A COMPARATIVE STUDY OF NESTING FORSTER'S AND BLACK TERNS

ROBERT D. BERGMAN, PETER SWAIN, AND MILTON W. WELLER

FORSTER'S Terns (*Sterna forsteri*) and Black Terns (*Chlidonias niger*) breed sympatrically in marshes throughout the prairie pothole region of southern Canada and the northern United States (Amer. Ornithol. Union, 1957). Nest-sites of Black Terns typically are on low and wet substrates, but Forster's Terns use higher and drier sites over water (Weller and Spatcher, 1965). This paper reports an effort to appraise potential competition for nest-sites by determining (1) the precise differences in nest-site utilization, and (2) the habitat characteristics of the nest locale which may influence site selection.

Preliminary observations were made during the summers of 1959 through 1963 in connection with studies of other marsh birds. Detailed investigations were conducted during 1966 to 1968 under sponsorship of the National Science Foundation Undergraduate Research Participation Program at Iowa State University. We are indebted to the following students who assisted in field work: James E. Doidge, Leigh H. Fredrickson, Daniel M. Herrig, and Larry O. Zach.

STUDY AREAS AND METHODS

The two major study areas were Rush Lake, south of Ayrshire, Palo Alto County, Iowa, and Dan Green Slough in Clay County, northwest of Ruthven, Iowa. Additional observations were made at Barringer Slough, Smith's Slough, and the Oppedahl area near Ruthven.

Cover maps were prepared annually from measurements made on the ice during the winter and spring, using an aerial photo as a base-map. According to the classification scheme used by Weller and Spatcher (1965) for semi-permanent, fresh-water marshes, Rush Lake was in the "hemi-marsh stage" throughout the study, having nearly equal amounts of open water and cattail (*Typha augustifolia*) and its hybrids. Muskrats were abundant and were responsible for many openings in the emergent vegetation. There was a slight increase in open water from 1966 to 1968. Dan Green Slough was in the "open-water stage" with only a few clumps of cattail as the result of an "eat-out" by a rising muskrat population that used most of the available vegetation for food and lodges. Clumps of cattail became progressively reduced throughout the study. During 1966 and especially 1967, there were few muskrats or muskrat lodges at Dan Green Slough. By 1968, the slough was nearly dry and observations were made only from shore.

Nests were found by using a canoe. Each nest was numbered and marked with a willow pole. The following data were recorded at each nest: (1) clutch size, (2) height of nest bowl above water, (3) origin of the nest substrate, (4) composition of nest

Journal Paper No. J-6158 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project No. 1504.

TABLE 1

FREQUENCY OF OCCURRENCE OF NESTS ON SINGLE SUBSTRATES, 1966–68.

	No. of Nests per Substrate					No. of Nests	Mean ± S.E.
	1	2	3	4	5		
Forster's Tern	73 (86%)	9 (11%)	0	1 (1%)	2 (2%)	85	1.2 ± 0.10
Black Tern	197 (100%)	0	0	0	0	197	1.0 ± —

substrate, (5) diameter of nest substrate at water level, and (6) species and relative abundance of plants that make up the surrounding vegetation at each nest site. Locations of nests were mapped on cover maps.

NESTS AND NEST-SITES

Both species of terns sometimes construct a shallow cup-nest with pieces of emergent plants on a substrate of submergent plants or on floating boards. More commonly, however, they use a substrate where little nest construction is necessary but add a few pieces of vegetation to the rim of a natural depression.

Spacing of nests.—Terns are social birds and usually nest in colonies. Spacing of nests seems to be influenced by the distribution of suitable nest substrates and, presumably, by territorial behavior. We did not study interspecific behavior, however, and observed no conspicuous interactions.

Nests of Black Terns tended to be grouped in certain favorable areas of the marsh, but their nests were dispersed within these areas. In no case was more than one Black Tern nest found on one substrate such as a muskrat lodge (Table 1). Forster's Terns were more social, however, and nests commonly were grouped in "islands" of cattail. Two or more nests occurred on one lodge 14 per cent of the time (Table 1) and large lodges contained up to 5 nests.

