chicks per nest ($t = -1.92$, df = 6, $P = 0.10$). However, a significance level of 0.05 may have been too rigorous, given our small sample sizes (n = 4), to detect the nearly threefold difference in hatching success we observed between roof and ground colonies (Table 1).

DISCUSSION

ESTIMATING SUCCESS

We measured only the net change in nests, eggs, and chicks and, therefore, could estimate only the minimum number produced in each colony. This method overestimates hatching success if, as is likely, some lost eggs and nests were not detected. Nests in three colonies were individually marked and we analyzed data from each with and without the benefit of individual nest identities. Our estimates of the number of eggs and nests in a colony were only slightly greater and the percent of eggs hatched slightly lower (2.3%) when individual nests were identified.

Mayfield (1961) found that failure to calculate daily survival rates throughout the nesting season produced strongly biased estimates of nest success. However, Johnson and Shaffer (1990) showed that a series of periodic searches was a sufficient, and often better, estimator of nest success than the Mayfield method when dealing with colonial species whose nests are initiated in synchrony, subject to catastrophic mortality, and easily detected by observers. Least Tern nests exhibit all these characteristics, thus we believe our estimates of hatching success are reasonably accurate. In any case, biases in our estimates apply equally to roof and ground colonies and should not affect use of the data as relative indices of productivity.

Roofs provided less cover for chicks than vegetated ground sites. To reduce any bias in detecting chicks, we observed colonies from a distance to spot fleeing chicks and searched vegetation for hiding chicks. In both ground and roof colonies we observed most chicks before they left the nest.

CAUSES OF NEST FAILURE

Tracks of house cats, raccoons (*Procyon lotor*), and foxes (probably *Vulpes vulpes*) were seen in the ground colonies and could often be followed from one empty tern nest to the next. Only the St. Andrews colony, which had the poorest hatching success (Table 1), contained tracks of all three predators. We found no evidence of mammalian predators on the roofs. Birds are known to prey on roof and ground colonies of Least Terns (Fisk 1978; Massey and Fancher 1989; R. Densmore, pers. comm.), but the only evidence we observed of predation by birds was one tern egg that was torn open.

Based upon the presence of litter and tracks and reports from property managers human activity in the colonies was infrequent, except at the St. Andrews colony where new footprints were found on each visit. Vehicle tracks were seldom seen and only within the Highway 98 colony. When human disturbance is limited, mammalian predation probably accounts for most differences in productivity between roof and ground colonies.

Two severe storms that struck northwest Florida in June 1989 caused considerable damage in some colonies. Heavy rains and high tides produced by the storms destroyed nearly every nest in the Phipps colony. On the Walmart and Publix roofs the heavy rains left many eggs in standing water, and on all the roofs high winds moved many eggs out of the nest scrapes. The high winds and flooding from severe storms are potentially a major cause of nest failure on roofs; unfortunately, our single season of data provides no long-term perspective on the frequency or severity of losses due to storms.

IMPORTANCE OF ROOFS

Our finding of greater hatching success in nests on roofs versus those on the ground was contradicted somewhat by the absence of significant differences in colony productivity between roof and ground sites. We suspect, however, that our small sample sizes prevented differences between the colony types from being detected as significant at the 0.05 level. The relatively high probabilities ($P = 0.10$) obtained with the small samples suggest that real differences in productivity exist between roof and ground colonies. Other evidence supports this conclusion. Fisk (1978) cited a study in northeast Florida that found higher nest success in roof colonies than ground colonies and Thompson (1979) reported similar results from South Carolina. Furthermore, all roof colonies we studied were active the next year, while two of the ground colonies were abandoned and a third had 70% fewer nests.

Whether roof colonies are more productive than ground colonies is perhaps of less concern than knowing they are as productive. Because roofs are novel, artificial nesting sites, they are often presumed to be unproductive or, at best, inferior to ground sites. In terms of hatching success, our data show roof colonies are as productive as ground colonies and probably more so. Still, roofs can present a variety of hazards to Least Tern eggs and chicks (Fisk 1975, 1978) and not all roof colonies are successful (Table 1). Compared with Least Tern colonies elsewhere (Massey and Atwood 1981, Burger 1984, Burger and Gochfeld 1990), the roof colonies we observed were only moderately successful. If our data are representative of most colonies and years, productivity in both roof and ground colonies is of concern.

Although Least Terns are typically loyal to former nesting sites, they will abandon sites that become physically unsuitable or are consistently unproductive (Burger 1984, Kotliar and Burger 1986, Atwood and Massey 1988). Unfortunately, Least Terns prospecting for nesting sites in northwest Florida have few undisturbed ground sites available because much of the suitable beach habitat has been usurped by humans. The proliferation of gravel-covered roofs has provided Least Terns a variety of new nesting sites that are relatively free of humans and mammalian predators. In addition, the nesting habitat provided by roofs, unlike that on the ground, remains essentially unchanged by storms or vegetative succession. More research on roof colonies is needed to determine annual variation in hatching success, actual fledging rates, availability of foraging habitat in urban areas, and means of increasing colony productivity.

The use of gravel-covered roofs by nesting Least Terns will probably increase as more of these roofs are built. Unfortunately, a smooth, rolled plastic, which is unsuitable for nesting terns, is now frequently used instead of tar-and-gravel to cover flat roofs. Even existing roofs are often renovated with plastic and several Least Tern colonies in northwest Florida have abandoned sites when gravel-covered roofs were replaced with plastic. If this trend continues, along with an increasing use of beaches by humans, the Least Tern population in the southeast will be seriously limited by the availability of productive nesting sites and increased protection of existing sites will become even more important.

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BREEDING DISTRIBUTION AND HABITAT OF PRAIRIE FALCONS IN NORTHERN MEXICO[1]

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Key words: Prairie Falcon; Falco mexicanus; *Mexico; distribution; breeding; habitat.*

The Prairie Falcon (*Falco mexicanus*) breeds in Canada and the United States (US) south to Baja California, southern Arizona, southern New Mexico, western Texas, and southeastern Coahuila (AOU 1983). C. A. Ely (1962) collected one of two immature Prairie Falcons on 30 June 1958 at a nest cliff in the mountains of southeastern Coahuila; this is the only published nesting record we are aware of for Mexico outside of Baja California. We observed Prairie Falcons, located Prairie Falcon nest sites, and collected limited data on their occupancy, productivity, and habitat during a study of Peregrine Falcons (*Falco peregrinus*) in northern Mexico between 1975 and 1986.

STUDY AREA AND METHODS

The study area (Fig. 1) included the mountains of northern Mexico, known as the Sierra Madre Occidental in northwestern Mexico and the Sierra Madre Oriental in northeastern Mexico. Sheer cliffs are common in the mountains and canyons. Cliffs in the northwest are of mostly igneous origin, those in the northeast are usually limestone. The climate varies with altitude and with proximity to the moist coastal regions or interior arid desert. Spring and summer temperatures generally range from 10–30°C in the mountains. Mean

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