ORGANOCHLORINES AND MERCURY IN COMMON EGRETS AND GREAT BLUE HERONS

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ABSTRACT

Reproductive success of a colony of common egrets (Casmerodius albus) *in California declined between* 1967 *and* 1970. *Successful nesting attempts decreased from* 52 *to* 28%, *and nests losing eggs increased from* 30 *to* 54%. *Reproductive success of great blue herons* (Ardea herodias) *in this colony showed no comparable trends over this period. Mean thicknesses of all egret and heron eggshells recovered from the floor of the heronry were* 15·2 *and* 10·4% *lower, respectively, than pre-*1947 *values. Eggs of both species, broken during incubation, were* 17% *below normal thickness. Concentrations of DDE recorded in egg lipids and in the carcasses of adults found dead or moribund were comparable with those found in other species now producing thin-shelled eggs. Polychlorinated biphenyls ranged up to* 15 *ppm in the brain and* 93 *ppm in the livers of adult egrets, and concentrations of total mercury in the liver ranged between* 2 *and* 9·5 *ppm. Dieldrin concentrations in the brains of four adult egrets found dead or moribund ranged between* 5 *and* 7 *ppm, suggesting death by dieldrin poisoning. Ratios of DDE to PCB in the more heavily contaminated egrets indicated that the birds had acquired the major part of their body residues on the wintering ground rather than in the immediate vicinity of the colony.*

INTRODUCTION

In 1961 two local branches of the National Audubon Society—the Marin and Golden Gate Chapters—acquired the Audubon Canyon Ranch, a traditional nesting site of over a hundred pairs of common egrets (*Casmerodius albus*) and great blue herons (*Ardea herodias*) combined. The heronry is located in the upper branches of a grove of redwoods (*Sequoia sempervirens*) in a canyon draining into Bolinas Lagoon, a shallow, tidal estuary just north of San Francisco. An outlook

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constructed on the north slope of the canyon permits observation of the birds and their nests without disturbance of the colony. The Audubon Canyon Ranch has become a popular attraction, and in 1968 the site was declared a national landmark. The setting is predominantly rural, and the only immediate source of pollution is the raw sewage discharged into Bolinas Lagoon by the small town of Bolinas (population approximately 1100).

In 1967 Mrs Helen Pratt began a study of the breeding biology of the common egrets and great blue herons of the Audubon Canyon Ranch. The data from 1967 and 1968 suggested that the productivity of the egrets was unexpectedly low. Eggs disappeared from approximately 30% of the nests, and the mortality of nestlings increased from 19% in 1967 to 43% in 1968 (Pratt, 1970). Prestt (1969) reported destruction of eggs by the parents in 40% of nests in a colony of grey herons (*Ardea cinerea*) in eastern England in 1968. Eggs collected from this colony were 20% below normal thickness. The mysterious disappearance of eggs of the peregrine falcon (*Falco peregrinus*) during incubation was one of the first symptoms of widespread reproductive failure of populations of that species (Ratcliffe, 1967, 1970; Hickey, 1969).

Observations were continued through 1969 and 1970 and indicated that the incidence of reproductive failures of the egrets was increasing throughout the time period from 1967 to 1970. The percentage of successful nesting attempts decreased from 52 in 1967 to 41 in 1968, 33 in 1969, and to 28 in 1970. The percentages of nesting attempts losing eggs increased from 30 in 1967, to 34 in 1968, 39 in 1969, and 54 in 1970. The percentages of the nesting attempts losing nestlings did not show any well-defined trends over the four-year period and were 8 in 1967, 17 in 1968, 11 in 1969, and 10 in 1970. In contrast to the egrets, the reproductive success of the herons showed no comparable trends (further details to be published later by Mrs Pratt).

Several of the eggshells found on the ground beneath the colony in 1969 were soft-shelled, similar in appearance to the collapsed eggs of the brown pelicans (*Pelecanus occidentalis*) and double-crested cormorants (*Phalacrocorax auritus*) found on Anacapa Island in 1969 (Risebrough *et al.*, 1970*a*). In 1970 an egg with a visible dent was observed in one nest, and adult egrets were observed tossing broken eggs from other nests, explaining, at least in part, the mysterious disappearance of eggs during incubation. Prestt (1969) observed this in grey herons in England and also deliberate breakage by the parents. Also in 1970, several adult egrets were found dying in convulsions, suggesting poisoning by one of several possible environmental pollutants.

In order to study the impact of environmental pollutants upon the breeding biology and reproductive success of the egrets and herons of this colony, a cooperative study was initiated in 1970 among the University of Wisconsin, the University of California, and local members of the Audubon Society. The present paper reports our initial results.

