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NESTING BIOLOGY OF LAUGHING GULLS IN RELATION TO AGRICULTURAL CHEMICALS IN SOUTH TEXAS, 1978–81

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Various aspects of the breeding biology of Laughing Gulls (*Larus atricilla*) have been studied extensively in Florida (Dinsmore and Schreiber 1974, Schreiber et al. 1979, Schreiber and Schreiber 1980), New Jersey (Bongiorno 1970, Burger and Beer 1976, Burger 1976, Montevecchi 1978), and Massachusetts (Noble and Wurm 1943), but little is known of their yearly fledging success in Texas or elsewhere. The Laughing Gull is a common colonial nester along most of the Texas coast, second only to the Cattle Egret (*Bubulcus ibis*) in breeding abundance; however, the Laughing Gull may be threatened in Texas because of suspected declines at certain traditional nesting locales (Blacklock et al. 1979). Since Laughing Gulls often nest in proximity to agricultural and industrial areas, we were concerned that environmental pollutants might be adversely affecting productivity. In 1978–1981 we conducted studies along the south Texas coast to learn more about the nesting ecology of Laughing Gulls and to evaluate the effects of environmental contaminants on reproduction.

STUDY AREAS AND METHODS

Our study areas were located at Corpus Christi, Nueces Co., (27°52′N, 97°30′W), Port Mansfield, Willacy Co., (26°14′N, 97°26′W), and Laguna Vista, Cameron Co., (26°06′N, 97°18′W), Texas, encompassing a 200-km stretch of the south Texas coast (Fig. 1). At these sites, Laughing Gulls nested on unnamed, dredged material islands 1–2 ha in size made of oyster shell and sand. About 50–75% of the island surfaces were covered by patches of low vegetation (<1 m) dominated by sea oxeye (*Borrichia frutescens*), coast bacopa (*Bacopa monnieri*), and glasswort (*Salicornia* spp.). The study island in Nueces Bay at Corpus Christi was flanked by industries on the south shore of the bay and by agricultural lands on the north shore; the one at Port Mansfield was located in the Laguna Madre, 0.8 km from the outlets of two major agricultural drains. The Laguna Vista island was about 20 km south of where the Arroyo Colorado, a major waterway that traverses the heavily farmed Rio Grande Valley, empties into the Laguna Madre.

In 1978, we studied Laughing Gulls only at Corpus Christi, expanding our studies in 1979–1981 to include Port Mansfield and Laguna Vista. We made approximate biweekly visits to nesting islands beginning in late January through mid-April each year. Thereafter study sites were visited once a week, usually on the same day. We began marking nests with numbered stakes when eggs first appeared in nests. We staked the first 60–75 nests receiving eggs each year at Corpus Christi and Laguna Vista; all nests were staked at Port Mansfield. Nest marking usually was completed within a 2-week period. Eggs within nests were marked with the assigned nest number and the egg sequence number when known. During weekly visits we collected data on the fate of eggs and young at marked nests; also, we counted all