Although we did not study tern nests in small marshes, we did note an absence of Forster's Terns in such places. Small water areas were used by Black Terns but usually these held only one pair, whereas larger marshes held many pairs (Provost, 1947:500).

Substrate utilization.—During the 3 years of intensive study, most nests were on muskrat lodges or feeding platforms (Table 2), but some floating materials were used. Usually they were rootstalks or rafts of emergent vegetation lodged between standing vegetation. At other lakes, we have observed that both species may build nests on floating boards held in place by emergent vegetation.

A comparison of nest-sites used at the two lakes indicates the significance of availability of substrates to their use (Table 2). Rush Lake, in the hemi-

TABLE 2

NEST SUBSTRATE UTILIZATION.

Substrate	Forster's Tern	Black Tern
A. Rush Lake, 1966–68		
Active Muskrat Lodge	58 (68%)	—
Inactive Muskrat Lodge	26 (30%)	42 (48%)
Muskrat Feeding Platform	—	20 (23%)
Floating Cattail Rootstalks	—	10 (11%)
Dead Floating Emergent Vegetation	2 (2%)	16 (18%)
Total	86 (100%)	88 (100%)
B. Dan Green Slough, 1966–67		
Active Muskrat Lodge	2 (10%)	—
Inactive Muskrat Lodge	3 (14%)	8 (7%)
Muskrat Feeding Platform	—	1 (1%)
Floating Cattail Rootstalks	12 (57%)	94 (86%)
Dead Floating Emergent Vegetation	4 (19%)	6 (6%)
Total	21 (100%)	109 (100%)
C. All Nests, 1966–68		
Active Muskrat Lodge	60 (56%)	—
Inactive Muskrat Lodge	29 (27%)	50 (25%)
Muskrat Feeding Platform	—	21 (11%)
Floating Cattail Rootstalks	12 (11%)	104 (53%)
Dead Floating Emergent Vegetation	6 (6%)	22 (11%)
Total	107 (100%)	197 (100%)

marsh condition, had a large muskrat population that provided abundant lodges and feeding platforms on which both Forster's and Black terns nested. Dan Green Slough, in the "open marsh" condition, had only a small muskrat population, and nest-sites associated with muskrat lodges or feeding platforms were relatively scarce compared with Rush Lake.

Almost all Forster's Terns nesting at Rush Lake used large, high muskrat lodges, 68 per cent of which were active (Table 2). Less than 15 lodges were present at Dan Green Slough. However, floating cattail rootstalks were common, and these were used by 57 per cent of the nesting Forster's Terns. In 1960, Rush Lake had a large central open water area with only one large island of cattail. Most of the nests found were in this island although there were numerous muskrat lodges in excellent stands of cattail toward the shore. Of 28 nests located in 1960, 12 (43 per cent) were on floating rootstalks resulting from high water levels; 18 were on muskrat lodges. This colonial

TABLE 3

HEIGHT OF NEST BOWL ABOVE WATER (CM), 1966–68.

Substrate	Forster's Tern		Black Tern	
	No. of Nests	Mean ± S.E.	No. of Nests	Mean ± S.E.
Active Muskrat Lodge	58	29.8 ± 2.5	—	— —
Inactive Muskrat Lodge	31	15.0 ± 1.8	51	3.4 ± 0.4
Muskrat Feeding Platform	—	— —	21	2.8 ± 0.2
Floating Cattail Rootstalks	12	6.0 ± 0.4	102	3.6 ± 0.2
Dead Floating Emergent Vegetation	6	4.7 ± 1.2	23	2.3 ± 0.3
Total	107	21.4 ± 5.3	197	3.3 ± 0.2

behavior reflects another aspect of nesting not well recorded in this study: their sociality seemingly exceeded preference for any specific nest-site.

Similar use of available sites was obvious for Black Terns. Seventy per cent of the nests were associated with muskrat structures at Rush Lake, but none were actively being used by muskrats. Most were old and soggy. Evidently because there were no muskrat lodges, eighty-six per cent of the nests at Dan Green Slough were built on floating cattail rootstalks.

