GROWTH AND SURVIVAL OF ROSEATE AND COMMON TERN CHICKS

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ALTHOUGH a number of studies have been made of the breeding biology of temperate zone terns of several species, only a few seem to have attempted to follow the growth of the young up to the time they can fly. Szulc-Olechowa (1964) and Cymborowski and Szulc-Olechowa (1967) studied the growth of Common Tern (*Sterna hirundo*) chicks in Poland, both in the wild and in captivity. In each of the other cases that have come to our attention, weights and measurements were obtained supplementary to work on other aspects of the reproductive cycle (see for example, Floyd, 1927; Heinroth and Heinroth, 1928; Marples and Marples, 1934; Palmer, 1941; Hardy, 1957; Boecker, 1967). Therefore it seemed desirable to attempt a study concentrating on growth and survival of tern chicks, particularly as we had the opportunity to compare in this respect Common and Roseate (*Sterna dougallii*) Terns nesting in the same colony.

In 1967 and 1968 we worked on Great Gull Island, one of a chain of islands that stretches across the eastern end of Long Island Sound between Orient Point, Long Island, New York, and Watch Hill, Rhode Island. Now the site of a large breeding colony of Roseate and Common Terns, the island was formerly the site of Fort Michie, maintained by the U. S. Army from the time of the Spanish-American War until the end of World War II. For a history of the tern colony on this island both before and after the period of military use, see Heilbrunn (1970) and Pessino (1970). Hays (1970b) presents a comprehensive account of breeding in the entire colony in the 1967 and 1968 seasons. Cooper et al. (1970) may be consulted for a description of the island ecology.

MATERIALS AND METHODS

In both years our experimental Common Tern nests were enclosed by fences of 1-inch poultry mesh 2 feet high. These contained the young until they flew. Most of our nests were in groups of 10 or more, but occasional single nests were enclosed by fences at least 4 feet in diameter, which did not make the adult birds desert. The nests were all numbered as part of an overall study of breeding of the two species on Great Gull Island (Hays, 1970b).

Because of their sheltered locations, Roseate Tern nests were more difficult to enclose. Erecting wire so that young birds could not slip underneath, either through the grass or on the concrete remaining from the old military structures, proved very difficult. We depended mostly on the fact that young Roseates, once they leave the nest, tend to stay in the same grass tunnels day after day.

In 1967 we spent 11 consecutive days (24 June–4 July) on the island, and the subsequent weekends of 7–9, 14–16, 21–23, 28–30 July. The period 24 June–4 July was near the peak of hatching. We made daily checks of 22 Common and 60 Roseate nests

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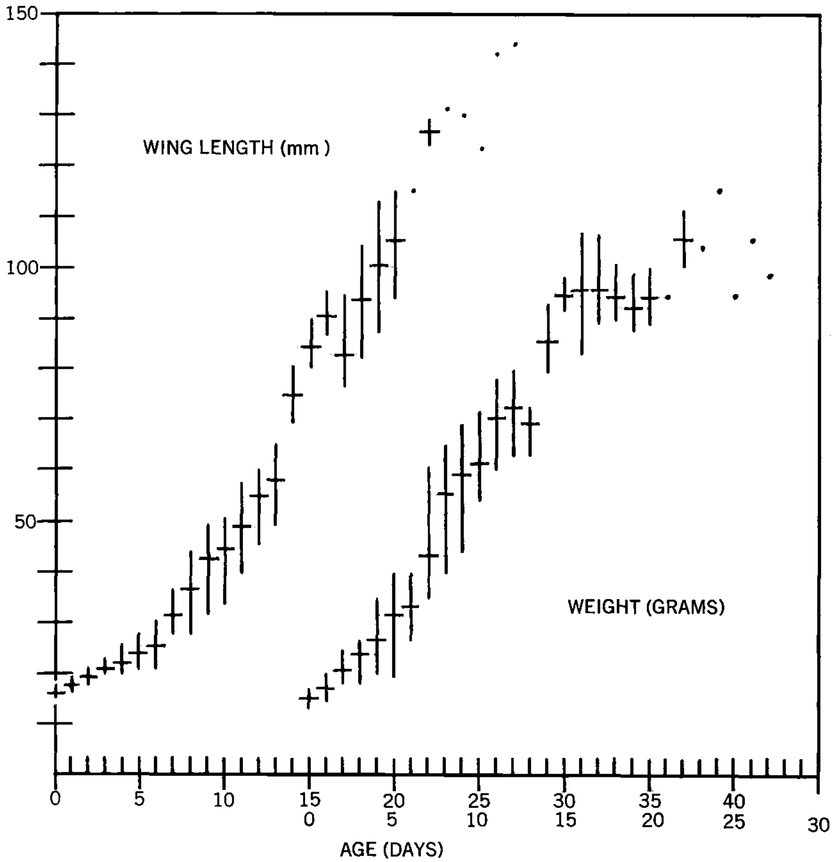

Figure 1. Wing measurements and weights (range and mean) of surviving Roseate Tern chicks in 1967.

in three experimental areas, recording hatching of all chicks within 24 hours (day 0 = day of hatching). Each newly hatched chick was banded with a numbered plastic band.

In 1968 we planned to follow up and extend the data obtained in 1967. We spent 23 June–7 July and the weekends of 15–16 June and 13–14 July on Great Gull Island. Helen Hays and Sara LeCroy took weights and measurements for us the weekend of 20–21 July. We made daily checks of 40 Common Tern nests. Although we checked a total of 76 Roseate nests, our data are incomplete because of heavy predation on newly hatched chicks, presumably by Black-crowned Night Herons (Collins, 1970). Therefore we present no data for Roseates in 1968.

