

HISTORY OF ONE HUNDRED NESTS OF ARCTIC TERN

BY OLIN SEWALL PETTINGILL, JR.

ON Machias Seal Island in the Bay of Fundy nest approximately two thousand pairs of Arctic Terns (*Sterna paradisaea*). Of the island's fifteen-acre surface above the high-tide line, only half is occupied by these birds. The remainder of the area is dominated by the lighthouse and whistlehouse, two keepers' houses, and other small accessory buildings. During visits made to Machias Seal Island in the summers of 1932 and 1935 I could not fail to observe the many nesting failures of the Arctic Tern because deserted nests and dead young were noticeable in every section of the island. These failures were particularly puzzling to me for Machias Seal Island seemed to hold environmental advantages far superior to the seabird colonies to the south where high percentages of nesting failures are well known. Machias Seal Island has no wild mammals, not even rats or mice. Few birds of predatory habits visit it during the breeding season. I have never observed there a hawk or owl, raven or crow, and very rarely a Herring Gull. Other nesting seabirds offer the Arctic Terns no serious competition. Because Machias Seal Island is approximately ten miles from the nearest point of the mainland and several miles farther away from the nearest human habitation, because it is separated still further by heavy tides and generally rough sea, and because it is without a port of landing, it has relatively few human visitors. Only the most ardent ornithologists visit it; other persons come only when having some business or family mission at the lighthouse. It rises abruptly from the sea leaving its surface well beyond the wash of even excessively high tides. It has no shifting sands. It is treeless, yet its loose, rocky shore and grassy interior provide shelters of many sorts for the nesting seabirds.

In 1937, I returned to Machias Seal Island determined to study the destructive forces operating here by following the history of a group of nests through the breeding season. Two days after my arrival on July 2, I selected, on the southern section of the island, one hundred nests with eggs still unhatched. I was particular in choosing a group which best represented the entire colony. The nests were adjoining ones; thus a small section of the colony was actually picked for investigation. Each nest was marked by a small wooden slab with one of a series of numbers from 1 to 100. Each slab was placed upright so that it could be seen for a considerable distance. A blind with many lookout holes was securely stationed in the midst of the group of nests so that a large number could be kept under observation at one time. When the eggs hatched, the young were carefully banded. A map of a part of the colony under study was drawn up showing

the location of each nest with reference to neighboring nests and to the geographic features. On succeeding days until my departure on July 28 the nests were methodically visited twice daily, once in the morning and once in the evening. Observations were occasionally made from the blind.

The one hundred nests contained altogether 144 eggs, distributed among the one hundred nests as follows: one nest with three eggs; 42 nests with two eggs; and 57 nests with one egg. *Fifty-three of these eggs failed to hatch.* The reasons for these failures insofar as I have been able to determine them are discussed below.

Ten eggs were stepped on by cattle. The lighthouse keepers, because of their isolation, kept three cows for dairy products. These animals were allowed to graze day and night and at no time were they tied up. They preferred not only the thick grass of the island's interior (a place occupied by buildings and, therefore, without nesting terns) but also isolated clumps of grass among the rocks along the shore where the terns were nesting, sometimes even passing to the high-tide line itself to pluck a few scattered blades.

Eight eggs were punctured by the adult terns. The beaks were used and the contents sometimes removed. I had opportunity to witness from the blind the puncturing of one of the eggs. An adult was seen to alight suddenly beside an unguarded nest and thrust its beak into an egg. The marauder was instantly set upon by several individuals from neighboring nests (possibly also by the owners who may have returned) and was driven away before it could devour the contents. I assumed from the belligerent behavior of the neighboring birds that it was a stranger in their midst, perhaps an unmated bird. The destruction of eggs in the above manner has been observed in other seabirds. Kirkman (1937, pp. 56-57) watched 'outside' Black-headed Gulls 'sucking' the eggs of a close-nesting group of the same species, much to the resentment of the individuals of that group. He did not find gulls within the group, or 'insiders,' sucking one another's eggs. Goethe (1937, pp. 60-62) observed similar egg-destruction among Herring Gulls, and believed that the marauders were unmated birds and certain breeding birds whom the unmated birds introduced to this practice through the taste for broken eggs. The puncturing of eggs was the result of nests being left unprotected for extended periods. While nesting Arctic Terns ordinarily alternate in incubation and so adjust their periods of feeding and incubation as not to leave the eggs unguarded, undetermined circumstances caused certain pairs to absent themselves for intervals as long as 30 to 35 minutes. I noted five instances in which the birds were away from the nests for over 50 minutes.