Substrate size.—A gross comparison of height of the nest bowl above water and substrate diameter of Forster's and Black Terns (Tables 3 and 4) indicates that Forster's Terns used larger nest substrates than did Black Terns. Heights of substrates for Forster's Tern nests averaged 21.4 cm (107 nests) above the water compared with 3.3 cm (197 nests) for Black Tern nests. Forster's Terns used nest substrates averaging 138.8 cm (94 nests) in diameter compared with 52.2 cm (197 nests) for Black Tern nest substrates.

TABLE 4

DIAMETER OF NEST SUBSTRATE (CM), 1966–68.

Substrate	Forster's Tern		Black Tern	
	No. of Nests	Mean ± S.E.	No. of Nests	Mean ± S.E.
Active Muskrat Lodge	54	171.8 ± 6.0	—	— —
Inactive Muskrat Lodge	31	104.1 ± 2.3	52	84.7 ± 5.8
Muskrat Feeding Platform	—	— —	20	47.9 ± 6.8
Floating Cattail Rootstalks	4	36.5 ± 3.5	105	41.6 ± 1.4
Dead Floating Emergent Vegetation	5	79.9 ± 2.1	20	27.8 ± 4.3
Total	94	138.8 ± 6.3	197	52.2 ± 2.5

Differences in site selection can be seen by comparing each nest substrate category between the Forster's and Black Tern (Table 3). In 1966, when both species used floating cattail rootstalks on Dan Green Slough, nest bowls of Forster's Terns still averaged 6.0 cm (12 nests) above the water but Black Tern nests averaged only 3.6 cm (48 nests). On inactive muskrat lodges, the average nest bowl height of Forster's Terns was 15.0 cm (31 nests), but those of Black Terns averaged 3.4 cm (51 nests) during 1966–1968.

The use of active muskrat lodges by Forster's Terns when Black Terns did not use this substrate probably does not account for all the difference in nest substrate size between the two species (Table 4). Because deserted lodges tend to flatten out from lack of care, these structures often enlarge during deterioration. Hence, one may conclude that Black Terns actually select smaller substrates than do Forster's Terns and that their use of any wet structure allows greater flexibility in selection of nest-sites.

VEGETATION SURROUNDING THE NEST

The presence and nature of vegetation surrounding the nest was recorded at each nest-site. At Rush Lake, all Forster's Tern nests were associated with an open pool of water. Nests usually were on muskrat lodges or on floating rafts of cattail at the edge of an opening created by muskrats. The higher and drier lodges used by Forster's Terns appeared unaffected by wave action, and vegetation surrounding the nest seemed of little importance. These lodges form an "island" habitat which, like the large "islands" of cattail, are preferred by Forster's Terns over other areas. In contrast, Black Tern nests occurred in a variety of vegetative situations from dense stands of cattail to "open water." In the latter case, their nests were protected from wave action by submergent or emergent plants. A total of 38 Black Tern nests (42 per cent) was found at Rush Lake in open water areas created by muskrats; the nest substrate in this situation was either a deteriorated muskrat lodge or a muskrat feeding-platform.

Floating vegetation (mainly *Lemna* spp.) occurred around nest-sites of both species but was more abundant around Black Tern nest-sites that were protected from wave action by emergent vegetation. Floating vegetation around nest-sites in open water was relatively light in density due to dispersion by wind and wave action. During this study, Forster's Tern nests were initiated before floating vegetation became abundant, but Black Tern nests were initiated both before and after the development of abundant floating vegetation.

CHRONOLOGY OF NESTING

During 1966, Forster's Terns began nesting at Dan Green Slough during the last week of May and at Rush Lake during the first week of June (Fig. 1).

