BILL COLOR CHANGES IN ADULT ROSEATE TERNS

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THE bill of the Roseate Tern (*Sterna dougallii*) is usually described as black with some red at the base. Pough (1951) says "Its bill is black except for a little red at the base (occasionally more)." Peterson (1947) refers to the bills with red as "variant." In his European guide (1954) he recognizes the seasonal factor saying, "Bill black with red base in summer, all-black in winter." Robertson (1964) noted that most of the Roseates seen at the end of May 1962 in the Tortugas, Florida, had red at the base of the bill. Bureau (1905), studying Roseates off the coast of Brittany, France, appears to be the only person to have noted a seasonal increase in the amout of red on the bill. He found that red first appeared in early June and gradually extended to cover half of the upper mandible and a third of the lower mandible. He also noted that the terns maintained this red and black bill color throughout their stay in the colony. Guichard (1955), also studying terns off the coast of Brittany, made the significant observation that the red basal coloration of the bill did not occur until rather late in the period of reproduction. He found that none of the birds observed on Ile aux Moutons 10 June 1953 bore a trace of red on the bill, while their eggs were almost ready to hatch. Cooper et al. (1968) concluded from field observations on Great Gull Island, New York, that the bills of Roseate Terns there begin to change color soon after the birds start to incubate. I find no discussion in the literature of the return to an all black bill.

The purpose of my study was to determine the nature, timing, and extent of the bill color changes in the Roseate Terns on Great Gull Island. An attempt was also made to determine what factors influence these changes. The study was conducted 16 June–4 July, 8 August–13 August and on all weekends, except 14–16 July between 8 July and 4 September 1967.

Great Gull Island, New York, 41° 12′ N, 72° 07′ W, is 8 miles off the northeastern tip of Long Island. It is a rocky island, about ½ mile long by 1/10 mile wide. In 1966 at least 1,100 pairs of Roseate Terns and 1,300 pairs of Common Terns (*Sterna hirundo*) nested here. The numbers in 1967 were about the same.

Roseate Terns were caught in wire mesh treadle traps set over their nests. Traps were placed first on nests with pipping eggs or newly hatched chicks, as the adults returned most quickly to such sites. Terns whose nests were located deep in rock crevices were nearly impossible to trap.

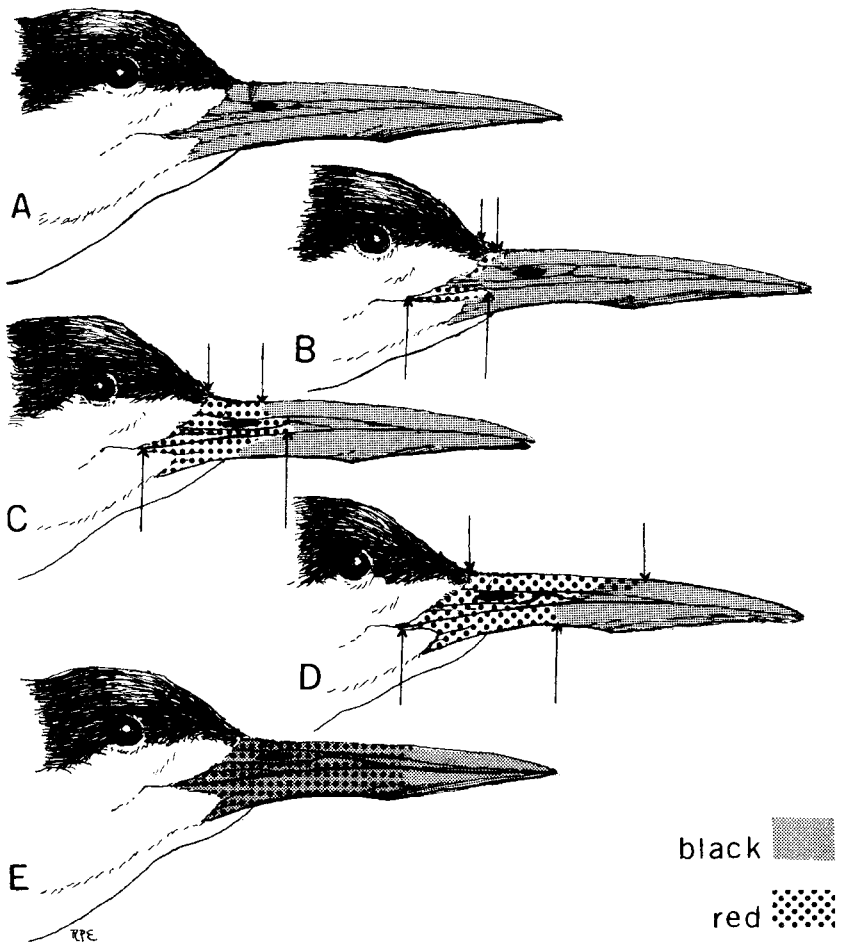

Figure 1, A–E. Several stages of bill color change in Roseate Terns. Arrows indicate where measurements were made.

