ABNORMAL CHICKS AND PCB RESIDUE LEVELS IN EGGS OF COLONIAL BIRDS ON THE LOWER GREAT LAKES (1971–73)

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THIS paper reports the incidence of abnormal chicks found in colonies of Black-crowned Night-Herons (*Nycticorax nycticorax*), Herring Gulls (*Larus argentatus*), Ring-billed Gulls (*L. delawarensis*), Common Terns (*Sterna hirundo*), and Caspian Terns (*Hydroprogne caspia*) in the lower Great Lakes. The residue levels of PCB in eggs collected from seven colonies are also reported.

Abnormal chicks of fish-feeding birds have, until recent years, been infrequently reported despite a number of studies of large colonies for various purposes. A search of the North American literature has produced the following instances of abnormalities recorded incidentally to other fieldwork. Of 1500 Herring Gull chicks banded in Witless Bay, Newfoundland in 1967, only one was found with an abnormality, this being a crossed bill (Threlfall 1968). In 8 years of banding more than 125,000 Sooty Tern (*Sterna fuscata*) chicks, Austin (1969) noted only one abnormal chick, (with extra toes at the tarsometatarsal joints) on the Dry Tortugas, Florida. During 12 years of study in Wyoming (1959–70), Smith and Diem (1971) handled 6147 juvenile California Gulls (*Larus californicus*). Three chicks with abnormalities were found, two with lateral deflections of the upper mandible, and one with a slightly crossed bill. Ryder and Chamberlain (1972) found a single abnormal chick (with polydactyly) in 359 Ring-billed Gull chicks banded on Granite Island in northern Lake Superior.

Hays and Risenbrough (1972) recorded an increase in the incidence of abnormalities in Common Terns and Roseate Terns (*Sterna dougallii*) on Great Gull Island, Long Island Sound, New York in 1970. In a total of 40 abnormal young of 3122 handled, various bill, eye, and foot deformities were noted in unhatched chicks and in chicks up to 3 days of age, and wing and tail feather losses were recorded in 2- to 3-week-old terns. In other colonies on the eastern seaboard 29 young Common Terns that were unable to fly because of feather loss were also reported for 1970. These abnormalities were similar to those produced in poultry (*Gallus domesticus*) on an experimental feeding diet contaminated with chick edema factor (Flick et al. 1965). In a PCB feeding study feather loss was seen (Vos and Koeman 1970). Tumasonis et al. (1973) found a high incidence of abnormal chicks hatching from eggs laid by PCB-

treated poultry and showed that the frequency of abnormal chicks was dependent upon the content of PCB in the egg. Higginbotham et al. (1968) reported that chlorinated dibenzo-p-dioxins cause chick edema disease. The chemically similar chlorinated dibenzofurans contaminate some PCB mixtures (Vos et al. 1970). Neither the chlorinated dibenzo-p-dioxins nor the chlorinated dibenzofurans have yet been found in wildlife tissues (Bowes et al. 1973), possibly because if they are present, they are at concentrations below the present levels of detection. The rates of abnormalities found in colonies of fish-feeding birds may be related to the level of toxic chemicals in their food.

Methods

Observations of abnormal chicks were made incidental to estimates of breeding success in colonies of fish-feeding birds on the lower Great Lakes between 1971 and 1973. Breeding success was measured in most colonies of ground-nesting species by enclosing a portion of the colony and by recording the number of nests, eggs, hatched chicks, and fledged chicks during successive visits. The tree-nesting colonies of Black-crowned Night-Herons were not enclosed, but the nests, eggs, and hatched young were marked individually.

Egg samples were collected from a part of seven of the colonies either adjacent to those areas that were enclosed, or, for unenclosed areas, from a central portion of the colony. Eggs were analyzed for PCB and other organochlorine materials by the methods outlined in Reynolds (1969). The concentrations of the polychlorinated biphenyls in the egg samples are reported here for two reasons. First, if the chlorinated dibenzofurans are present, they may have their primary origin in the PCB mixtures, and therefore be most closely correlated with PCB concentration. Second, the lipophilic properties of these microcontaminants may determine that they move in food chains in concentrations proportional to the other organochlorine contaminants such as the PCB.

The residue values are expressed as geometric means in dry matter parts per million as a log normal distribution of the residues is assumed.

Results

The colony locations where abnormal chicks were found are shown in Fig. 1. Details of the number of chicks examined, abnormal chicks found and estimates of PCB content in the egg samples are shown in Table 1. Table 2 lists the type of deformity noted, and age and condition of the abnormal chicks.