Seven eggs disappeared from nests. I have no doubt that they were carried away by terns. (Such feats are physically possible by inserting the

bill in the egg and thus gaining a firm hold, either by spreading the mandibles or by grasping the contents.) My belief is supported by the fact that I commonly found, scattered here and there over the rocks, eggs the majority of which were either broken or simply punctured. They were too far from nests to have been rolled to these positions. Probably they were either dropped here from mid-air or taken here to be devoured by marauding terns who had carried away the eggs after puncturing them.

Two eggs, each from a different nest, were found resting outside the nests and deserted while the adult birds continued incubating the eggs remaining in the nests. One egg was only ten inches from the nest, the other twelve. The adult terns had probably pushed the eggs accidentally from the nests but were evidently incapable of rolling them back. While these individual terns lacked the capacity to rescue their eggs, some Arctic Terns and closely allied birds have shown considerable abilities in this respect. For instance, Tinbergen (cf. Kirkman, 1937, p. 216) found two pairs of Arctic Terns that could return eggs four inches from the nest. Hagar (1937, p. 7) reported that the Least Terns, birds much smaller than Arctic Terns, could retrieve eggs if not more than fifteen to eighteen inches away. Kirkman (1937, p. 145) recorded remarkably high percentages of Black-headed Gulls as capable of rolling back into the nest eggs that were nine and twelve inches away.

Two eggs were observed to be carried away partially hatched. In both cases the chicks were nearly clear of their shells. The reason is understandable. Eggshells are removed usually within two or three hours after hatching. Here the instinct seems to have functioned too soon, the eggshells being taken away before the chicks were clear of them. Instances of this sort have been observed in the Song Sparrow (Nice, 1937, p. 145), Hermit Thrush (personal observation), and other passerine birds.

On July 27, the day before leaving the island, the eggs still unhatched were broken open and examined. Eight were sterile, showing no evidence of embryological development. Of these, four were single eggs in the nest. All had been incubated over a period of several days. The remaining fourteen eggs were found to contain dead embryos of which five died in the process of hatching. Desertion is suspected as being the cause of the death of at least two of these embryos and doubtless accounted for the death of several more whose nests had been left uncovered for excessively long periods.

Altogether 91 eggs hatched young of which 23 fledged and probably left the island. *Thus 68 young either met their death in the vicinities of their nests or were lost to the section of the island under study.*

Fifteen chicks ranging in ages from two to nine days died during a severe northeast storm of July 13. Meteorological observations at the nearby

Bowdoin Scientific Station showed the maximum temperature of the day to be 61° F., the minimum 48° F. It was the coldest day during the period when the study was made. It rained rather heavily during the day and there was no sun except in the late afternoon. The wind velocity was twenty miles per hour. Although the storm was well under way at dawn, no chicks were found dead at that time. By nightfall, however, several chicks were found dead in their nests while others died in crevices in the rocks where they had crawled to seek shelter.

For two hours during the morning of this day I watched the portion of the colony under study. I observed several prolonged absences from the nest leaving the eggs and young exposed. In two nests nearby the young appeared to suffer from lack of brooding. But I observed only one marked variation from the ordinary nesting routine: *there was a lack of young-feeding*. Whereas earlier observations showed that the feeding of young birds occurred every five to thirty minutes, at this time only one chick was fed among *all* of those under observation.

I am of the opinion that one of the major causes of death during the storm was starvation due to the inability of the adult birds to obtain food. The day was heavily overcast with a dense fog during the early part of the morning. The roughened surface of the water together with poor visibility probably prevented the birds from seeing and catching their prey. The chicks, not receiving enough food, were considerably weakened and unable to resist the lowered temperature and the severe weather conditions when left uncovered for even short periods. Whitlock (1927, pp. 154-157) has previously observed that oceanic birds are unable to secure enough food during periods of rough weather at sea. After a heavy three-days' gale at Leighton, near Fremantle, Australia, he found in a "semi-exhausted condition" such birds as the Crested, Bridled, Roseate, and Lesser Noddy Terns.

Four chicks which were four, fifteen, seventeen, and seventeen days old respectively, were stepped on and crushed by cows, two being killed during the night. The ability of young terns to 'freeze' on being approached by an 'enemy' appears to have been fateful in these instances. It is surprising that a seventeen-day chick is incapable of escaping from such a death.