In both years we weighed and measured the wing chord on each known-age chick. As we were unable to spend enough consecutive days on the island to follow any single chick from hatching to flying, our graphs and charts are compiled from a composite of data for many chicks of known age.

We hoped to devise a method of estimating accurately the age of a chick of unknown hatching date, and with this in mind in 1967 we measured, in addition to the wing

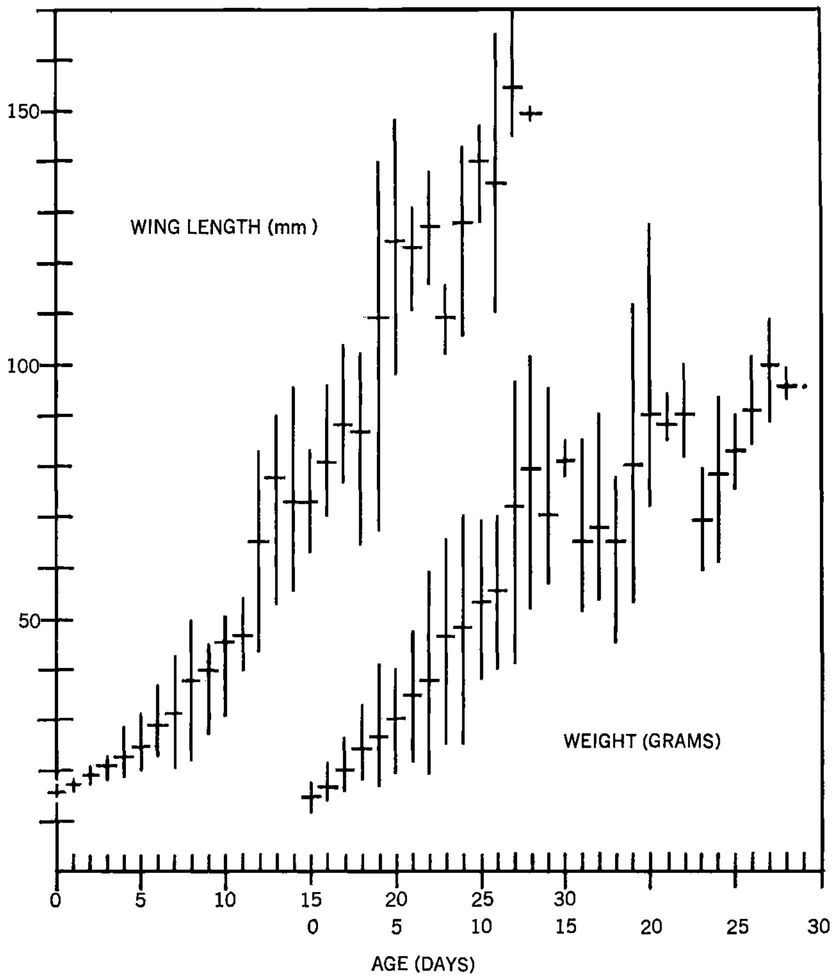

Figure 2. Wing measurements and weights (range and mean) of surviving Common Tern chicks in 1967.

chord, the tarsus and exposed culmen. When the juvenal plumage began to appear, we also measured daily the longest (ninth) primary from its insertion into the wing to its tip, and the tail from the insertion of the two central rectrices to the tip of the outermost rectrices. Of these, only the length of the ninth primary seemed to have sufficient nonoverlap to offer promise as a simple method of aging chicks, so we repeated only this measurement in 1968.

In 1967 we took weights to the nearest 0.1 g with a triple beam balance; in 1968 we weighed chicks to the nearest 0.5 g with a Pesola spring balance. We made measurements both years with dial calipers to the nearest 0.1 mm. We noted the disappearance of the egg tooth in both years to compare this character in the two species.