METHODS

Field collections

Eggshells were collected at least once a week throughout the nesting season from the floor of the heronry. Both egrets and herons customarily drop or toss hatched and broken eggshells out of the nest, although occasionally they are carried away from the heronry and dropped, or are crushed into the nest by the young (Palmer, 1962). Dead nestlings that had fallen to the ground were collected and frozen until analysis. Five adult egrets found on the floor of the heronry were picked up dead or observed until death, and frozen until analysis.

Bolinas Lagoon is the principal feeding area of both the egrets and herons during the breeding season, and fish samples were therefore obtained in a preliminary attempt to determine the magnitude of pollutant contamination. The collection was made with an auto-trawl on 16 November 1970, in a shallow area of the lagoon extending from the shore of Kent Island. Egrets and herons are often seen fishing in this and other shallow areas of the lagoon. Species composition of the fish taken by the birds is not known but probably relates to abundance within the size limits usually taken by both heron and egret (approx 2·5–20 cm). Thus, the individuals of the two most abundant fish species, the shiner perch (*Cymatogaster aggregata*) and the walleye surfperch (*Hyperprosopon argentium*) were saved for analysis. The fish were immediately wrapped in aluminum foil and frozen with dry ice.

Eggshell identification and measurements

Identification of eggshells as common egret or great blue heron was made on the basis of size, shape, texture and colour. Each of these parameters overlap somewhat between the species, but, in general, common egret eggshells were smaller, elliptical to subelliptical in shape (Preston, 1953), smoother in texture, and greenish, while great blue heron eggshells were larger, subelliptical to ovate in shape, rough in texture, and with a bluish hue. While a few shells were impossible to identify clearly by species, the great majority of large shell fragments were clearly identified as belonging to one particular species or the other. We feel that the exclusion of the few large fragments in the middle category did not significantly bias the thickness measurements. After separation into species, the shells were again classified as being either 'hatched' or broken. A 'hatched' shell was one which had one or more of the following characteristics: large end of the shell chipped away, shell membrane separated from the shell, or dried blood vessels attached to the shell membrane. A shell with dried albumin or yolk inside was classified as broken, although it might have had one of the characteristics of 'hatched' shells. All other shells were classified as broken. Some eggs which actually had been broken late in incubation were probably included in the 'hatched' category while, conversely, no eggs which had actually hatched were included in the broken category.

Eggshell-thickness measurements were taken from the eggshell fragments using the method of Anderson & Hickey (1970). Thickness of common egret eggshells collected before 1947 was measured from specimens in the Museum of Vertebrate Zoology, University of California, Berkeley, and in the Museum of the Western Foundation of Vertebrate Zoology, Los Angeles. Thickness data for pre-1947 great blue heron eggshells were provided by D. W. Anderson.

Statistical treatment of the thickness data was carried out by calculating a mean and 95% confidence limits about the mean. Non-overlap of these confidence limits indicated that differences between two means were statistically significant (Steele & Torrie, 1960).

Determination of residue of chlorinated hydrocarbons and of mercury

Determination of concentrations of the DDT compounds, dieldrin, endrin, and of the polychlorinated biphenyls followed methods described by Risebrough *et al.*, (1970b). The broken eggs with dried fragments of yolk were extracted with 2:1 hexane-acetone in a Soxhlet apparatus without mixing with sodium sulphate. Nestlings were weighed and then homogenised with a Hobart food chopper. A subsample was ground with sodium sulphate in a Waring blender until a dry, free-flowing powder was obtained which was extracted with 2:1 hexane-acetone in a Soxhlet apparatus. Adult egrets were weighed, and the livers, breast-muscle samples, and brains were dissected out for individual analysis. A portion of each liver was saved for mercury determination. The remainders of the carcasses, minus the feet and flight feathers, were homogenised, and a subsample was taken for the determination of lipid content.

The fish were weighed, then pooled, and ground with sodium sulphate in a Waring blender. A lipid extract of each species was then prepared with Soxhlet extraction, and the methodology used in the determination of chlorinated hydrocarbons was identical to that used with the bird preparations.

Liver samples from the five adult egrets were sent to Gulf Radiation Technology Division of Gulf Energy & Environmental Systems, Inc., San Diego, California, for the determination of total mercury concentration by neutron-activation analysis. The analytical procedure is described by this company as follows: 'Weighed portions of each sample were sealed in vials and irradiated at a flux of 10^{12} thermal neutrons/cm^2/sec together with a mercury comparator standard. The irradiated samples were digested, in the presence of mercury carrier, in a mixture of HNO_3 and H_2SO_4 under reflux conditions. Radiochemical procedures were used to isolate mercury as a metal. Multichannel gamma-ray spectrometry was used to identify and quantitate mercury.'

