DEVELOPMENTAL DEFECTS IN COMMON TERNS OF WESTERN LONG ISLAND, NEW YORK

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RECENT publications (Gochfeld 1971; Hays and Risebrough 1971, 1972; Nisbet 1972) have called attention to the fact that abnormalities are being found among young terns of several species, more frequently now than in the past. Extensive field studies by the Austins and their associates in the Cape Cod, Massachusetts tern colonies from the 1920s onward provided an excellent baseline for comparison with current observations. The numerous reports by the Austins (for example 1929, 1932, 1933, 1934, 1946) rarely mention abnormalities among the 4000 to 12,000 young terns they handled in most seasons. Austin (1946) noted that the role of disease in tern mortality was unknown but that disease epidemics were apparently rare. Ulcerated eyes and subcutaneous emphysema have been reported (Austin 1929, Floyd 1929), while skeletal defects were presumably infrequent.

Observed abnormalities may be hereditary, may reflect teratogenic processes operating on the developing embryo (or even on the chick after hatching), or may reflect trauma or disease. Occasional reports of deformities of extremities have appeared in the literature on terns, without indication of whether these might have been traumatic in origin or congenital. For example deformed legs, which may result from teratogenic processes, may also result from strangulation of circulation if the bird becomes entangled in grass or string (Gochfeld 1973). In view of the available background information on terns and of the concern with changes in the environment, it is important to document as accurately as possible the changing incidence of abnormalities revealed by current fieldwork.

STUDY AREA AND METHODS

Periodically since 1964 I have studied the terns breeding in colonies in or near Jones Beach State Park, on the barrier beach of Long Island, New York. The principal colonies studied were near Short Beach Jetty, West End Beach, Wantagh Parkway, and Cedar Beach, about 30–45 miles (48–72 km) east of New York City. The colony descriptions and some data on productivity and mortality are given elsewhere (Gochfeld 1966, 1971, 1973, 1974; Gochfeld and Ford 1975). All colonies are close to roads and are subject to frequent disturbance by humans. The Common Tern (*Sterna hirundo*) is the dominant species in all four colonies, and the only one in which I have found nontraumatic defects. Table 1 gives the estimated total number of pairs of Common Terns breeding in these four colonies in each year of the study.

The West End colony, the only one active in 1969, was visited 2 to 4 times weekly from mid-May to mid-July, and weekly thereafter. Other colonies were visited at least weekly. Nests and eggs were marked in several seasons, and almost all young birds found were caught, banded, and examined for defects, and were re-examined if recaptured. All terns found dead were examined and removed or buried.

Where possible, defects were classified as (1) believed caused by trauma, infection, etc., or (2) resulting from developmental or hereditary factors. At present category 2 could not be further subdivided. Exogenous toxic compounds could produce defects classified in either category, but in this report only the occurrence of presumed developmental or hereditary defects is considered.

Defining the population "at risk."—Measuring the prevalence of a disease or defect in a population at a given time requires an estimate of the number of individuals that could potentially be affected. This "at risk" group differs for different conditions. For example, all embryos are "at risk" of possible developmental defects that occur early in development, but for late-occuring conditions such as feather-loss (Gochfeld 1971), which cannot be recognized until the young terns are at least 10 to 14 days old, only those chicks that survive to this age are "at risk."

An additional problem results from differing conspicuousness of conditions. Crossed bill and feather loss are easily detected, while defects causing death early in embryonic development are likely to be overlooked and the eggs reported as infertile. In fact very little useful data exist on the prevalence of prehatching defects, as relatively few fieldworkers have examined unhatched eggs. Hays' fieldwork on Great Gull Island is a notable exception (Hays and Risebrough 1972).

Data on the number of eggs laid in a colony are available in some reports, but are poor estimates of the "at risk" sample for any condition, because the magnitude of egg loss from various causes, including infertility, are rarely known. An estimate of the number of pairs of terns in a colony is just as useful, particularly as such estimates can be made with relatively little disturbance (Nisbet 1972, Gochfeld MS). Also many reports on terns give estimates of the number of nesting pairs present, without other data.