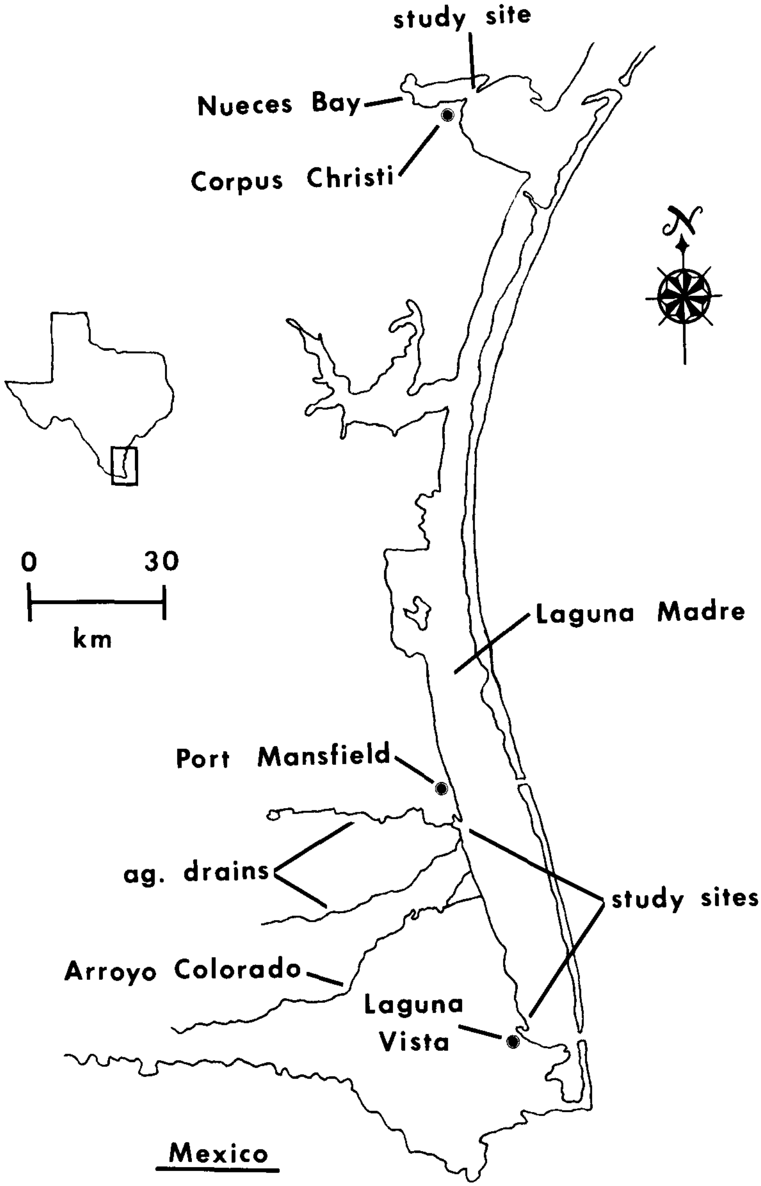

FIG. 1. Laughing Gull study-sites on the south Texas coast.

unmarked nests with eggs as an indicator of colony size. We were only able to keep an accurate account of chicks in marked nests up to about 1 week posthatch; after that, some chicks would depart the nest and hide in surrounding vegetation when we drew near. Chicks found dead each week were removed from the islands. As the chicks approached fledging (flying age), they would gather at the ends of the small islands away from us. By carefully searching the vegetation for chicks as we proceeded through the colony each week and then counting those chicks at the ends of the islands, we were able to estimate overall productivity for the colony (fledglings/total nests) at each locality. Chick counts ceased once young were observed flying. Although some degree of asynchrony existed, most chicks reached fledging age within a 2-week period. Only marked nests were used in estimating clutch-size, hatching success, and fate of chicks to 1 week; total nests were used in estimating fledging success on a colony basis.

At the initiation of egg-laying each year we collected one fresh egg from each of 201 unmarked nests on islands adjacent (usually <1 km) to study sites for organochlorine residue analyses. Also, intact eggs that failed to hatch in marked nests were analyzed to determine if residues were implicated in egg failure. The chemical analyses were conducted at the Patuxent Wildlife Research Center following the methods described by Clark et al. (1983). Quantification limits were 0.1 ppm for organochlorine pesticides and 0.5 ppm for polychlorinated biphenyls (PCBs) on a wet weight basis. Residues in 5% of the samples were confirmed by mass spectrometry. To determine if shell thinning had occurred, we compared eggshell thicknesses of the eggs we collected with those of eggs collected in Texas in the 1920s before the pesticide era and now housed at the Welder Wildlife Foundation, Sinton, Texas. Eggshells were measured with a micrometer to the nearest 0.01 mm.

RESULTS AND DISCUSSION

Nesting chronology and colony size.—The colonies studied were known to exist at least since 1973 (Texas Colonial Waterbird Society 1982). Colony size was fairly consistent during our study among years; the average number of breeding pairs on study islands was 200 at Corpus Christi, 53 at Port Mansfield, and 220 at Laguna Vista. Laughing Gulls are permanent residents in coastal Texas, but are not always associated with the breeding islands (Burger and Beer 1976). Toward the end of January each year a few gulls (usually <20) were seen loafing on study islands. Most were in winter plumage; only 2% had black heads. By mid-February, about 25% of the nesting population had gathered on the islands and some pairs were seen standing on the island interiors. By mid-March, 50–75% of the expected breeders had gathered on the islands and courtship activity had begun in earnest; 95% of the gulls had black heads but less than 20% had red bills. By the time egg-laying began in late April, all adults had bright red bills. We never saw immature-plumaged birds breeding and none were seen around the nesting islands after about mid-April.