TABLE 1
Daily Measurements of Surviving Tern Chicks

Day	No.	Weight	Wing
Roseate Tern, 1967			
0	9	13.1– 16.6 (14.8)	15.2– 17.4 (16.2) [8 only]
1	10	14.4– 19.8 (17.5)	16.5– 19.0 (17.6)
2	11	18.0– 25.1 (21.0)	17.3– 21.0 (19.2)
3	15	18.5– 27.2 (23.7)	19.7– 23.4 (21.0)
4	17	20.2– 34.5 (27.2)	20.0– 25.6 (22.4)
5	15	19.1– 40.0 (31.8)	20.9– 27.9 (24.4)
6	8	27.2– 40.5 (33.4)	20.9– 31.0 (25.8)
7	6	35.4– 60.9 (43.2)	27.4– 37.5 (31.8)
8	11	39.8– 66.2 (55.4)	26.9– 43.6 (37.4)
9	12	46.5– 69.3 (59.1)	32.4– 49.3 (42.7)
10	9	53.9– 72.2 (62.1)	34.5– 50.8 (45.4)
11	5	60.1– 78.2 (70.0)	40.0– 58.2 (48.9)
12	5	62.8– 80.1 (73.1)	47.3– 60.5 (55.0)
13	3	62.7– 73.1 (69.3)	49.3– 66.1 (58.2)
14	2	79.2– 92.8 (86.0)	69.0– 81.0 (75.0)
15	4	92.3– 97.7 (95.2)	80.4– 90.0 (84.3)
16	4	83.3–107.5 (95.8)	87.0– 96.0 (90.8)
17	3	89.2–107.4 (95.3)	77.0– 95.0 (83.3)
18	4	89.8–100.8 (93.9)	82.0–104.1 (92.7)
19	4	88.4– 99.4 (92.9)	87.0–113.0 (101.4)
20	5	88.8–100.0 (93.9)	94.0–116.0 (107.2)
21	1	95.2	116.0
22	4	101.5–111.7 (106.4)	124.0–129.0 (127.3)
23	1	104.5	131.0
24	1	116.4	130.0
25	1	94.5	123.0
26	1	106.3	142.0
27	1	99.5	144.0
Common Tern, 1967			
0	13	12.0– 17.7 (14.8)	15.0– 17.5 (15.8)
1	10	14.3– 22.1 (16.8)	15.8– 18.4 (17.2)
2	11	16.2– 26.6 (20.0)	17.0– 21.4 (18.9)
3	12	18.2– 32.8 (24.1)	17.9– 23.1 (20.6)
4	13	17.3– 41.4 (27.0)	19.5– 28.6 (22.9)
5	13	19.4– 40.2 (30.0)	19.9– 31.9 (25.1)
6	9	21.7– 48.5 (34.6)	23.0– 37.0 (28.8)
7	9	18.6– 59.2 (38.4)	21.4– 42.7 (32.3)
8	7	25.7– 66.0 (47.5)	21.7– 50.5 (38.3)
9	7	26.2– 69.6 (47.7)	27.2– 45.5 (40.2)
10	6	37.8– 69.2 (53.5)	31.1– 50.8 (46.4)
11	3	40.3– 70.0 (55.7)	39.9– 53.8 (46.9)
12	5	41.4– 97.3 (71.9)	42.9– 82.6 (64.9)
13	5	52.5–101.9 (78.9)	52.9– 90.5 (78.0)
14	4	56.6– 96.5 (69.9)	56.2– 96.5 (73.1)
15	2	77.6– 84.2 (80.9)	62.6– 82.6 (72.6)
16	3	52.1– 84.8 (63.9)	70.0– 96.0 (81.0)
17	4	52.7– 90.4 (67.8)	77.0–104.0 (88.4)
18	3	44.6– 77.9 (65.4)	64.0–102.0 (86.7)
19	5	52.8–112.1 (80.4)	67.5–140.0 (109.3)
20	5	71.7–126.9 (89.6)	98.0–148.0 (123.8)
21	3	84.0– 93.6 (88.0)	111.0–131.0 (123.3)
22	2	82.1–100.3 (90.2)	116.0–138.0 (127.0)
23	2	59.2– 79.3 (69.3)	102.0–116.0 (109.0)
24	4	61.0– 92.9 (78.5)	106.0–143.0 (127.8)
25	3	75.7– 90.0 (83.3)	128.0–147.0 (140.3)

TABLE 1 (CONTINUED)

Day	No.	Weight	Wing
26	4	80.6–101.8 (91.5)	110.0–165.0 (136.5)
27	3	86.5–109.4 (100.1)	145.0–17C.0 (154.1)
28	2	93.1– 98.6 (95.9)	148.0–151.0 (149.5)
29	1	95.6	151.0
Common Tern, 1968			
0	6	13.0– 16.5 (14.9)	13.1– 16.0 (14.9) [5 only]
1	6	14.5– 22.8 (17.3)	16.0– 18.7 (16.8) [5 only]
2	6	16.0– 26.0 (21.4)	16.9– 19.4 (18.0)
3	6	17.5– 36.0 (27.1)	17.4– 24.1 (20.6) [5 only]
4	5	26.0– 38.5 (33.9)	20.4– 27.4 (24.3)
5	4	30.5– 42.0 (37.1)	24.1– 32.0 (27.3)
6	6	30.0– 52.5 (40.6)	22.1– 37.3 (30.3)
7	2	35.0– 48.0 (41.5)	27.8– 34.8 (31.3)
8	3	42.0– 63.5 (51.8)	31.0– 44.1 (37.6) [2 only]
9	4	45.0– 76.0 (62.3)	35.2– 56.3 (45.8)
10	6	48.5–102.5 (69.7)	40.7– 63.9 (51.7)
11	5	65.0– 75.5 (68.8)	49.2– 67.4 (57.8)
12	7	71.0–102.0 (80.2)	53.8– 80.5 (66.2)
13	8	62.0–100.0 (84.1)	62.0– 88.9 (75.8)
14	4	84.5–101.0 (93.3)	68.5– 98.4 (79.7)
15	5	100.0–115.0 (109.0)	77.9–104.0 (91.0)
16	7	87.0–119.0 (105.3) [6 only]	78.1–111.7 (98.1)
17	6	67.0–120.0 (101.4) [5 only]	77.5–118.5 (102.0)
18	4	67.0–117.0 (103.3)	98.0-131.8 (112.3)
19	4	64.0–120.0 (102.9)	99.8–138.6 (124.9)
20	6	63.0–129.0 (97.2)	103.0–138.5 (122.9)
21	2	109.0–131.0 (120.0)	117.4–150.1 (133.8)
22	4	103.0–126.0 (114.0)	122.7–161.2 (143.6)
23	1	103.0	149.0
24	2	108.0–115.5 (111.8)	143.0–154.9 (149.0)
25	2	108.5–109.0 (108.8)	149.6–162.9 (156.3)
26	2	107.0–114.0 (110.5)	171.6–176.5 (174.1)

Roseate Terns

As mentioned above, we were able to obtain growth data on Roseate Terns only in 1967. Our 60 study nests held a total of 105 eggs. Of these 51 hatched and 38 of the chicks were of known age. Of these 17 are presumed to have survived the preflight stage. Our criteria for including data for a particular chick are necessarily arbitrary as we were unable to determine exactly when the birds were able to fly. We think it is valid to assume that birds showing regular weight gains through day 9 survived to fledging (= free-flying stage). The 7 chicks that we found dead were day 6 or younger and each had been losing weight for several days. The 14 chicks of unknown fate were last handled on days 0 (3), 1 (2), 2 (1), 3 (1), 4 (1), 5 (4), 6 (1), and 7 (1).