Fifteen chicks were found to have met their death in the following ways:

(1) Six chicks were found dead after some form of maltreatment. All were located within two to six feet of their nests. Three showed serious mutilation on the heads and backs while the remaining ones merely showed bruises on the backs of their heads. These six chicks were unquestionably killed by adult terns, presumably those birds owning neighboring nests. This form of infanticide is commonly observed in ground-nesting seabird colonies. Watson (1908, pp. 215-216), in his studies at the Tortugas Islands, was one of the first authorities to call attention to this phenomenon

among terns. He found that chicks of Sooty Tern were attacked by adults still incubating eggs and without chicks of their own. His findings were comparable to mine at Machias Seal Island. Here chicks left their nests to seek shade and shelter in the nearby rock crevices and grass clumps. To reach these they oftentimes had to come near incubating terns and were frequently attacked. If the parent birds were not in the vicinity to come to their defense, the results were frequently fatal.

(2) Three chicks were found dead in their nests. Circumstances led me to believe that they had perished as a result of desertion. Two of the chicks belonged to one nest. They were observed to be noticeably chilled and weak in the evening as if improperly fed and brooded. No adults appeared to protest my presence at the nest or to come down to the nest when I entered the blind for an hour. Early the next morning they were found dead near their nest. Their bodies were stone-cold and there was a deposit of night moisture on their down. The third chick, the sole offspring in the nest, was noticed to be dying one day as a result of lack of care. It was decidedly weak in the morning and was found dead in the afternoon. No adult was seen to pay any attention to the nest during an hour's wait in the blind.

(3) Four chicks drowned in small rain-pools. All were within four days of age. Two, each belonging to a different nest, were drowned in pools formed as a result of the storm of July 13; these chicks died at the beginning of the storm in the night. Adult birds were present at the nests in the morning and several times were observed to attempt brooding in spite of the water in which the corpses of the chicks were floating.

(4) One day-old chick became entangled in a thick clump of grass and was unable to extricate itself. I had difficulty in removing the dead bird, so greatly was it ensnared. The chick had wandered in to seek shelter during the absence of the adults.

(5) Two chicks, two and three days old respectively, crawled too far into the crevices of rocks and became wedged in.

(6) One chick, two days old, fell from the ledge shelf on which its nest was located to a grassy shelf four feet below. The chick died from exposure, as the old birds failed to follow it.

Twenty-nine chicks disappeared during the course of the study at ages ranging from one to eighteen days. I could find no trace of them either among the one hundred nests or in their vicinity. Their disappearance I have attributed to two major factors:

(a) *'Kidnapping.'*—Small chicks were carried away and presumably killed. My assumption is based on one personal observation. While at Machias Seal Island in 1932 I saw one adult bird pounce suddenly upon a newly hatched chick, grasp it in its bill, and fly away with it about twenty-

five feet, then let it drop to its death on the rocks below. The adult paid no further attention to it. Kirkman (1937, p. 117) has watched similar occurrences among the Black-headed Gulls; there are so-called 'rogue gulls' which seem especially addicted to this form of behavior and cause considerable destruction.

(b) *Wanderlust*.—As the chicks advanced in age and the periods between broodings lengthened, many of them were observed to wander from their nests to seek shelter and shade and to hide. Normally there appeared to be a limit to their travels since suitable places could be found nearby. The chicks thus became localized and usually could be found in their vicinities. I became accustomed to looking for certain chicks under a particular clump of vegetation, or in a particular rock crevice. Observations from a blind showed that the adults sometimes brought food to these areas and brooded the chicks there. The chicks which were finally fledged varied little in their wanderings.

I soon became aware of a peculiar phenomenon. Certain chicks, which had up to varying ages been localized, suddenly began to wander and could not be checked. I found one chick over a hundred feet from its own nest; another, fifty feet. These birds I brought back to their territories. The next visits found them gone. From the blind I observed chicks beginning to move away from their nests, not to seek shelter but to keep walking, seemingly "to go somewhere but nowhere in particular." Occasionally they would approach other nesting adults, only to be viciously warded off. Many times I noticed unbanded chicks coming in among the hundred nests and passing on through. One pair of terns on losing their own chicks accepted the offspring in a neighboring nest. The adopted offspring were of the same ages as the ones lost.

The chicks that I observed wandering were obviously uncomfortable. I can only guess at the causes of this behavior. Either they were not being brooded or fed adequately, or both. A similar wandering behavior has been observed in other seabird colonies, but to my knowledge, no satisfactory explanation has ever been given. Herrick (1935, pp. 113-114) has observed that this wandering away from nesting territories is characteristic of young Herring Gulls.