Nest-building began each year around the third week in April at Corpus Christi and Laguna Vista but did not commence until the last week of April at Port Mansfield. Almost all the nests were built directly on the ground adjacent to surrounding vegetation, unlike Laughing Gulls in New

Jersey salt marshes which nest primarily on mats in tall grass (Montevecchi 1978). Nest material in this study consisted mostly of dead stems of sea oxeye and saltbush (*Baccharis* spp.), although a few nests contained green pieces of glasswort and coast bacopa. Nests usually were well constructed, averaging about 5 cm high × 8 cm wide. Egg-laying in Texas did not begin until construction of nests was well along and almost all the nests received at least one egg. In contrast, Laughing Gulls in Florida (Schreiber et al. 1979) and New Jersey (Burger 1976) laid eggs in nests in various stages of completion and birds in New Jersey continually added nest material throughout incubation. In the Florida study, 14% of the nests initiated did not receive eggs and nests never contained green material.

The initiation of egg-laying was consistent at our study sites among years, as shown for other populations (Montevecchi et al. 1979), but the timing varied somewhat among sites. The average dates on which females laid first eggs were 21 April at Laguna Vista (N = 209), 26 April at Corpus Christi (N = 264), and 6 May at Port Mansfield (N = 157). Montevecchi et al. (1979) demonstrated a latitudinal gradient where Laughing Gulls at higher latitudes laid first eggs later; birds in Massachusetts began laying on 21–31 May, in New Jersey on 18 May, and in Florida on 15–20 April. Our data do not fit this pattern; Texas birds, nesting at a somewhat lower latitude than Florida birds, tended to lay later than Florida birds.

Hatching peaked toward the end of May at Corpus Christi and Laguna Vista, and in early June at Port Mansfield. By the first 2 weeks in July, most chicks could fly considerable distances, indicating that fledging occurred at about 5–6 weeks after hatching. The mean fledging age of Laughing Gull chicks in Florida was 42.5 days, ranging from 35–50 days (Schreiber and Schreiber 1980). After chicks fledged in Texas, they remained on the nesting islands for 3–5 weeks, usually loafing in large groups on the shores of the islands. Most of the adults also were present but by mid-August few birds of any age were associated with the nesting islands.

Productivity.—Nest success (fledglings/total eggs) or productivity (fledglings/total nests) for each of the three study areas is presented in Tables 1, 2, and 3. Clutch-size varied significantly (ANOVA, $F = 3.7$; df = 3, 160; $P < 0.05$) at Corpus Christi among years, ranging from 2.4–2.8 (Table 1). Sixty-five percent (N = 172) of our staked nests there had three-egg clutches, 30% (N = 78) had two-egg clutches, and 5% (N = 14) had one-egg clutches. Clutch-size at Port Mansfield was consistent ($P > 0.05$) among years (Table 2) and the overall average was significantly lower ($t = 5.07$, df = 541, $P < 0.01$) than at the other two sites because of a larger proportion ($\chi^2 = 22.56$, df = 1, $P < 0.01$) of two-egg clutches. Forty-six percent (N = 73) of our staked nests at Port Mansfield had three-egg clutches, 46% (N = 73) had two-egg clutches, and 8% (N = 9) had one-egg clutches.

TABLE 1
LAUGHING GULL PRODUCTIVITY AT NUECES BAY, CORPUS CHRISTI, 1978–1981

Parameter	1978 (N = 57)	1979 (N = 75)	1980 (N = 70)	1981 (N = 62)	Total (N = 264)
Clutch-size					
Mean	2.7	2.8	2.5	2.4	2.6
Mode	3	3	3	3	3
Range	2–3	1–3	1–3	1–3	1–3
Survival rates					
% successful nests[a]	82	92	7	89	68
% eggs hatched	67	75	4	71	54
Eggs hatched/nest	1.8	2.1	0.1	1.7	1.4
Nest success (%)[b]	26	18	0	58	23
Fledglings/total nests	0.7	0.5	0	1.4	0.6

[a] Percentage nests that hatched at least one young.
[b] Fledglings/total eggs.