The 17 chicks for which we present data were last handled on the following days: 9 (1), 10 (3), 12 (1), 16 (1), 18 (1), 20 (2), 21 (1), 22 (3), 23 (1), 24 (1), 25 (1), and 27 (1). Figure 1 and Table 1 show the ranges in weights and wing measurements by day of age and the average for each age. Survival in relation to clutch size in the 48 clutches for which we have complete data (Table 3) is discussed below.

Common Terns

Our 1967 data on Common Terns are based on 13 chicks. We followed 21 nests containing a total of 45 eggs of which 38 hatched; 14 chicks were subsequently found

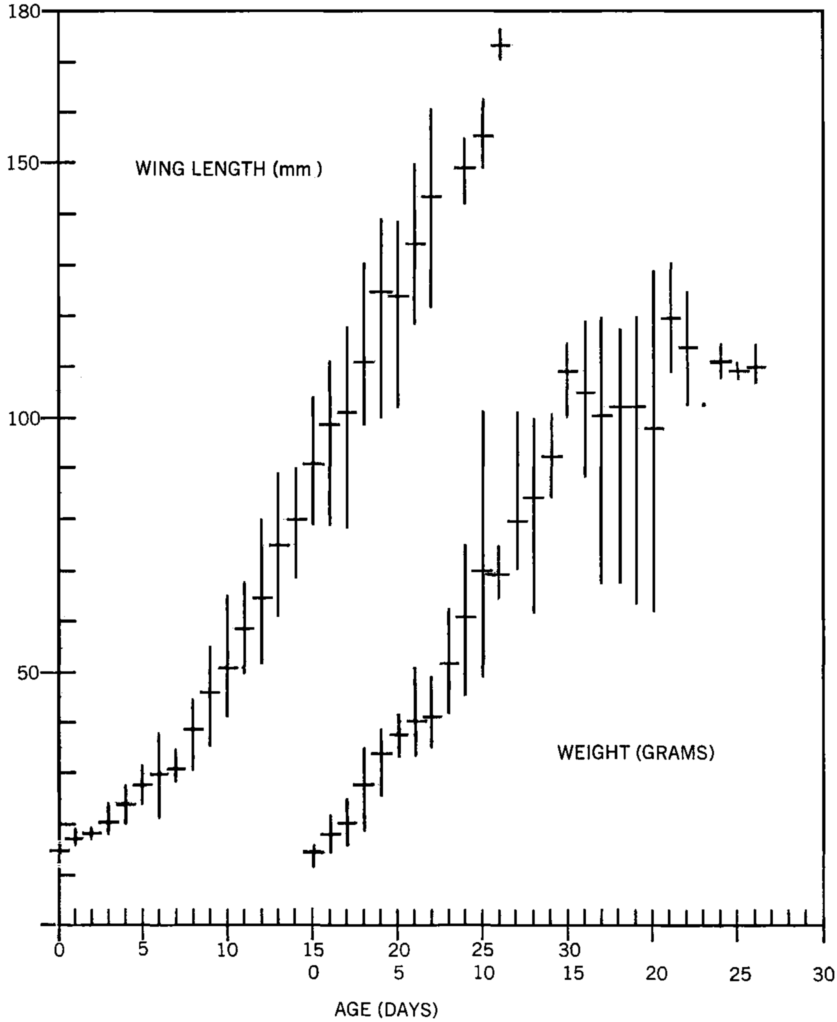

Figure 3. Wing measurements and weights (range and mean) of surviving Common Tern chicks in 1968.

dead. Nine of these deaths occurred between days 3 and 5. The five remaining deaths occurred on days 6, 8, 12, and 20 (2), apparently from starvation; 11 other chicks disappeared by day 7 and were presumed dead. As with the Roseates, we cannot be sure exactly when the birds were able to fly, but the 13 Common chicks for which we present data were last handled on the following days: 20 (2), 22 (1), 24 (2), 25 (2), 26 (2), 27 (2), 28 (1), 29 (1), and all are presumed to have fledged. Figure 2 and Table 1 show the weights and wing measurements with the averages for each day of age, based on data for these 13 chicks.

In 1968 we followed 40 nests of Common Terns containing a total of 89 eggs, of which 56 were known to hatch. The 15 chicks that showed consistent weight gains and presumably fledged were last handled on the following days: 13 (1), 16 (1), 17 (1), 18 (1), 20 (4), 22 (2), 23 (1), 24 (1), 25 (1), and 26 (2). Data are presented in Figure 3 and Table 1. Of the remaining 41 chicks 38 disappeared by day 3 and were probably largely victims of predation (Collins, 1970). The other three birds were last handled on days 10, 17, and 21 and were losing weight. The bird handled on day 21 was found dead 6 days later. Survival in relation to clutch size for the 2 years (Table 3) is discussed below.

Discussion

A comparison of the measurements of the two species taken in 1967 shows that the wing length of both is approximately the same at hatching, averaging 16.2 mm for 8 Roseate chicks and 15.8 for 13 Common chicks. The chicks apparently begin to fly at 3 to 4 weeks of age and at this time the Common Terns have longer wings, with a maximum measurement of 144 mm for a Roseate and of 170 mm for a Common, both measured on day 27.