Otherwise traps were set on nests as encountered while at the same time an attempt was made to sample groups on all parts of the island.

The terns were banded with individually color-coded combinations and the amount of red on their bills was measured. Measurements were made to the nearest half millimeter with dividers and ruler, and after 29 June with dial calipers. Two measurements were made: along the culmen from the edge of the feathers at the base of the bill to the point at which red was no longer visible, and along the lower mandible from the gape to the point on the commissure where red ended (Figure 1, B–D). The second

TABLE 1

MILLIMETERS OF RED ON THE CULMEN OF ROSEATE TERNS WITH EGGS OR WITH CHICKS NOT MORE THAN 3-DAYS OLD

Date	Birds measured[1]	Mean	Range	Standard deviation	Standard error
21 June	17	2.5	0.5–11	2.43	0.59
22 June	17	2.9	1.0–10	1.97	0.48
23 June	26	2.8	1.0–10	2.06	0.40
24 June	57	2.1	0–8	1.43	0.28
25 June	29	2.8	1.0–5.5	1.02	0.19
26 June	12	3.8	1.5–15	3.61	1.04
27 June	47	4.0	1.0–10	2.76	0.40
28 June	31	4.1	1.5–15	2.46	0.44
29 June	38	4.6	1.0–14	2.88	0.47
30 June	8	3.4	2.0–4	0.74	0.26
1 July	3	4.2	3.5–4.5		
2 July	3	4.5	4.0–5		
3 July	3	4.3	3.5–5		
7 July	2	10.5	6.0–15		
21 July	2	9.3	6.0–12.5		
22 July	5	6.8	3.0–10		
23 July	4	8.6	5.5–20.5		
29 July	4	8.8	5.5–15		

[1] Numbers of different individuals: no remeasured individuals included.

measurement was highly variable and not a good index of the amount of red on the rest of the bill. For this reason it is not used here.

Gross measurements were used because the distance from the base of the feathers to the anterior end of the nares is almost exactly the same in all Roseate Terns. In 50 Roseate Tern skins of both sexes at the American Museum of Natural History, this distance measured 9 mm in 42 and varied by 0.5 mm in 8. Later in the season when red extended beyond the nares, the extent of red as a percentage of total bill length was also computed.

The change from an entirely black bill (Figure 1A) to a red and black bill takes place as follows: The soft parts around the rictus are the first to become red. Red is next seen along the culmen and along the sides of both mandibles (Figure 1B). The amount of red may not be exactly equal on both sides of the mandibles, but I found no consistent pattern. Red frequently extends farther on the sides of the upper mandible toward the nares than it does on the culmen or on the lower mandible (Figure 1C). Along the tomia the red usually extends to about the same point on both the upper and lower mandibles. The red may be rather pale or very

TABLE 2

COMPARISON OF RED ON THE CULMENS OF THOSE ROSEATE TERNS WITH EGGS AND THOSE WITH CHICKS

	Number of birds		Mean mm of red		Standard deviation		Standard error	
	E[1]	C[1]	E	C	E	C	E	C
24 June	18	9	1.7	2.0	1.2	1.3	0.3	0.4
25 June	10	12	2.0	3.3	0.7	1.1	0.2	0.3
27 June	19	18	3.6	4.7	2.9	3.1	0.6	0.7
28 June	9	12	3.0	5.2	0.8	3.6	0.3	1.0
29 June	15	10	5.5	4.5	1.9	0.9	0.5	0.3

[1] E signifies adult Roseates with eggs; C, those with chicks.

bright, orange-red or blood red. The maximum measured amount of red extended just half way along the culmen (Figure 1D). The maximum observed in the field extended along at least two-thirds of the culmen.

When Roseate Terns arrive at Great Gull Island the first week of May their bills are entirely black. Photographs and observations indicate that no red appears on their bills until they have nests with eggs (Cooper et al., 1968). At first the visible red increases slowly. The bills of incubating terns usually do not have more than 4 mm red, although exceptional individuals may have up to 11 mm. Of the Roseates measured before 25 June 90 per cent were incubating (Table 1).