At Laguna Vista, we found no difference ($P > 0.05$) in clutch-size among years (Table 3) but the proportion of three-egg clutches was greater ($\chi^2 = 17.32$, df = 1, $P < 0.01$) than at the other two sites; 75% (N = 157) of our nests there had three eggs, 22% (N = 46) had two eggs, and 3% (N = 5) had one egg. Since birds nested earlier on the average at Laguna Vista, more three-egg clutches may reflect a larger proportion of older birds nesting there. Schreiber et al. (1979) reported clutch-size of 2.8 and 2.5 in 1975 and 1976, respectively, for a Laughing Gull colony in Florida, with a higher proportion of two-egg clutches occurring in 1976 (43%) than in 1975 (15%). Most of our females laid three eggs, as seen by the mode for each year among sites (Tables 1, 2, 3), but at Port Mansfield in 1980, 59% of the females laid only two eggs. Egg loss due to depredation of eggs probably did not affect clutch-size, although we saw Laughing Gulls peck a few eggs during our visits. Undoubtedly some eggs and chicks were lost to predators, such as Black-crowned Night-Herons (*Nycticorax nycticorax*) which nested on some of the islands, but we never saw evidence of mammalian or reptilian predators. Nevertheless, egg depredation could have been missed since we visited colonies only once a week. Our estimates of clutch-size, however, compare favorably with that of Schreiber et al. (1979) who reported only minor depredation of Laughing Gull eggs.

Hatching success (eggs hatched/total eggs) at marked nests varied significantly ($\chi^2 = 101$, df = 2, $P < 0.01$) among locations, ranging from 4–82% at sites among years (Tables 1, 2, 3). High storm tides were responsible for the 4% success rate recorded at Corpus Christi in 1980; on 19

TABLE 2
LAUGHING GULL PRODUCTIVITY AT PORT MANSFIELD, 1979–1981

Parameter	1979 (N = 51)	1980 (N = 51)	1981 (N = 55)	Total (N = 157)
Clutch-size				
Mean	2.4	2.3	2.4	2.4
Mode	3	2	3	3
Range	1–3	1–3	1–3	1–3
Survival rates				
% successful nests[a]	84	76	89	83
% eggs hatched	63	52	71	63
Eggs hatched/nest	1.5	1.2	1.7	1.5
Nest success (%)[b]	50	30	54	46
Fledglings/total nests	1.2	0.7	1.3	1.1

[a] Percentage nests that hatched at least one young.
[b] Fledglings/total eggs.

May, 95% of our staked nests were inundated and destroyed. Flooding of nests in Texas is rare and is not a continuing problem because of the low tide fluctuations and the fact that Laughing Gulls usually nest well above the high tide mark. In contrast, flooding of nests in New Jersey was the greatest source of nesting failure (Montevecchi 1978). Success at Port Mansfield was reduced in 1979 and 1980 (Table 2) probably due to poor hatchability; 20% (1979) and 22% (1980) of the eggs incubated failed to hatch. This category accounted for only 6% of the egg loss at the other two sites for all years combined, (excluding the 1980 Corpus Christi flooding). An average of 3% of the eggs at all sites (N = 630 nests) disappeared during incubation and 13% of the eggs disappeared during the hatching period; their fate is unknown. Only 1% of the eggs were found outside the nests abandoned or depredated. The overall hatching success for two-egg clutches (63%) was significantly lower ($\chi^2 = 16.49$, df = 1, $P < 0.01$), than for three-egg clutches (74%). Hatching success of Laughing Gulls in Florida in 1975 was higher in two-egg clutches (93%) than in three-egg clutches (78%), but the reverse (71% vs 87%) was true in 1976 (Schreiber et al. 1979). In studies with Herring Gulls (*Larus argentatus*), hatching success was lower in two-egg clutches (50%) than in three-egg clutches (72%) (Brown 1967). In our study, there was a significant relationship between average clutch-size and hatching success (Spearman's rank correlation, $r = .71$, df = 8, $P < 0.05$); as clutch-size at the various sites among years increased, so did hatching success.