The young of both species probably fly as soon as their wings are long enough to support their weight. Their wings continue to grow during the autumn. We measured a Roseate and a Common chick kept in captivity from 27 July 1968, when they were approximately 5 weeks old and able to fly, until 18 September 1968, when their wings began to show evidence of cage wear. The wing of the Roseate grew from 160 to 212 mm; the wing of the Common from 182 to 251 mm. Wing measurements made on 11 skins of Common fall juveniles have a range of 230–259 mm. No Roseates of comparable age were available. These measurements compare with adult measurements of 232.1 mm average for 20 Roseate and 263.4 mm average for 19 Common Terns. (These are chord measurements made on museum specimens collected on Long Island, New York, or in Massachusetts. No sexual dimorphism in size is evident.)

Weights at hatching in 1967 were 13.1–16.6 g (average 14.8) for 9 surviving Roseate Terns and 12.0–17.7 g (average 14.8) for 13 surviving Common Terns. Data in the literature on weights of the two species are scanty. Palmer (1941: 86) gives some from his own work and from that of Floyd (1927) and the Heinroths (1928) for Common Terns. Palmer's weight of 12 g for a day 2 chick is light compared with ours, but his weights of various chicks from days 5 through 21 agree well with ours. Data the Heinroths collected are also similar. Floyd's weights of 10–12 g at hatching seem light; 11.8 g was the lowest hatching weight for any of the young Common Terns that we weighed, whether or not they survived. His weights of 53 and 69 g on day 8 agree well with our data. Szulc-Olechowa (1964) and Cymborowski and Szulc-Olechowa (1967) give average hatching weights of approximately 21.4 and 18.0 g, respectively, for wild-hatched Common Terns in Poland. This is heavy compared to our birds, as are their average weights of 126.1 and approximately 130.0 g for fledglings. The Marples (1934) weighed 30 chicks on day 0 and found a range of 9.57 to 16.95 g, but they had no data on survival, and these figures suggest that they included some nonviable chicks.

The only published weights for Roseate Terns we have been able to find are those that Floyd (1927) took of two young that weighed 20 and 24 g at hatching. Another Roseate, not weighed subsequently, weighed 16 g at hatching. The heaviest young Roseate we weighed in either year was a 17.5 g chick in 1968 that did not survive. However Floyd's data are similar to our own for the two weights of a bird on day 7 and day 10.

Shortly before fledging the weights of our birds were quite variable, varying in the Roseates from 94.5 g for a day 25 bird to 116.4 for one on day 24, and in the Commons from a very low 61.0 on day 24 to a high of 126.9 on day 20. Part of this is undoubtedly due to length of time since the last feeding. Once a young bird regurgitated 9 g of semidigested fish just after being weighed. (We did not correct for food regurgitated during or after weighing.) However the low of 61.0 g undoubtedly represents an abnormally low weight. This chick weighed 13.9 g at hatching, was extremely light throughout the growth period, but made consistent though small gains, and is thus included.

We took no adult weights in 1967, but weights Gary and Mary Sue Schnell took on Great Gull Island in 1968 show that 56 Common Terns varied from 103 to 129 g (average 116.1) and 46 Roseate Terns varied from 92 to 125 g (average 107.6). Palmer (1941) gives an average adult weight of 123.1 g for Common Terns in Massachusetts, and Szulc-Olechowa (1964) shows an average adult weight of 127.3 g in Poland. Thus our birds reached approximately adult weight before fledging. In fact adults in the Great Gull Island colony may have averaged somewhat lighter in 1967 than in 1968; as shown below, food was apparently scarce in 1967.

The wide range in hatching and adult weights is not easily explainable, but further work may show that both geographical and year to year variation occurs. That the average hatching and adult weights were greater in both years in Poland than were ours in New York points to a possible geographical difference in these two populations.

Our data on the few birds for which we have a number of weights obtained between the ages of 2 and 4 weeks indicate that young birds reach a maximum weight about equal to that of adults at approximately 3 weeks of age, and that it then drops somewhat during the next few days until fledging at 3 to 4 weeks. We do not have sufficient data to state this quantitatively. The graph Cymborowski and Szulc-Olechowa (1967) published shows this same drop in weight prior to fledging in both wild and hand-reared Common Terns. This loss of weight may be correlated with rapid growth and drying out of feathers during this period, as Ricklefs (1968) has shown in other birds. It may also reflect increased activity (wing-flapping and short flights, for example) in birds about to fly.

Tarsal and culmen growth is very similar in the two species. The tarsus is 13.0–14.8 mm at hatching in Roseates and 12.8–14.8 in Commons. At fledging it is 20.5–21.5 and 20.5–22.0, respectively; adult tarsus measurements for Roseates are 19.0–21.0 and for Commons are 19.5–23.0. The culmen in Roseates is 9.0–9.5 mm at hatching and is 9.0–10.0 in Commons. At fledging it is 23.0–24.0 and 24.0–27.0, respectively; adult culmen measurements for Roseates are 36.5–40.0 and for Commons are 33.5–39.0. Tarsal growth has leveled off by days 10–12 in both species; the culmen continues to grow, but rather more slowly after about day 14, with some indication of a plateau between days 15 and 20. Thus the tarsus reaches adult size rather quickly while the culmen is only approximately two-thirds adult size at fledging. These two measurements show too much overlap to be useful in estimating the age of young birds. Hailman (1961) found the same to be true of tarsal measurements of Laughing Gull (*Larus atricilla*) chicks during the first few days.