Whenever possible all chicks hatching in the Jones Beach colonies were examined within the first few days of life, when they were usually found close to the nest. Each chick handled was listed, even if it was too young to band, and this figure, including probably 80–90% of all chicks hatching in some colonies, is used as the "at risk" sample for congenital defects (i.e. those evident at hatching). Chicks were given numbered leg bands when their primary feathers emerged at approximately day 5. By this time they are much more mobile and more difficult to find, so that the number of 5-day-old and older chicks captured represents an estimated 40 to 75% of the actual number of such chicks, depending on vegetation cover and intensity of effort. This sample is considered "at risk" for late-occurring defects. The number of chicks handled and banded each year is given in Table 1.

Abnormalities

Table 1 shows the annual occurrence of seven types of developmental abnormalities on western Long Island. Although these abnormalities were originally discovered independently in the Jones Beach colonies and at Great Gull Island, 75 miles (120 km) to the east, it is remarkable that most types of abnormalities were found in both places. Moreover,

TABLE 1
OCCURRENCE OF ABNORMALITIES AMONG YOUNG COMMON TERNS (1964 TO 1973)[1]

	1964	1969	1970	1971	1972	1973	Total	% prevalence[2]
No. nesting pairs (est.)	1000[3]	1200	2761	3230	3028	4180	15,398	
No. chicks handled	647	1602	2090	2941	2350	812	10,442	
No. chicks banded	322	1321	1702	1793	1817	694	7,649	
Flight feather loss	0	1	25	33	5	2	66	0.90[4]
Absence of down	0	1	9	10	6	1	27	0.28
Crossed bill	0	0	1	4	2	0	7	0.07[4]
Underdeveloped mandible	0	0	2	5	3	0	10	0.10
Maldeveloped limbs	0	0	0	3	2	1	6	0.06
Supernumerary digits	0	0	0	1	0	0	1	0.01
Microphthalmia or anophthalmia	0	0	1	1	0	0	2	0.02
No. birds affected	0	2	35	51	16	4	104	0.73

[1] Combined total for four colonies (see text).
[2] Totals from 1969–73 (excluding 1964) used as basis for prevalence figures.
[3] This estimate based on secondhand report.
[4] Estimate of prevalence based on total number of chicks banded; otherwise estimates based on number of chicks handled from 1969–73.

the defects appeared simultaneously (1969–70) in colonies that had been well-studied previously. Banding studies have shown that very little interchange of birds takes place between these two breeding sites. The abnormalities have been well illustrated by Hays and Risebrough (1972).

1. *Feather loss.*—This was the commonest defect both on eastern and on western Long Island, accounting for 63% of all abnormal birds found in the Jones Beach colonies. It involves faulty development of feathers and their subsequent loss. Mainly the flight feathers are involved, although in severe cases, contour feathers are abnormal as well. Close examination of the rachises of dropped feathers showed the cortex was thinned and often cracked. Flight feathers are subject to considerable strain when the young birds are about ready to fly, and usually they seemed to have broken off at the base. This disorder bears a striking resemblance to French molt, a condition affecting psittacine birds in captivity (Taylor 1969 and pers. comm.). Its occurrence in the Long Island terns is apparently the first instance in wild birds and in non-psittacines. The cause of that dramatic disease of cage birds is still not known, although Taylor (1969) reports some studies that weakly suggest vitamin deficiences might predispose birds to it. He considers this condition as a syndrome that may result from a variety of factors interfering with the supply of nutrients to the feather follicle during formation.