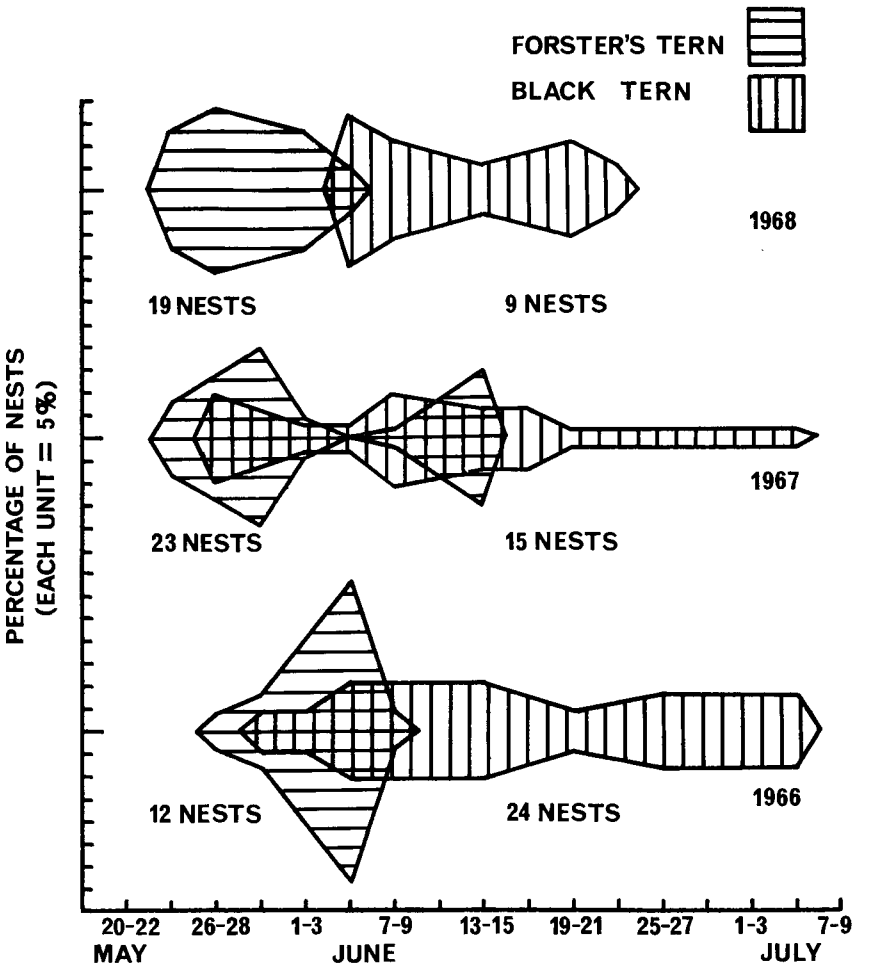

FIG. 1. Chronology of nest initiation by Forster's and Black Terns on Rush Lake (1966–68) and Dan Green Slough (1966–67).

Hatching was complete at both marshes by the last of June. In 1967 and 1968, the first nests of a Forster's Tern colony were found during the last week of May at Rush Lake, but all nests were destroyed within two weeks. In 1967, a second colony began nesting during the middle of June, presumably renesting birds of the first group, but all nests again were destroyed before hatching.

Black Terns began nesting during the last week of May in 1966 and 1967, and new nests were found continually through the first week of July (Fig. 1). In 1967, heavy rains during the middle of June destroyed a large number

TABLE 5

NEST SUCCESS BY NEST SUBSTRATE, 1966–68.

Substrate	Successful	Unsuccessful	Undetermined
Forster's Tern:			
Active Muskrat Lodge	7 (12%)	49 (84%)	2 (4%)
Inactive Muskrat Lodge	3 (10%)	27 (87%)	1 (3%)
Muskrat Feeding Platform	—	—	—
Floating Cattail Rootstalks	1 (8%)	10 (83%)	1 (8%)
Dead Floating Emergent Vegetation	2 (33%)	4 (67%)	—
Total	13 (12%)	90 (84%)	4 (4%)
Black Tern:			
Active Muskrat Lodge	—	—	—
Inactive Muskrat Lodge	18 (39%)	22 (48%)	6 (13%)
Muskrat Feeding Platform	6 (30%)	11 (55%)	3 (15%)
Floating Cattail Rootstalks	24 (23%)	76 (72%)	5 (5%)
Dead Floating Emergent Vegetation	8 (38%)	12 (57%)	1 (5%)
Total	56 (29%)	121 (63%)	15 (8%)

of the Black Tern nests and nests found in early July probably were a product of renesting. In 1968, new nests were initiated from 6 June through 22 June.