Except for the flooded colony at Corpus Christi in 1980, most of the

TABLE 3

LAUGHING GULL PRODUCTIVITY AT LAGUNA VISTA, 1979–1981

Parameter	1979 (N = 71)	1980 (N = 69)	1981 (N = 69)	Total (N = 208)
Clutch size				
Mean	2.6	2.8	2.8	2.7
Mode	3	3	3	3
Range	1–3	1–3	2–3	1–3
Survival rates				
% successful nests[a]	97	96	96	96
% eggs hatched	81	82	82	81
Eggs hatched/nest	2.1	2.3	2.3	2.2
Nest success (%)[b]	50	29	57	48
Fledglings/total nests	1.3	0.8	1.6	1.3

[a] Percentage nests that hatched at least one young.
[b] Fledglings/total eggs.

Laughing Gull pairs each year were able to hatch at least one egg (Tables 1, 2, 3). Laguna Vista birds were especially prolific, with 96% of the nests being successful (Table 3). Although infrequent, nest abandonment was the major cause of the reduction in successful nests, especially at Port Mansfield (Table 2). Consequently, the percentage of successful nests at locations differed significantly ($\chi^2 = 60.04$, df $= 2$, $P < 0.01$). Clutch-size had no significant effect ($P > 0.05$) on hatching success, for 89% of two-egg nests hatched at least one young compared to 93% of three-egg nests. Since one-egg clutches were rare (6%), they were excluded from the analysis. Schreiber et al. (1979) reported that 65% of two-egg nests within an enclosure were successful compared to 88% of three-egg clutches.

Fledging success (fledglings/total nests) on a colony basis was highly variable, ranging from 0–1.6 fledglings per nest (Tables 1, 2, 3) and averaging 1.0 fledgling per nest. Except for 1981, productivity was consistently low at Corpus Christi. In 1978, about 25% of the chicks, ranging in age from a few days to several weeks, and over 100 adults at the Corpus Christi site died within a 3-day period from exposure to parathion, an organophosphate (OP) insecticide used on nearby cotton fields (White et al. 1979). Certain of the OPs are extremely toxic to wildlife for short periods after application and the number of reports of mortality in exposed avian populations has increased in recent years (Mendelssohn and Paz 1977, Zinkl et al. 1978, Stone 1979, White et al. 1979, White et al. 1982b). The adults had gathered poisoned insects from the sprayed fields and fed them to their young. In addition, many chicks probably died from starvation or exposure as a result of the death or inattentiveness of their parents (White et al. 1983). Again in 1979, a large number of chicks of varying age died over a several-week period at Corpus Christi, reducing productivity to only 0.5 fledglings per nest (Table 1). Because of the necrotic condition of the carcasses, we were unable to determine the cause of mortality, but OP insecticide poisoning was suspected since OPs were used heavily in the area. In a series of brain assays from chicks found dead on nearby islands, acetylcholinesterase (AChE) levels were inhibited up to 98%, indicating death from an OP insecticide. OPs kill primarily by inhibiting AChE in the nervous system, thereby disrupting synaptic transmission of nerve impulses (Hill and Fleming 1982). None of the chicks fledged at the Corpus Christi colony in 1980 where flooding occurred although 7% of the nests hatched at least one young (Table 1). Fifty-three pairs renested there and 42% of them were successful, but at one-week posthatch there were only 0.08 live chicks per nest and none fledged.

Fledging success was similar each year at Port Mansfield and Laguna Vista (Tables 2, 3), but fewer young fledged in 1980 at both colonies than in 1979 or 1981. Poor hatching success (52%) was the major cause of nest failure at Port Mansfield (Table 2) in 1980. However, about 33% of the chicks at Laguna Vista that year died from suspected OP poisoning. Brain AChE activity in a sample of the dead birds was greatly inhibited, indicating exposure to an OP compound, and inhibition was enough to account for death ($>50\%$) in all instances (Ludke et al. 1975). The gastrointestinal tracts of the dead birds were empty, thereby negating our efforts to identify the causative agent in stomach contents. However, discussion with local landowners and pesticide applicators revealed that EPN, an OP insecticide, was being used extensively on cotton crops in the area. EPN is representative of a group of OPs that causes delayed neurotoxicity in birds (Francis et al. 1980, Ohkawa et al. 1980). Delayed mortality could have accounted for the empty stomachs in the dead birds, since the digestion process would have continued in sick birds that were unable to feed. We do not believe that the chicks starved to death since AChE activity was greatly depressed. Food restriction did not alter brain AChE activity in lab studies with chickens (Brust et al. 1971).