SUMMARY AND CONCLUSIONS

The accompanying table summarizes the history of one hundred nests of the Arctic Tern at Machias Seal Island. A study of this table shows clearly that the greatest loss of eggs and young was due, not to the vicissitudes of the environment of Machias Seal Island (i. e., external factors), but to the various factors arising within the colony itself (i. e., internal factors). The internal factors causing greatest loss may be grouped under the following headings:

(1) *Marauding by adults of nests and young.*—Certain individuals became addicted to puncturing eggs, carrying away eggs, and 'kidnapping' young. Evidence points to the fact that these marauding tendencies occurred in individuals either not mated or not nesting in the part of the colony where the damage was being done.

(2) *Failure of nesting drive.*—Certain pairs of terns failed to incubate steadily, thus exposing their eggs to marauding terns. Others failed to complete incubation, causing the death of embryos. Still others deserted their young, thus either causing their immediate death, or forcing them to wander about on the island with varying results.

The causes of marauding and failure of the nesting drive are open to speculation. The lack of sufficient food in the waters surrounding Machias Seal Island is suspected as being an indirect cause of both marauding and failure of the nesting drive, so that the adult birds are forced to take eggs and young for food purposes and to stop incubation and young-rearing through lack of food for themselves and young. When taking into consideration the fact that there were approximately four thousand adult terns on Machias Seal Island requiring food for themselves *several times a day* and

SUMMARY OF HISTORY OF ONE HUNDRED NESTS OF THE ARCTIC TERN

Record	Number	Per cent
Total eggs in nests.....	144	100
Egg failures due to external factors:		
Cattle.....	10	6.9
Egg failures due to internal factors:		
Rolled from nests.....	2	1.3
Sterility.....	8	5.5
Death of embryos.....	14	6.2
Punctured.....	8	5.5
Carried away at hatching.....	2	1.3
Disappeared from nests.....	7	4.8
Total eggs to hatch completely.....	91	63.
Young killed due to external factors:		
Storm of July 13.....	15	10.7
Cattle.....	4	2.7
Young killed due to internal factors:		
Killed, probably by neighboring adults.....	6	4.1
Deserted.....	3	2.0
Drowned in rain-pools.....	4	2.7
Entangled in grass.....	1	0.6
Wedged in rocks.....	2	1.3
Lost by fall from ledge.....	1	0.6
Disappeared from nests, probably either as a result of kidnapping or wanderlust.....	29	20.1
Young lost to study due to slipping of bands.....	3	2.0
Known total of young to fledge.....	23	15.9

approximately 2500 young during the height of the breeding season requiring food *every five to thirty minutes*, it is wholly possible that there was a shortage of food for such a concentrated population.

Very likely another cause of failure of the nesting drive is its incomplete development in certain individuals breeding during their first, second, and third years. Austin (1938, p. 20) in his trapping and banding studies of Common, Roseate, and Arctic Terns at Cape Cod, Massachusetts, has stated that "egg-laying by a tern the summer following its birth, if it does occur, is anomalous, also that incubation the year following is a precocious and usually futile expression of an incompletely developed sex-urge." He also states "that terns do not begin procreating actively until the end of their third year" and "attain maximum accomplishment in their fourth."

A comparison of the results of this study with the results recently obtained by Hagar (1937, pp. 5-8) in a similar study of the 428 nests of a Least Tern colony at Plymouth Beach, Massachusetts, is of great interest. Both studies showed a high number of egg failures and chick mortalities. Whereas the greatest loss of eggs and young at Machias Seal Island was due to internal factors, at Plymouth Beach the greatest loss was due to two external factors: rats took an estimated 66.5 per cent of the eggs and nearly 50 per cent of the young; storm-tide washes took 19.4 per cent of the eggs. The results of both studies may be summarized thus:

	MACHIAS SEAL ISLAND 100 nests of the Arctic Tern		PLYMOUTH BEACH 428 nests of the Least Tern	
	Number	Per cent	Number	Per cent
Total eggs laid	144	100	820	100
Total eggs hatched	91	63	212	26
Total young fledged	23	15.9	75	9

The above comparison raises the question: If a tern colony is protected from external destructive forces, will there still be a high percentage of nesting failures? The answer naturally depends on the size of the colony and the food supply. The history of the one hundred nests in the *large* colony of Arctic Terns at Machias Seal Island offers an affirmative answer. In the first place there would be an inevitable loss due to the nesting of individuals with an incomplete development of the nesting drive. In the second place there would be sharp competition for food that would by necessity increase the number of nesting failures in the colony.

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*Carleton College**Northfield, Minnesota*