Three colonies of Black-crowned Night-Herons were investigated in 1972 and 1973. No abnormalities were discovered in 1972 in 33 chicks examined on Pigeon Island (Lake Ontario) or in the 154 chicks examined in the two colonies in Lake Erie (Pelee Island and East Sister Island). The mean estimated residue levels of PCB in eggs collected from these colonies was 304 ppm (Lake Ontario, $n = 3$) and 144 ppm (Lake Erie, $n = 5$). A single abnormal chick with a crossbill was discovered among the 39 chicks examined in the Pigeon Island colony in 1973 (Table 2).

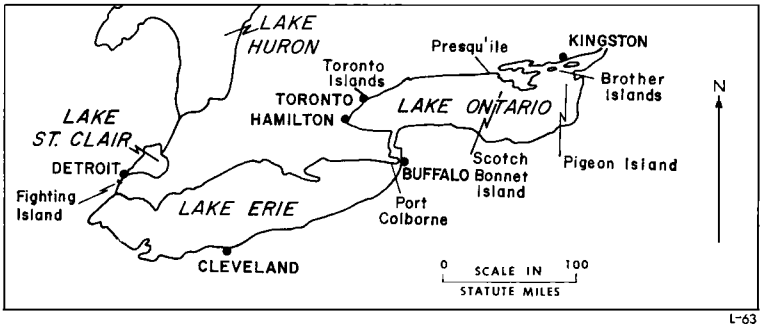

Fig. 1. Location of colonies with abnormal chicks.

Nine Herring Gull colonies were investigated in 1972 and 1973. More than 850 chicks were examined each year and in only one of these was a presumed abnormality identified (Table 2). This chick was caught and examined and found to be normal except that at the age of approximately 45 days it was unable to fly, and subsequent observations up to 90 days showed that it was still flightless. Residue levels of PCB were higher in the eggs of Herring Gulls than in any other species (Gilbertson and Reynolds 1974). The estimated mean residue level of the five colonies in Lake Ontario in 1972 was 580 ppm ($n = 10$), and the mean estimated residue level of the three colonies in Lake Erie in 1972 was 300 ppm ($n = 6$).

The principal abnormality found in the Ring-billed Gull colonies was a leg deformity in about two dozen chicks in the Muggs Island colony (Toronto) in 1972 and 1973 (Table 2). It is not possible to estimate what proportion of the total chick population on Muggs Island these birds represent, as we have no reliable estimate of the number of chicks present. These young birds were unable to stand or walk properly and moved about on the ground by using their wings as the principal means of locomotion. Examination of one 20-day-old chick with these signs, caught in 1974, showed that the gastrocnemius tendon and the hypotarsal sesamoid of both legs slipped from the condyles on the cartilaginous articular surface on the tibiotarsus. The bird thus had no support at the tibiotarsal tarsometatarsal joint. This condition has been called perosis in poultry and has been mainly attributed to a deficiency of manganese. Whether the abnormalities in the Muggs Island colony were caused by this factor or whether they were due to some other condition is not at present known. To our knowledge, perosis has not been described in wild birds before.

One abnormal Ring-billed gull chick with a bill deformity was found

TABLE 1

FISH-FEEDING BIRD COLONIES WITH ABNORMAL CHICKS IN THE LOWER GREAT LAKES AND PCB LEVELS IN WHOLE EGG CONTENTS

Species, year, location[1]	No. of chicks examined	No. of abnormal chicks	Percent of abnormal chicks	PCB in dry matter (ppm)
Black-crowned Night-Heron				
1973 Pigeon Island	39	1	2.6	Not measured
Herring Gull				
1973 Port Colborne	ca. 100	1	ca. 1.0	Not measured
Ring-billed Gull				
1972 Muggs Island	ca. 2000	ca. 6	ca. 0.3	418 (351–498, n = 2)[2]
1973 Muggs Island	ca. 2500	ca. 20	ca. 0.8	Not measured
1973 Pigeon Island	Not measured	1		Not measured
Common Tern				
1971 Hamilton Harbor	151	2	1.3	399 (347–463, n = 32)
1972 Brother Island	5	1	20	Not measured
1972 Presquile: Bluff Island	54	1	1.9	281 (pool of 5)
1972 Muggs Island	ca. 420	5	1.2	243 (2 pools of 5[3])
1972 Hamilton Harbor	89	1	1.1	Not measured
1972 Port Colborne	733	1	0.1	181 (107–227, n = 4)
1972 Fighting Island	152	1	0.7	144 (73–180, n = 5)
1973 Toronto Harbor Spit	125	1	0.8	Not measured
1973 Port Colborne	ca. 1000	1	ca. 0.1	Not measured
Caspian Tern				
1972 Pigeon Island	ca. 100	1	ca. 1.0	359 (171–566, n = 4)

[1] All locations are in Lake Ontario except Port Colborne (Lake Erie) and Fighting Island (Detroit River).
[2] Geometric mean (range and sample size).
[3] Mean of samples taken early (May) and late (July).

on Pigeon Island in 1973. No further abnormalities were noted in the more than 500 chicks examined from four additional colonies under investigation in the three lower Great Lakes during 1972 and 1973. The mean PCB residue in eggs collected from the Ring-billed Gull colonies in 1972 was 379 ppm (n = 4) in Lake Ontario, 101 ppm (n = 2) in Lake Erie, and 113 ppm (n = 2) in Lake Huron.