RESULTS AND DISCUSSION

Eggshell thinning

The mean thicknesses of both 'hatched' and broken eggshells collected in 1969 and 1970 were significantly lower than those of museum eggshells of both species

(Table 1). Over 80% of the common egret eggshells collected were broken, while only 29% of the great blue heron eggshells collected were broken. When all eggshells of each species are pooled, the average decrease in thickness of the egret eggshells was 15·2%, greater than the mean decrease of 10·4% found in eggshells of the great blue heron. In each species the thickness of 'broken' eggshells was significantly lower than the shell thickness of 'hatched' eggs.

TABLE 1

EGGSHELL THICKNESS (MEANS ±95% CONFIDENCE LIMITS) AT THE AUDUBON CANYON RANCH IN 1969 AND 1970, COMPARED TO MUSEUM DATA

Category of egg	*Common Egret*			*Great Blue Heron*		
	n	*Thickness*	*% decrease*	*n*	*Thickness*	*% decrease*
Pre-1947 specimens	235	0·295 ± 0·003	—	38	0·396 ± 0·006	—
'Hatched' and broken shells	64	0·250 ± 0·007	−15·2	59	0·355 ± 0·010	−10·4
'Hatched' shells only	13	0·272 ± 0·013	−7·8	42	0·365 ± 0·011	−7·8
Broken shells only	51	0·244 ± 0·008	−17·3	17	0·328 ± 0·018	−17·2

The sample of eggshells with which we worked was of necessity biased. Many of the thinner eggshells could not be identified and measured since they were presumably crushed into the nest or broken into tiny fragments upon falling to the ground. The thinnest eggshells found were almost without a shell, with the membrane accounting for over half of the total thickness. Some of the broken eggs probably broke as a result of falling from the nest, predation, abnormal abrasion, etc., rather than shell thinning; but nearly all broken eggshells collected were much thinner than museum specimens. The average reduction in the thickness of broken eggs of both species was 17%. Most of the eggs of the great blue heron survived incubation. In contrast, 54% of the nesting attempts of the common egrets suffered egg loss during incubation in 1970. Possible interspecific variation in susceptibility to breakage is suggested by comparison with Prestt's finding (Prestt, 1969) that only 40% of nests of grey herons in England had egg breakage, while eggs collected from the colony had thickness indices 20% below the normal, greater than the 15·2% reduction we report here.

Residues in eggs, nestlings and fish

Table 2 lists the residue concentrations of the DDT compounds and of PCB found in egg-yolk lipids, nestlings found dead, and in fish from Bolinas Lagoon. Concentrations in the fish were exceptionally low, lower than concentrations found in marine fish from coastal waters to the south (Risebrough *et al.*, in press). PCB was more abundant than the DDT compounds in these fish, indicating that birds feeding on them might be expected to have more PCB than DDE. Residue concentrations in nestlings were low on a wet-weight basis, but on a lipid basis approached, or were equivalent to, the concentrations in yolk. The mean of the DDE residues for egret nestlings was more than twice that for heron nestlings. Also, the mean DDT:PCB ratio for egret nestlings was more than twice that for heron nestlings, the latter being nearly the same as for the fish we analysed. This

TABLE 2

DDT AND PCB RESIDUES IN YOLK LIPIDS OF BROKEN EGGS, AN EMBRYO, NESTLINGS FOUND DEAD, AND IN FISH FROM BOLINAS LAGOON. CONCENTRATIONS IN THE EMBRYO, NESTLINGS, AND IN THE FISH ARE IN PARTS PER MILLION, WET WEIGHT