Although Forster's Tern nests were initiated only a few days before the first Black Tern nests, the bulk of the colony of Forster's Terns initiated nest simultaneously, but new Black Tern nests were initiated throughout June and into July (Fig. 1).

CLUTCH SIZE

The average clutch size was calculated from the observed clutches only if the egg numbers did not change during one week of observation. Clutch size in both Forster's and Black Terns ranged from 1 to 4 eggs. The average clutch size of 92 Forster's Tern nests was 2.5 ($\pm$ 0.07) eggs while the average Black Tern clutch was 2.6 ($\pm$ 0.02) eggs for 151 nests. For both species, clutches of three eggs occurred most frequently (58 per cent of Forster's and 63 per cent of Black Terns), and clutches of 2 eggs were more frequent than clutches of either 1 or 4.

INCUBATION PERIOD

The incubation period was determined by the time elapsed between the last egg laid and the last egg hatched in a clutch. Because nests usually were visited only once weekly, relatively few nests provided accurate records of

incubation periods. Average incubation period for 11 Forster's Tern nests was 24.2 days and for 28 Black Tern nests was 21.4 days.

NEST SUCCESS

Nest success for Forster's and Black terns during 1966 to 1968 is compared by nest substrate in Table 5. Nests were considered successful if at least one young hatched and appeared to have survived at the nest-site. This was determined by rechecking the nest weekly after hatching. The fate of some nests was not determined because evidence of success or failure was not found. Nest success of Forster's Tern nests for which fate was determined was 12 per cent (13 of 107 nests) compared with 29 per cent of 192 Black Tern nests. Causes of failure of tern nests were attributed to one of the following: wind and wave action, muskrat activity, and predation or intraspecific strife. During June of 1967, heavy rains caused rising water levels and increased muskrat building activity. This evidently caused some destruction of Forster's Tern nests because egg shells were found buried under fresh cattail cuttings. Destroyed eggs were found with small punctures so that some intraspecific strife may have been involved (Bongiorno, 1968), but the possibility of damage by other birds cannot be ignored (Pessino, 1968). Wind and wave action evidently caused most of the failures of Black Tern nests during this study, particularly in open areas where the sparse emergent vegetation was not sufficient to protect the low nests.

Unfortunately, there is no obvious pattern of nest success according to nest-site or area. Year by year analyses showed that the best success of Forster's Terns was in 1966 when 36 per cent of 46 nests hatched compared with only 4 per cent of 26 nests in 1967 when heavy rains and rising water levels were involved. There also was a suggestion of higher nest success of Forster's Terns on active lodges (39 per cent of 18 nests in 1966) versus inactive (17 per cent of 12 nests in 1966) or floating cattail rootstalks (8 per cent of 12 nests in 1966).

DISCUSSION

The results of this study indicate that when Forster's Terns and Black Terns inhabit the same marsh, they seemingly do not compete for nest-sites. The most clear-cut difference was the use of higher and drier nest-sites by Forster's Terns while Black Terns utilized lower and wetter sites. Active or recently active muskrat lodges were the only nest substrates utilized by the Forster's Tern at Rush Lake even though other nest substrates were available. Muskrat lodges provide the highest nest substrate on the marsh and seemed to be preferred, but lower sites were used at Dan Green Slough when muskrat lodges or new, high muskrat lodges were not available. Nevertheless, even these

nest sites were larger and higher above the water than were Black Tern nest-sites of similar material in the same marsh. Black Terns nested on a variety of nest substrates at Rush Lake but all were low and wet whereas sites used by Forster's Terns were usually dry.