The Common Tern colonies contained the greatest proportion and widest variety of chick abnormalities, but the mean incidence of abnormalities noted in the chicks examined from these colonies was less than 1%. Three colonies, two in Lake Ontario (Salmon Island and Wellers Bay) and one in Lake Erie (Rondeau Park in 1973), contained no recorded abnormalities in the approximately 500 chicks examined. The mean PCB residue in eggs collected from these three colonies was 155 ppm (n = 4) compared to a mean level of 257 ppm (n = 24) in eggs collected from colonies that produced abnormal chicks.

TABLE 2
AGE, CONDITION, AND TYPE OF ABNORMALITY OF CHICKS OF FISH-FEEDING BIRDS IN THE LOWER GREAT LAKES

Species, year, location	Number	Age examined (in days)	Condition	Deformity
Black-crowned Night-Heron				
1973 Pigeon Island	1	ca. 20	Alive	Crossed bill
Herring Gull				
1973 Port Colborne	1	ca. 45	Alive	Unable to fly, otherwise normal
Ring-billed Gull				
1972 Muggs Island	ca. 6	ca. 20	Alive	Slipped tendon
1973 Pigeon Island	1	ca. 20	Alive	Crossed bill
1973 Muggs Island	ca. 20	ca. 20	Alive	Slipped tendon
Common Tern				
1971 Hamilton Harbor	1	Unhatched	Dead	Downcurved lower mandible
1971 Hamilton Harbor	1	3	Dead	Crossed bill
1972 Brother Island	1	4	Alive	Supernumerary toes at tarsometatarsal joint
1972 Presquile	1	1	Alive	Small eyes, crossed bill
1972 Muggs Island	1	1–2	Alive	Crossed bill
1972 Muggs Island	2	ca. 5–6	Alive	Crossed bill
1972 Muggs Island	1	1–2	Alive	Crossed bill
1972 Toronto Island	1	Pipping	Dead	Short lower mandible
1972 Hamilton Harbor	1	1–2	Alive	Crossed bill
1972 Port Colborne	1	1–2	Alive	Supernumerary toes at tarsometatarsal joint
1972 Fighting Island	1	ca. 4	Dead	Crossed bill
1973 Toronto Harbor Spit	1	1–2	Alive	Crossed bill
1973 Port Colborne	1	1–2	Alive	Crossed bill
Caspian Tern				
1972 Pigeon Island	1	ca. 15	Alive	Crossed bill

A single deformed chick with a crossbill was found among approximately 100 Caspian Tern chicks examined on Pigeon Island (Table 2). No abnormal chicks were found among the 179 chicks examined on the South Limestone Islands in Lake Huron. The mean PCB residue levels in eggs collected from these colonies was 359 ppm (Pigeon Island, n = 4) and 174 ppm (South Limestone Island, n = 3).

DISCUSSION

The observations on the incidence of abnormalities reported in this paper were made by a number of investigators (see Acknowledgments) whose primary responsibility was to collect data on reproductive performance. Although an effort was made to maintain consistency in the

data collection procedures, some of the colonies received much more detailed attention than others. Variations in the intensity of effort given to a particular colony was a function of the size of the investigative team, the numbers of colonies each team had responsibility for, and the ease of access to the various colonies. Thus, whereas some colonies were visited daily, others were visited much less frequently with time intervals in excess of one month. Furthermore, as the principal objective of the larger study was not directly related to noting the incidence of abnormalities, the data reported here are neither as complete nor as detailed as would be desirable. Despite these limitations, we believe that certain trends are suggested by the information available.

First, the incidence of abnormalities in all species taken together for all years was higher in Lake Ontario than in Lake Erie. Treating each colony as a separate breeding unit in each year, the data show that of a total of 28 colonies in Lake Ontario 12 (42.9%) contained one or more recorded abnormalities, whereas the rate in Lake Erie was 4 of 15 (26.7%). A summary of recent DDE and PCB analyses of Canadian bird tissues (Gilbertson and Reynolds 1974) strongly suggests that the levels of these contaminants are greater in eggs of fish-feeding birds on Lake Ontario than in those on Lake Erie. An association may exist between toxic residues in the eggs and tissues of adult birds and the incidence of abnormalities in their chicks, but the small sample size, the presence of unidentified residues, and the differences in sampling procedures preclude a more definite analysis.