Roseate chicks retain the egg tooth much longer than Common chicks do. We suspect that it does not drop off in the Roseate, but rather is worn down until it disappears. The time this happens varies but seems to occur between days 10 and 13. In Common chicks we believe the egg tooth drops off; it had disappeared in most cases by day 6, sometimes by day 3 or 4. It was still present on one day 11 chick, but gone by day 12. In comparison, Wolk (1954) found that no egg tooth was lost earlier than 12 days in the Least Tern (*Sterna albifrons*) and Hawksley (1957) found that it disappeared in 3 days in the Arctic Tern (*Sterna paradisaea*). Gardiner (in Clark, 1961) suggests that precocial birds perhaps lose the egg tooth earlier than altricial birds and Parkes and Clark (1964) note the egg tooth wears off in some groups, "notably passerines." The difference in length of retention and manner of loss of the egg tooth in these closely related species of terns suggests that once the egg tooth has performed its function at hatching, the method of loss in this genus may be a matter of chance.

Survival throughout the colony was low in both 1967 and 1968. In 1967 fish apparently were relatively scarce. Several observers noted adult terns pirating fish from other adults and even snatching fish from young birds (Hays, 1970a). Other circumstantial evidence includes our observations that none of our experimental Common Tern nests in 1967 had more than one young survive, whereas in 1968 two young survived in each of two nests. Also in 1967 several of our known-age Common chicks were found dead at 1 week of age or older (one on day 12 and two on day 20) apparently of starvation. By contrast, in 1968 no instances of fish stealing were seen and more fish were found on the ground in the colony. Most of the deaths occurred in very young birds and were correlated with a 3-day period of cold, wind-driven rain that fell during the peak hatching period; also large numbers of newly-hatched young disappeared, apparently taken by predators.

These observations lead us to believe that more food was available to the young in 1968. In addition to the larger supply of fish available to the colony as a whole, the early death of many chicks from inclement weather and predation permitted the surviving chicks to receive an unusually large share of food. Comparison of our growth data for Common Terns in both years supports this view. Although wing lengths at hatching and at fledging did not differ significantly, Figures 2 and 3 show that the average weight attained before fledging was considerably more in 1968 than in 1967 (approximately 110–120 g in 1968 and 90–100 g in 1967). Despite the greater abundance of food for chicks in 1968, the early losses made the percentage fledged in 1968 (26.8 percent of those that hatched and were banded) lower than that in 1967 (34.2 percent).

As mentioned above, wing measurements were relatively constant in 1967 and 1968. Ashmole (1962) found that young Black Noddies (*Anous tenuirostris*) that hatched later in the season had shorter wings than those hatched earlier. This was apparently due to starvation of the later chicks. Ashmole's data included all chicks of known age, whether or not they survived. He mentions that his data on individual chicks indicate that the wings of starving chicks grow, but slowly, in the period shortly before death. Our young that died also followed this pattern, but the surviving chicks increased steadily and similarly in wing length both in 1967 and 1968. A wing growth rate independent of body weight may be of great selective advantage in a bird as aerial as a tern.

It would of course be very useful to have a way of estimating the age of any chick, and it was with this in mind that we made so many measurements in 1967. After it became apparent that wing growth was relatively constant in successful chicks in both years, it seemed that perhaps length of the longest (ninth) primary might be used as a rough estimate of age in chicks. And it probably is possible with this measurement (see Table 2) to estimate within approximately 5 days the age of a healthy chick picked up at random on Great Gull Island, but size varies so widely that it is not always easy to tell which chicks are not being fed properly until death is near. As we have no data on geographical variation in chick size, our data are not necessarily applicable in other colonies. Thus while we consider ninth primary length to reflect age more closely than other parameters we measured, we believe it has only limited usefulness as a rough age estimate within the colony in

TABLE 2
LENGTH OF NINTH PRIMARY IN TERN CHICKS

	Roseate		Common			
Day	1967	No.	1967	No.	1968	No.
3	1.5		0.5– 2	(5)	—	
4	1 – 4	(13)	1.5– 4	(11)	—	
5	1 – 4	(13)	0.5– 6.5	(13)	—	
6	1 – 5.5	(7)	2 – 10	(9)	—	
7	4 – 7	(5)	3 – 14	(9)	—	
8	2.5–12	(11)	5 – 16.5	(7)	—	
9	5 –16	(12)	5 – 16.5	(7)	—	
10	6 –18	(9)	7 – 20	(6)	19.9–21.9	(2)
11	10 –21	(5)	10 – 24	(3)	26	
12	10 –26	(5)	13 – 43	(5)	17.5–36.1	(4)
13	17 –28	(3)	25 – 49	(5)	22.5–43.5	(5)
14	32 –42	(2)	23 – 41	(4)	26.9–34	(3)
15	40 –47	(4)	28 – 44	(2)	32.6–54.2	(4)
16	45 –51	(4)	38 – 55	(3)	42.9–58.5	(4)
17	38.5–52	(3)	42 – 61	(4)	47.8–63.2	(2)
18	43 –64	(4)	31 – 60	(3)	51 –73.9	(3)
19	51 –70	(4)	34 – 80	(5)	65.2–76.8	(2)
20	52 –71	(5)	58 – 93	(5)	59.1–79.2	(3)
21	72		64 – 80	(3)	61.5–85.8	(3)
22	74 –80	(3)	70 – 86	(2)	66.3–88.6	(4)
23	83		62 – 68	(2)	85.6	
24	79		73 – 91	(3)	81.6–94	(2)
25	82.5		80 – 96	(3)	87.8–97	(2)
26	70		61 –113	(3)	102.9	
27	95		95 –120	(3)	—	
28	—		94 –100	(2)	—	
29	—		101		—	

which the measurements were made. Perhaps future work in other colonies will show it to be more generally applicable.