TABLE 2

OCCURRENCE OF FEATHER LOSS IN COMMON TERNS OF WESTERN LONG ISLAND (1969–73)

Year	Cases	Chicks banded[1]	% prevalence	Between year significance of difference[2]
1969	1	1321	0.07	
1970	25	1702	1.47	1969–70, $P < 0.001$
1971	33	1793	1.84	1970–71, $P < 0.25$
1972	5	1817	0.28	1971–72, $P < 0.001$
1973	2	694[3]	0.29	1972–73, $P > 0.25$
				1970 and 1971 vs. 1972 and 1973, $P < 0.001$

[1] Chicks at least 5 days old used as estimate of at risk sample for feather loss.
[2] Chi-square test applied to 2×2 contingency table.
[3] Small sample reflects reduced fieldwork in 1973.

The peak incidence (see Table 2) for this and all other abnormalities was in 1970 and 1971, when slightly over 1% of the chicks handled and 1.5% of the chicks banded suffered the condition. These cases varied from the loss (usually symmetrical) of one outer remex, to the loss of all remiges, rectrices, and much body plumage as well. The decrease to five cases in 1972 and two in 1973 appears significant ($P < 0.001$). Because of differences in sampling among our colonies, and between ours and other groups, no intercolony comparisons of prevalence are possible. Nisbet (1972) found feather loss among Common Terns in Massachusetts and Woolfenden and Robertson (pers. comm.) found it among Sooty Terns (*S. fuscata*) in Florida. Roseate Terns (*S. dougallii*) were among those afflicted at Great Gull Island where they make up about half the population, but not on western Long Island where they comprise less than 2% of the nesting birds.

2. *Absence of down.*—This was the second most common abnormality on western Long Island. It was apparent at hatching and occurred in 0.27% of chicks handled. It varied from complete or partial absence of down, to the occurrence of short, sparse, "nappy" down, and the category may therefore be heterogeneous from a pathogenetic viewpoint. It occasionally accompanied other defects (for example see Hays and Risebrough 1972, Figs. 1 and 5). Several newly hatched chicks or chicks found dead in the egg showed absence of down in association with maldevelopment of extremities or hypodevelopment of the mandible. The figures for this condition (Table 1) exclude the many chicks found with small discrete downless patches on their head, often associated with scalp lacerations attributable to attacks by territorial adult terns, which may peck wandering chicks severely (Austin 1929).

3. *Maldevelopment of the limbs.*—This condition is of particular

interest because it may represent part of the spectrum of phocomelia, a syndrome known to be produced by the teratogenic drug thalidomide. In my series only the lower extremity was involved in four cases, which included deformed or absent toes and shortening of the tibiotarsus with clubbing of the distal end. The humerus was shortened in one case and the radius and ulna and tibiotarsus in the sixth case. Three of these chicks also lacked all or most of their down, and one of these had the upper mandible only 60% of its normal length. This latter bird was found dead in the egg. Two of the others were found in pipped eggs—one alive, the other dead; and two others hatched normally, but died in the first day of life. Five siblings of these chicks were examined and all appeared normal.

4. *Crossed bill.*—This is a dramatic condition (see Hays and Risebrough 1972, Fig. 1; Hanebrink and Beadles 1971) that has been reported frequently among passerine birds but not often among nonpasserines (Pomeroy 1962). It may result from a variety of disturbances including trauma, and it appears occasionally in cage birds whose bills are not properly trimmed. In addition to terns of eastern and western Long Island, it has been found in Massachusetts (Nisbet 1972). The seven cases on western Long Island represent 0.07% of the chicks handled. I kept one Common Tern with a severely crossed bill for 4 months. It could not pick up food itself, nor manipulate fish in its beak, but it ate well when the fish was placed headfirst in its gape.

5. *Hypodeveloped mandible.*—I found 10 such cases on western Long Island, all involving the upper mandible, while Hays and Risebrough (1972, Fig. 3) illustrate a chick with an underdeveloped lower mandible. Two of the cases were part of a multiple defect syndrome involving maldeveloped limbs and/or absence of down.

6. *Other defects.*—One case of an extra toe (see Austin 1969) and one case of microphthalmia (see Berger and Howard 1970), were found on western Long Island. One case involving multiple defects included anophthalmia. Otherwise eye defects and supernumerary digits seemed not to be a part of the apparent epidemic of defects described above. Hays (Hays and Risebrough 1972, see Figs. 4, 6) found supernumerary limbs in one tern chick and microphthalmia in at least one other.