The second trend suggested by our data is the apparent variation in the incidence of observed abnormalities among the different species. The Herring Gull colonies showed a zero incidence of deformed chicks at hatching despite having the highest recorded PCB residue levels in their eggs, whereas the Common Tern colonies, which had the lowest recorded PCB residue levels in their eggs, showed the highest incidence of chick deformities. This difference may be an artifact of unequal data collecting procedures, as most of the Common Tern colonies were larger and received more detailed attention than the Herring Gull colonies. However two of the Herring Gull colonies (Port Colborne, 1972 and 1973 and Muggs Island, 1973) were under intensive investigation and visited at least twice each week during the breeding season. A third Herring Gull colony (Mohawk Island) was visited at least once a week during 1972, but observations there were less intensive than those made on the resident Ring-billed Gull colony. Nevertheless these colonies showed a zero incidence of chick deformity up to the time of fledging at 28 days. Although the single incidence of any character resembling an abnormality was noted in the Port Colborne colony, the chick involved

was around 45 days when first handled and 90 days of age when last seen, well beyond the age of any other abnormal chick recorded and undoubtedly noted only because of the close attention given this colony.

The absence of post-hatch deformed Herring Gull chicks may be due to a variety of factors. First, adult Herring Gulls may kill such chicks on hatching. Second, deformed chicks may die before hatching. High embryonic mortality was noted in a Herring Gull colony in Lake Ontario (Gilbertson and Hale 1974). Recent examination (Gilbertson MS) of artifically (n = 48) and naturally (n = 9) incubated Herring Gull eggs from Scotch Bonnet Island, Lake Ontario revealed one dead embryo (artificially incubated) with the tip of the lower mandible growing at right angles to the axis of the bill and one chick (naturally incubated) with a deformed heart. Such abnormalities would, of course, escape detection in the field where no similar pathological procedures were conducted. Third, it is possible that the obvious absence of deformed chicks up to and beyond the fledging stage reflected the real situation in the field during 1972 and 1973. If this were the case then it might indicate a difference in species susceptibility to a teratogenic agent. This third explanation has a measure of support in that experimental work on the teratogenic effect of PCB does indicate a variation in species susceptibility in Mallard ducks (*Anas platyrhynchos*) and in poultry. Mallard ducks fed PCB produced no abnormal ducklings despite residue levels in two eggs of about 110 ppm and 190 ppm on a dry matter basis (Heath et al. 1972). In contrast, Tumasonis et al. (1973) found abnormal young chickens at between about 10 ppm and 30 ppm in the yolk on a wet weight basis, which is nearly equivalent to the same values on a dry matter basis for the whole egg. Though the PCB mixtures may have contained different concentrations of the teratogenic agent, these two experiments suggest that poultry are probably more susceptible to the teratogenic effects of PCB than are mallard ducks. Thus, although the situation may be considerably more complex, these findings and our observations suggest that if toxic chemicals are affecting the reproductive biology of Herring Gulls and Common Terns in the lower Great Lakes, the impact may be realized in quite different parts of the breeding cycle.

We further note that both the incidence of abnormalities and the apparent level of PCB and DDE contamination were higher in the Common Tern colonies in the lower Great Lakes than in the tern colonies investigated by Hays and Risebrough (1972). No feather loss in fledging chicks was found on the Great Lakes colonies. Excluding those chicks that appeared normal at hatching but that later exhibited feather loss abnormalities, the Great Gull Island Roseate Terns contained a single

gross abnormality (crossed bill) of the 1777 chicks banded (0.05%), while of 4405 Common Tern chicks examined in the same area, 10 (0.23%) had gross abnormalities at hatching. These values are substantially lower than rates recorded in Common Tern colonies that we visited (Table 1). Similarly, breast muscle residues of DDE and PCB in Common Tern chicks from Great Gull Island showed median levels of 2.1 ppm and 25.0 ppm on a wet weight basis respectively. While we recognize that these values are not directly comparable, the residue levels of PCBs appear to be higher in the eggs of Common Terns collected in the lower Great Lakes (Table 1).

The similarity of some of the deformities at hatching in the Great Lakes colonies to those found in the Long Island Sound colony (Hays and Risebrough 1972) suggests a common casual factor with a relatively specific effect on embryo pathogenesis. This effect may be more widespread in its occurrence than is currently apparent from the literature. We therefore encourage other investigators working with species of colonial fish-feeding birds to be alert for incidences of abnormalities, however small, in their populations. It is only through such accumulated observations that any species-dependent causal relationship between residue levels and the incidence of chick abnormalities will be determined.

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