Our data on survival according to clutch size for the nests within our experimental areas are presented in Table 3. While the sample size is small and may not be representative of the colony as a whole, some interesting relationships do emerge. In Roseates the percentage of eggs hatched in 1-egg clutches (35.7) was much lower than the percentage of eggs hatched in 2-egg clutches (58.6). This is probably because we included some clutches that were deserted before completion. But survival per hatched egg is almost twice as great in 1-egg clutches (66.7 percent) compared with all 2-egg clutches considered together (35.3 percent). It is important to note that survival was as great in 2-egg clutches of which only one egg hatched, as in 1-egg clutches. Thus in 1967, a year of food shortage, Roseate chicks that hatched without siblings apparently had a good chance for survival. The nearly equal survival per egg in 1- (25.0 percent) and 2-egg clutches (20.7 percent) is the result of uncompleted clutches of one egg not hatching and poor survival in clutches of two in which both hatched,

TABLE 3
Survival According to Clutch Size

Clutch size	No. of nests	Percent of eggs hatched	Chicks survived		
			Percent per hatched egg	Percent per egg	Per pair of adults
Roseate, 1967					
1	16	35.7	66.7	25.0	.25
2	29	58.6	35.3 (66.7 if 1 hatched) (28.9 if 2 hatched)	20.7	.41
3	1	00.0			
4	2	00.0			
Common, 1967					
1	2	00.0			
2	14	89.3	40.0 (66.7 if 1 hatched) (36.4 if 2 hatched)	35.7	.71
3	5	86.7	23.1 (25.0 if 1 hatched) (22.2 if 2 hatched)	20.0	.60
Common, 1968					
1	1	00.0			
2	29	56.9	33.3 (28.6 if 1 hatched) (34.6 if 2 hatched)	19.0	.38
3	10	76.7	17.3 (00.0 if 1 hatched) (16.7 if 2 hatched) (20.0 if 3 hatched)	13.3	.40

but some of the adults that deserted uncompleted clutches may have nested successfully elsewhere. The apparently much greater survival per pair having two eggs compared with those having one probably does not reflect a true picture of colony success. Three- and 4-egg clutches were uncommon and the few in our study area were not considered significant.

In the Common Tern in 1967 the survival of young in our 2-egg clutches, only one of which hatched (66.7 percent), was the same as in Roseate nests containing only one chick. The survival in nests having both eggs hatch is much lower (36.4 percent). It is interesting to note the high and almost equal percentage of eggs that hatched in both 2- and 3-egg clutches (89.3 and 86.7, respectively). However the survival per hatched egg was low in 3-egg clutches. In 1968 the percentage of eggs hatched appears greater in 3-egg clutches. But with heavy and presumably random predation a proportionately greater number of eggs would be taken from 2-egg clutches, for often one egg only was taken and also there were almost three times as many 2-egg as 3-egg nests within our fences. As hatchability was similar in 2- and 3-egg clutches in 1967, the difference in 1968 is probably due to predation. On the other hand, survival per hatched egg is almost twice as high in 2- (33.3 percent) as in 3-egg clutches (17.3 percent). This is at least partly due to the survival of both chicks in two 2-egg clutches.

In neither 1967 nor 1968 did the small number of 1-egg Common clutches hatch, and all these may have been uncompleted clutches.

We saw no evidence of predation in 1967, and the 89.3 and 86.7 percent eggs hatched is probably a fair measure of hatching success. The low figure for 1968 reflects the effects of predation on newly-hatched, unbanded chicks as well as on eggs, and no accurate estimate of hatching success could be made. The total figures for the percentage of banded chicks surviving are slightly lower in 1968 than in 1967. It seems reasonable to assume that the heavier fledglings in 1968 might have a better chance to survive the critical postfledging period and bring the survival closer in the 2 years.

Common Terns, with higher hatching success and larger average clutches, probably always average more chicks per pair than Roseates, and potentially they may have *much* greater success. If indeed such bumper years occur, the numbers of Commons may fluctuate more widely than the numbers of Roseates, and the overall wastage of young may be greater in Commons, as hatching success is high even in years of poor survival.

While basic differences in their adaptations for breeding undoubtedly exist between species, any year's outcome is a balance of many variables, some of which may affect small clutches more than large (any factor that causes partial loss of a clutch), others may have equal effects regardless of shortage), and still others may exert their effects according to the propor- clutch size (climate), others may affect large clutches more than small (food tions of different clutch sizes in the colony (predation). As the balance in a species at one locality may change from year to year, comparisons between populations from widely separated localities and from different breeding seasons should be made only with extreme care.

Temperature Regulation

The development of endothermy in birds has received much attention recently, but most of the data obtained are for altricial species. The information for precocial or semiprecocial species is still fragmentary. Data we collected for 17 Roseate and 27 Common Tern chicks in 1967 are presented in Figure 4. Readings of cloacal temperatures were made with a Schultheiss thermometer after the chicks had been in a stable ambient temperature for 30 minutes. More readings at higher ambient temperatures would have been desirable but we were unable to obtain them.