During the hatching peak, 25–29 June, the mean amount of red increases. Using those Roseates measured for Table 1 for which I had nesting data, I compared the mean bill measurements of Roseates with chicks and Roseates with eggs (Table 2). The means for both groups increase, the group with chicks showing slightly higher means on 4 days. Except on 25 June the differences between the means of the two groups were not statistically significant at the 95 per cent level, possibly because the chicks of the birds measured were usually less than a day old.

Two terns whose bills were measured when their chicks hatched and remeasured 3 days later showed a post-hatching acceleration of red. The red on the bill of one of these increased from 5 to 10 mm, on the other from 3 to 12 mm. It is difficult to obtain measurements for this acceleration because chicks more than a day old wander out of the traps and cannot be used to attract the adults. By about 4 July, shortly after the hatching peak, enough increase had occurred for the red on the bills of most Roseates to be quite noticeable.

Observations indicate that the red continues to increase for some time, perhaps for 3 weeks after the chicks hatch. The maximum extent of red

seems to be attained just about when the young begin to fly, usually about the last week of July.

The change to a red and black bill occurs in all nesting Roseate Terns of both sexes. A few completely black-billed Roseates were seen as late as 23 July. As these were usually at the periphery of the colony and showed no attachment to a nest site, I believe that they were nonbreeding birds.

Thus some relationship exists between the timing of the bill color change and the nesting status of the terns on Great Gull Island. The data for Roseates measured in July (Table 1) further illustrate this relationship and indicate that season alone does not regulate the timing of the change.

As no red can be seen on the bill until a tern has eggs, even late in July birds just beginning to incubate have only a small amount of red. Roseate Terns may renest if their first clutch is destroyed. The bills of such birds would be expected to have more red than those of birds on their first clutch. This probably explains why the bills of some of the Roseates in July were very red although the birds were still incubating (Table 1).

Late in the season the bill reverts to black again. This change is qualitatively very different from the acquisition of the red base. At first black pigment appears diffused throughout the entire area of red (Figure 1E). The red may begin to fade just preceding or during the return of the black. The red gradually disappears and the black intensifies until the bill is again all black.

As the black diffuses over a wide area, this bill color change cannot be measured effectively. I did examine and photograph several terns that Donald Cooper mist netted 29 and 30 July, the first birds seen with returning black, and 10 August, a bird with considerable black. Between 30 July and 4 September I studied the birds from a rowboat off the island, a good vantage point for watching the many Roseates standing on the rocks near the shore. I examined the bills of all the Roseates, paying particular attention to color-banded birds that were measured earlier in the season.

Some evidence suggests that the return to an all black bill does not begin so long as a tern has nonflying young. The bill of one Roseate, for instance, had 14 mm red 29 June and an estimated 15–20 mm red 19 August. This bird had apparently renested for its egg was damaged in June and it was feeding a chick on 19 August.

The bills of about 50 per cent of the Roseates remaining on the island in August retained visible red and did not appear to be changing. These birds were probably the parents of nonflying young. When no young are

present the complete change from a red and black to an all black bill can take place within a month. One Roseate whose bill measured 20 mm or 50 per cent red on 23 July was noted 19 August with a completely black bill. When this bird was measured in July it had a newly hatched chick; one week later the chick could not be found and was presumed dead. Some terns stayed in the vicinity of the island after they seemed to have finished nesting, accounting perhaps for the 50 per cent of Roseates on the island in August whose bills were visibly changing to all black. Only two had bills that had changed completely.

On 4 September two Roseate Terns remained on Gull Island with their chick; their bills were still red and black. On the same date of 19 Roseates seen along the Connecticut coast 12 had bills changing to all black and 7 had completely black bills. On 17 September all but one of approximately 200 Roseate Terns noted at the eastern end of Long Island, New York had very dark or all black bills.

Hormones are almost certainly responsible for the direct regulation of bill color changes in Roseate Terns. As the change to a red and black bill takes place after rather than before mating, the hormones and mechanisms involved may be quite different from those described for other species (Witschi, 1961).

So far I have no information on the significance of the bill color changes. Quine and Cullen (1964) have shown that a red and black bill is very effective in eliciting the pecking response of young Arctic Tern (*Sterna macrura*) chicks. Unlike the Arctic Terns, however, Roseate Tern chicks do not peck at the parent's bill to be fed.

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