Overall, Laughing Gull pairs in Texas fledged 1.0 young per nest for a nest success rate of 39%. The 4-year average of 1.0 fledgling per nest was below what Laughing Gulls are capable of attaining; in 5 of 10 colony attempts pairs produced an average of 1.4 fledglings per nest. Schreiber et al. (1979) reported productivity similar to our overall estimate for Florida birds within an enclosure; their colony produced flying young from 41% of the total eggs laid, or 1.1 fledglings per total nests. We know of no other published accounts of productivity in Laughing Gulls. Although human

TABLE 4
ORGANOCHLORINE RESIDUES (PPM, WET WEIGHT) IN LAUGHING GULL EGGS FROM THE TEXAS COAST

Location years (N)	DDE	Dieldrin	PCBs	Heptachlor epoxide	Toxaphene
Corpus Christi	1.7[a]	0.08	2.0	0.2	0.06
1978–1981 (92)	(92)[b]	(31)	(74)	(30)	(10)
	0.3–91[c]	ND[d]–1.0	ND–14	ND–0.7	ND–1.2
Port Mansfield	3.7	0.06	1.0	0.06	0.2
1979–1981 (56)	(56)	(7)	(47)	(2)	(15)
	0.8–63	ND–0.9	ND–6	ND–0.3	ND–2.2
Laguna Vista	1.3	0.05	2.0	0.03	0.06
1979–1981 (53)	(53)	(3)	(50)	(2)	(6)
	0.3–47	ND–0.5	ND–10	ND–0.7	ND–0.6

[a] Geometric mean.
[b] Number of eggs containing detectable residues.
[c] Range.
[d] ND = not detected.

disturbance can adversely affect reproduction, especially in the pre-egg and incubation stages (Schreiber 1979), we do not believe that our weekly visits were detrimental. In fact, we observed that Laughing Gulls in Texas were reluctant to flush from their nests until we had approached within 5–10 m. Most birds quickly returned to their nests or chicks after we had left the immediate area. Also, egg depredation by Laughing Gulls was rare during our visits and we never saw gulls or any other birds take chicks.

Organochlorine residues and shell thickness.—Of 201 eggs analyzed for organochlorine pesticides and polychlorinated biphenyls (PCBs) during the 4-year period, all contained detectable residues of DDE (the major metabolite of DDT), ranging from 0.3–91 ppm wet weight (Table 4). In addition, 85% of the eggs contained PCBs, ranging from 0.5–14 ppm, but dieldrin, heptachlor epoxide, and toxaphene were detected less frequently and residues were low, seldom exceeding 1 ppm for any of these compounds.

Except for a 39% decrease between 1978 and 1979 at Corpus Christi, geometric mean levels of DDE in eggs remained relatively unchanged at sites among years, although the high extremes detected in individual eggs each year varied greatly. DDE means were highest (ANOVA, $F = 3.8$; df = 2, 198; $P < 0.05$) in eggs at Port Mansfield, perhaps reflecting their location near the outlets of two major agricultural drains (Fig. 1). DDE residues in Laughing Gull eggs were low since only 3% of the eggs contained >10 ppm DDE. Eggs that failed to hatch were no higher ($P > 0.05$) in DDE residues than were fresh ones, indicating that DDE probably had little effect on hatchability. Lipid content of eggs averaged 9.7 ± 0.4%, but was not significantly correlated ($P > 0.05$) with DDE residues. Eggshell thinning was detected at all colonies, ranging from 7–14%, but we found no significant relationship ($P > 0.05$) between eggshell thickness and log DDE residues in eggs. In addition, there was no significant relationship ($P > 0.05$) between percentage shell thinning and hatching success. PCBs, dieldrin, heptachlor epoxide, and toxaphene residues were far below known-effect levels (Stickel 1973, 1975) and are not suspected of causing reproductive problems. Roseate Spoonbills (*Ajaia ajaja*) had good reproduction in Texas with pollutant levels similar to what we report here for Laughing Gulls (White et al. 1982a).