Even shortly after hatching some tern chicks were capable of maintaining a body temperature 10–12° above ambient. By day 3 all chicks tested maintained a nearly stable body temperature independent of ambient temperature. It was still below those temperatures recorded for 15 recently trapped

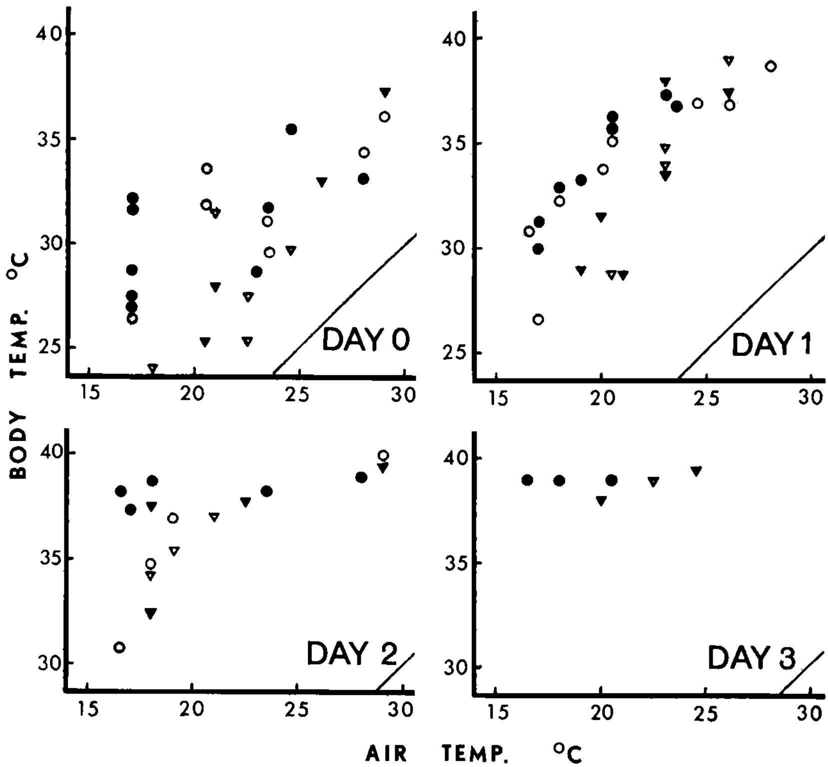

Figure 4. Temperatures of Common and Roseate Tern chicks: Common, ●; Roseate, ▼. Closed symbol indicates that the chick survived to at least day 6; open symbol that it died or disappeared before day 6.

adults, which ranged from 40.9–43.6° (average 42.6). The higher values for the adults are probably due in part to their activity during trapping and handling. Chicks of the Western Gull (*Larus occidentalis*) were similarly noted to have well-developed capacities for temperature regulation when still less than a week old (Bartholomew and Dawson, 1954), particularly as compared with altricial young of other species nesting nearby.

The young of both Roseate and Common Terns remain in or near the nest for the first few days and are closely brooded by the parents. After this the young leave the nest when the adults are away and hide in the nearby vegetation. The time at which chicks begin to range farther from the nest and the time at which the parents begin staying away from the nest for longer periods corresponds with the time when the chicks can maintain body temperatures fairly close to those of adults.

One of the factors contributing to the death of newly-hatched younger chicks in a brood is undoubtedly their becoming chilled during the long absences of adults with larger chicks to feed. The vigor with which chicks beg for food declines rapidly when they become chilled. The returning adult finds the older chick warm and capable of rushing up and begging vigorously for food, and the younger, chilled chick is ignored. The nests in which more than one chick survived for the longest periods were those whose chicks hatched within a relatively short period of time (1 to 2 days). Of chicks hatching 2 to 3 days apart, the younger usually died within 3 or 4 days, probably shortly after using up the reserve of yolk. This hatching interval difference represents still another variable that must be taken into account when analyzing comparative survival.

Tern chicks exposed to direct solar radiation soon show signs of discomfort and seek shade. When kept in the sun they quickly overheat and use gular flutter as an evaporative cooling mechanism. This we noted on several occasions, even in chicks only 1 to 2 days old. This mechanism has been reported in the adults and young of many species but was apparently absent in Western Gull chicks (Bartholomew and Dawson, 1954).

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Summary

Known-age chicks of Roseate and Common Terns (*Sterna dougallii* and *S. hirundo*) were weighed and measured in 1967 and 1968 on Great Gull Island, New York. Predation negated the Roseate data in 1968. Commons and Roseates in 1967 weighed and measured about the same at hatching but Commons averaged heavier and had a longer wing at fledging. Tarsal and exposed culmen measurements are similar, but show too much individual variation for use as age indicators. The egg tooth is lost earlier in the Common Tern, in which it apparently drops off by day 6, than in the Roseate Tern, in which it seems to wear off and may still be present up to day 13.

The 2-years' data on the Common Tern are compared. Hatching weights were similar but fledging weights were lower in 1968, presumably because of a food shortage. Wing growth was very similar and is apparently

independent of weight in surviving chicks. In both species the wing continues to grow for some time after the birds are able to fly.

The length of the ninth primary may be used as a rough estimate of age, but this may vary geographically and must be used with caution. Chicks become completely endothermic on day 2 to 3, at about the time when parental brooding becomes less continuous.

The survival of chicks in relation to clutch size is discussed for the nests within our study areas for which we have complete data. While the sample size is small, we found hatchability of Roseate eggs lower than that of Commons. In 1967 Roseate chicks that hatched without siblings had a much better chance for survival than chicks with a sibling. Common Terns suffered from a higher loss of chicks after hatching than did Roseates.

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