CHANGE IN INCIDENCE

Other fieldworkers reporting abnormalities in Common Terns (e.g. Hays and Risebrough 1972, Nisbet 1972) agree that a real increase in the prevalence of abnormalities occurred in 1969–70. The data presented here for all abnormalities show a significant increase ($P < 0.001$) from

1969 to 1970, no change ($0.5 > P > 0.25$) from 1970 to 1971, and a significant decrease in feather loss in 1972 ($P < 0.001$). These differences have been tested using 2×2 contingency tables and Chi-square tests. The difference between 1973 and earlier seasons is not significant ($P > 0.1$), but the amount of fieldwork in 1973 was much reduced.

At the same time defects have appeared among Roseate Terns (Hays and Risebrough 1972) and among Sooty Terns (Robertson and Woolfenden, pers. comm.) in greater frequency than in previous years. Literature review on the crossed bill abnormality among nonpasserine birds (Gochfeld MS) suggests that the increased prevalence of this defect may be widespread both geographically and taxonomically.

I found no abnormalities in 1964 among the 644 chicks handled, and I did little fieldwork in 1965–1968. The absence of abnormalities in 1964, although statistically significant ($P < 0.001$), may reflect in part the low number of birds handled or my relative lack of experience with them. Combining the data for 1964 and 1969 gives a total of two abnormalities among 2246 chicks handled, which is significantly less than in subsequent years ($P < 0.001$).

Discussion

The occurrence of defects in several tern species in several regions suggests that some widespread environmental factor is operating on the terns. The increased concern with and attention to abnormalities by field biologists might account in part for the apparent increase in their occurrence. In all cases the same fieldworkers have had at least several seasons experience with the tern colonies prior to the initial observations of defects. Hays and Risebrough (1972) discuss the association between abnormalities found at Gull Island and concentrations of polychlorinated biphenyl compounds (PCB's), while I (Gochfeld 1971) found higher levels of mercury in birds with feather loss than in nonaffected chicks of the same age. Both PCB's and mercurial compounds are known to have mutagenic or teratogenic as well as toxic effects on tissues (Fiskejo 1970, Ramel 1969, Vos and Koeman 1970). These associations, although circumstantial at present, do direct attention toward the role of environmental contamination in producing the above-mentioned defects. At present no additional information is available to explain the sudden occurrence of the abnormalities.

To document the relationship between defects and concentrations of one or more chemicals, large numbers of normal and abnormal birds will have to be analyzed. Final proof will involve producing comparable abnormalities in experimental animals. If synergistic interaction between

two or more chemicals is involved, such studies will prove even more difficult. As bird populations afflicted by a high incidence of defects cannot wait for such elegant proofs, management principles must be based on inferences drawn from the study of the geographic and taxonomic distribution of the defects, from their prevalence, and from their pathologic properties. Knowing the distribution of the defects will facilitate the search for offending compounds and the eventual demonstration of causal relationships.

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SUMMARY

A variety of developmental abnormalities, formerly rare or unknown, appeared in several colonies of Long Island terns, at low prevalence in 1969 and at significantly higher levels in 1970 and 1971. The prevalence of feather loss was lower in 1972 and 1973, and continued observation will be needed to determine long range trends. The commonest abnormality, feather loss, occurred in at least 0.7% of chicks in 1969–73. Among chicks reaching 2 weeks of age, the prevalence was nearly 1.5%. Other defects involved the skeletal, nervous, and cutaneous systems.

Chemical contaminants in the birds' environment have been implicated in the production of such defects. While the tedious process of analyzing normal and abnormal birds continues, surveillance of the populations and documentation of the prevalence of abnormalities is important. New information on the locations of abnormalities, the species involved, and the types of defects as well as on the feeding behavior of the birds, would be extremely useful in clarifying the possible cause or causes of the defects.

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