CONCLUSIONS

Our data indicate that exposure to highly toxic OP insecticides, such as parathion and EPN, may impair reproduction in Laughing Gulls. During three of four breeding seasons, OP compounds were implicated in mortality that reduced fledging success by as much as 33%. The adults were attracted to recently-sprayed fields, possibly even keying on spray planes, as a readily obtainable source of dead and dying insects. One farmer in 1978 reported dead adults in his cotton fields shortly after the crops had received a parathion treatment; he observed the birds hawking insects over the fields and foraging between the rows even as the spray was being applied. On many occasions we have seen Laughing Gulls and swallows (Hirundinidae) hawking insects over cotton fields but we have no prior knowledge of pesticide use on these areas. Unfortunately, chick stage in the gull colonies usually coincides with the time of peak spraying in the cotton fields, thereby exposing the chicks to poisoned food items brought by the parents.

It is difficult to assess whether or not 1.0 fledgling per nest is adequate to maintain a stable population, not only from a logistics standpoint, but also because of a scarcity of reproductive data on this species. Recent censuses have indicated that Laughing Gull numbers in Texas have remained stable (Texas Colonial Waterbird Society 1982), but the use of highly toxic OP compounds on agricultural crops near the breeding colonies may pose serious threats to the population. We recommend that less toxic materials to birds, such as malathion (Hill et al. 1975), be used on crops in areas where breeding colonies occur and that spraying be delayed, when feasible, until the chicks have fledged.

SUMMARY

Laughing Gulls (*Larus atricilla*) were studied along the south Texas coast during 1978–1981 to determine productivity and to evaluate the effects of environmental pollutants on

reproduction. The average clutch-size was 2.6, ranging from 2.3–2.8. Sixty-six percent of the eggs hatched and 82% of the pairs hatched at least one egg. Productivity (fledglings/total nests) averaged 1.0 fledgling per nest. DDE and other organochlorine residues were low in eggs (usually <3 ppm wet weight) and were not suspected of causing reproductive problems. However, organophosphate pesticides sprayed on crops near the study areas reduced productivity by as much as 33% during 3 of 4 years, implying that certain of these chemicals may pose serious threats to the population.

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LITERATURE CITED

BLACKLOCK, G. W., R. D. SLACK, D. R. BLANKINSHIP, A. H. CHANEY, K. A. KING, J. C. SMITH, AND L. MULLINS. 1979. Texas colonial waterbird census, 1977–78. Pp. 252–259 *in* Proc. First Welder Wildl. Found. Symp. Welder Wildlife Foundation, Sinton, Texas.

BONGIORNO, S. F. 1970. Nest-site selection by adult Laughing Gulls (*Larus atricilla*). Anim. Behav. 18:434–444.

BROWN, R. G. B. 1967. Breeding success and population growth in a colony of Herring and Lesser Black-backed Gulls, *Larus argentatus* and *L. fuscus*. Ibis 109:502–515.

BRUST, R. A., S. MIYAZAKI, AND G. C. HODGSON. 1971. Effect of dursban in the drinking water of chicks. J. Econ. Entomol. 64:1179–1183.

BURGER, J. 1976. Daily and seasonal activity patterns in breeding Laughing Gulls. Auk 93: 308–323.

——— AND C. G. BEER. 1976. Territoriality in the Laughing Gull (*Larus atricilla*). Behaviour 55:301–320.

CLARK, D. R., JR., R. L. CLAWSON, AND C. J. STAFFORD. 1983. Gray bats killed by dieldrin at two additional Missouri caves: aquatic macroinvertebrates found dead. Bull. Environ. Contam. Toxicol. 30:214–218.

DINSMORE, J. J. AND R. W. SCHREIBER. 1974. Breeding and annual cycle of Laughing Gulls in Tampa Bay, Florida. Wilson Bull. 86:419–427.

FRANCIS, B. M., G. L. HANSEN, T. R. FUKOTO, P. Y. LU, AND R. L. METCALF. 1980. Ecotoxicology of phenylphosphonothioates. Environ. Health. Perspect. 36:187–195.