Black Terns apparently preferred emergent vegetation surrounding the nest-site. The density of the vegetation varied, but this habitat requirement functioned to reduce wind and wave action around the low nest-site. At Rush Lake, Forster's Tern nest-sites were surrounded by open water, which varied from a small pool created by muskrats to a large open pool. Open water surrounding the nest-site may be a result of Forster's Tern utilization of muskrat lodges and not necessarily a nest-site stimulus, but they will use very isolated lodges in the middle of open water. Floating vegetation generally was more abundant around nest-sites of Black Terns because emergent vegetation reduced wind and wave action, but terns nesting late in the season may select for such areas.

Different food habits and methods of feeding also may reduce competition between Forster's and Black Terns. Martin, Zim and Nelson (1951) state that Black Terns are insectivorous, feeding primarily upon mayflies, dragonflies, caddisflies, beetles, and spiders. Forster's Terns eat fish as their staple food although some aquatic insects may be taken. In a publication on gulls and terns of southern U. S. S. R., Borodulina (1966) classified Black Terns mainly as insectivores that occasionally feed on small fish and tadpoles. He observed that Black Terns are especially ichthyophagous in areas where stunned young fish float on the surface. Borodulina also described differences in wing structure and flight behavior that adapts the Black Tern and the black-capped terns of the genus *Sterna* to their common foods.

Possibly the evolution of these terns was one of isolation on small (Black Tern) versus large (Forster's Tern) water areas, which also is related to their insectivorous (Black Tern) versus ichthyophagous (Forster's Tern) food habits. At the present time they nest in the same marshes with little or no obvious competition for nest-sites.

SUMMARY

Forster's Terns and Black Terns occur in the same large marshes, but Black Terns nest in small "potholes" in dense vegetation, or more densely vegetated sites on large marshes. During this study, Black Terns used a variety of low and wet nest substrates, averaging only 3.3 cm above the water. In contrast, Forster's Tern nests were placed an average of 21.4 cm above the water and most frequently were placed on large muskrat lodges (83 per cent). Forster's Tern nests usually were on substrates in or at the edge of open pools of water surrounded by "islands" of cattail but Black Tern nests occurred in vegetative situations ranging from dense stands of cattail to "open water."

LITERATURE CITED

AMERICAN ORNITHOLOGISTS' UNION. 1957. Check-list of North American birds. Fifth ed., Baltimore, Maryland.

BONGIORNO, S. F. 1968. Egg puncturing behavior in Laughing Gulls. Auk, 85:697–699.

BORODULINA, T. L. 1966. Biology and economic importance of gulls and terns of southern U. S. S. R. water bodies. Israel Program of Scientific Translations Ltd., Jerusalem.

MARTIN, A. C., H. S. ZIM, AND A. L. NELSON. 1951. American wildlife and plants. Dover Publications, Inc. New York.

PESSINO, C. M. 1968. Redwinged Blackbird destroys eggs of Common and Roseate Terns. Auk, 85:513.

PROVOST, M. W. 1947. Nesting of birds in the marshes of northwest Iowa. Amer. Midland Naturalist, 38:485–503.

WELLER, M. W., AND C. E. SPATCHER. 1965. Role of habitat in the distribution and abundance of marsh birds. Agriculture and Home Economics Experiment Station Spec. Rpt. 43. Iowa State University, Ames, Iowa.

DEPARTMENT OF ZOOLOGY AND ENTOMOLOGY, IOWA STATE UNIVERSITY, AMES, IOWA 50010, 12 FEBRUARY 1969.

REQUEST FOR INFORMATION

As a part of the study on Golden Eagle ecology juveniles of this species were color-marked in southwestern Idaho to determine movement and migration patterns. Marked birds carry a crescent-shaped vinyl band around the humeral area of one or both wings. The colors used were red, pink, yellow, orange, dark green, white, and blue. Information desired includes: color of marker on each wing; the date and location of the sighting; and the observer. Send any information to Michael N. Kochert, Idaho Cooperative Wildlife Research Unit, University of Idaho, Moscow, Idaho 83843.