HILL, E. F. AND W. J. FLEMING. 1982. Anticholinesterase poisoning of birds: field monitoring and diagnosis of acute poisoning. Environ. Toxicol. Chem. 1:27–38.

———, R. G. HEATH, J. W. SPANN, AND J. D. WILLIAMS. 1975. Lethal dietary toxicities of environmental pollutants to birds. U.S. Fish and Wildl. Serv., Spec. Sci. Rept., Wildl. No. 191, Washington, D.C.

LUDKE, J. L., E. F. HILL, AND M. P. DIETER. 1975. Cholinesterase (ChE) response and related mortality among birds fed ChE inhibitors. Arch. Environ. Contam. Toxicol. 3: 1–21.

MENDELSSOHN, H. AND U. PAZ. 1977. Mass mortality of birds of prey caused by Azodrin, an organophosphate insecticide. Biol. Conserv. 11:163–170.

MONTEVECCHI, W. A. 1978. Nest site selection and its survival value among Laughing Gulls. Behav. Ecol. Sociobiol. 4:143–161.

———, M. IMPEKOVEN, A. SEGRE-TERKEL, AND C. G. BEER. 1979. The seasonal timing and dispersion of egg-laying among Laughing Gulls (*Larus atricilla*). Ibis 121:337–344.

NOBLE, G. K. AND M. WURM. 1943. The social behavior of the Laughing Gull. Ann. N.Y. Acad. Sci. 45:179–220.

OHKAWA, H., H. OSHITA, AND J. MIYAMOTO. 1980. Comparison of inhibitory activity of various organophosphorous compounds against acetylcholinesterase and neurotoxic esterase of hens with respect to delayed neurotoxicity. Biochem. Pharmacol. 29:2721–2727.

SCHREIBER, E. A. AND R. W. SCHREIBER. 1980. Breeding biology of Laughing Gulls in Florida. Pt. II: Nestling parameters. J. Field Ornithol. 51:340–355.

———, R. W. SCHREIBER, AND J. J. DINSMORE. 1979. Breeding biology of Laughing Gulls in Florida. Pt. I: Nesting, eggs, and incubation parameters. Bird-Banding 50:304–321.

SCHREIBER, R. W. 1979. Reproductive performance of the eastern Brown Pelican, *Pelicanus occidentalis*. Contrib. Sci. Nat. Hist. Mus. Los Angeles County 317:1–43.

STICKEL, L. F. 1973. Pesticide residues in birds and mammals. Pp. 254–312 *in* Environmental pollution by pesticides (C. A. Edwards, ed.). Plenum Press, New York, New York.

STICKEL, W. H. 1975. Some effects of pollutants in terrestrial ecosystems. Pp. 25–74 *in* Ecological toxicology research (A. D. McIntyre and C. F. Mills, eds.). Plenum Press, New York, New York.

STONE, W. B. 1979. Poisoning of wild birds by organophosphate and carbamate pesticides. New York Fish and Game J. 26:37–47.

TEXAS COLONIAL WATERBIRD SOCIETY. 1982. An atlas and census of Texas waterbird colonies, 1973–1980. Caesar Kleberg Wildl. Resear. Inst., Texas A & I Univ., Kingsville, Texas.

WHITE, D. H., K. A. KING, C. A. MITCHELL, E. F. HILL, AND T. G. LAMONT. 1979. Parathion causes secondary poisoning in a Laughing Gull breeding colony. Bull. Environ. Contam. Toxicol. 23:281–284.

———, C. A. MITCHELL, AND E. CROMARTIE. 1982a. Nesting ecology of Roseate Spoonbills at Nueces Bay, Texas. Auk 99:275–284.

———, ———, AND E. F. HILL. 1983. Parathion alters incubation behavior of Laughing Gulls. Bull. Environ. Contam. Toxicol. 31:93–97.

———, ———, L. D. WYNN, E. L. FLICKINGER, AND E. J. KOLBE. 1982b. Organophosphate insecticide poisoning of Canada Geese in the Texas Panhandle. J. Field Ornithol. 53:22–27.

ZINKL, J. G., J. RATHERT, AND R. R. HUDSON. 1978. Diazinon poisoning in wild Canada Geese. J. Wildl. Manage. 42:406–408.

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