Tissue	*Species, date*	*% lipid*	*DDE*	*Total DDT*	*PCB*	*Ratio of Total DDT to PCB*
Egg yolk lipid	Heron, 20 April	100	108	122	50·6	2·4
(Concentrations in lipid weight)	Probable Heron, 30 March	100	287	320	Not detected	>100
	Egret, no date	100	248	285	40·3	7·1
	Unidentified, 24 April	100	94	108	241	0·45
Embryo	Probable Heron, no date	3·6	1·2	1·4	1·2	1·2
Nestling	Egret, 5–6 days, 11 May	2·2	4·0	4·1	1·3	3·2
	Egret, 1·5–2 weeks, 11 May	1·2	1·1	1·2	1·7	0·7
	Egret, age unknown 13 May	1·2	1·1	1·2	4·6	0·26
	Egret, 2–2·5 weeks, 11 May	2·1	2·1	2·2	0·7	3·0
	Egret, 1–2 weeks, 15 May	1·7	3·2	3·3	1·8	1·8
	Egret, 1 week 7 May	1·2	0·55	0·59	1·75	0·34
	Heron, 2 weeks, 24 April	1·6	0·49	0·56	1·35	0·41
	Heron, 3 weeks 24 April	1·0	1·18	1·33	1·82	0·73
	Heron, 4–5 weeks, 24 April	1·2	0·16	0·18	0·49	0·37
Nine whole fish Mean wt 12·1 gm	*Hyperprosopon argentium* 16 November	2·4	0·025	0·036	0·072	0·50
Six whole fish Mean wt 22·6 gm	*Cymatogaster aggregata* 16 November	4·7	0·012	0·019	0·079	0·24

indicates that the heron nestlings probably received most of their residues from local sources. The egret nestlings had presumably received additional residues from the female, who had picked up these residues from the winter feeding area. The egg residues are expressed on a lipid basis since this is considered the most meaningful way to compare concentrations of fat-soluble pollutants in eggs that are broken or dehydrated.

An inverse correlation between the thickness of eggshells and concentrations in the egg of DDT compounds, primarily DDE, has been found in herring gulls (*Larus argentatus*) (Hickey & Anderson, 1968), white pelicans (*Pelecanus erythrorhynchos*) and double-crested cormorants (*Phalacrocorax auritus*) (Anderson *et al.*, 1969), great blue herons (Vermeer & Reynolds, 1970), prairie falcons (*Falco mexicanus*) (Enderson & Berger, 1970; Fyfe *et al.*, 1969), and in peregrine falcons (*Falco peregrinus*) (Cade *et al.*, 1971). The small size of our sample of eggs with sufficient yolk for analysis does not permit a comparison between shell thickness and residue concentrations. Experimental work has shown that DDT compounds, primarily DDE, may induce shell thinning at concentrations commonly found in wild birds (Heath *et al.*, 1969; Stickel & Rhodes, 1970; Wiemeyer & Porter, 1970).

Eggshell thinning appears to be a major cause of the reproductive failures of the egrets observed in the colony. As a result of the increasing number of nesting attempts that have lost eggs and the decrease in the percentage of successful nesting attempts, the number of young fledged per breeding pair has fallen from 1·4 to 1·0 between 1967 and 1970 (further details to be published later by Mrs Pratt). There are few data on the reproductive success of this species in the literature, but a study of common egrets on the San Joaquin River in California near Los Banos in 1970 showed 1·8 young fledged per nest (Page, 1970).

Data for reproductive success in the great blue herons at the Audubon Canyon Ranch during the period from 1967 to 1970 show no consistent trends. The percentage of nesting attempts that lost eggs varied from 4 % to 17 %, and the percentage of successful nesting attempts ranged from 56 to 87. Numbers of young fledged per breeding pair ranged from 1·5 to 2·0 (further details to be published by Mrs Pratt), lower than the 2·63 young fledged per active nest in 1970 in a great blue heron rookery near Lincoln, California (Wilburn, 1970). We do not have sufficient data to show, however, that the average shell thinning of 10·4 % found in the heron eggs from Audubon Canyon Ranch is affecting overall reproductive success.

Adult residue levels

Five adult egrets were obtained from the floor of the heronry. Of these, number 1 was found dead on 17 April 1970. The left wing was broken, small cuts were on the side of the head, the bill contained an amount of dried blood, blood on the brain indicated a concussion, and the cheeks were green as in birds in breeding condition. The bird was a female with active ovaries and an oviduct distended to a diameter of approximately 12 mm. It was probably killed accidentally.

Number 2 was a male with testes 1·3 and 1·7 cm long. It was observed in convulsions at 1430 h on 8 May, and died at 1540, trembling and with convulsive wing movements.

Number 3 was a male with testes 1·3 and 1·7 cm long. It was observed alive on the floor of the heronry on 12 May and found dead 24 h later.

Number 4 was a female with ovaries 1·7 cm in diameter. It was found dead on the floor of the heronry on 11 May.

Number 5 was a male with testes 1·4 and 2·0 cm long. It was observed at 0915 h on 11 May, moving its head up and down approximately eight times in convulsions and was found dead about 1500 h.

The first bird, which died of injuries, had 6·7% lipid in its carcass and lower concentrations of the DDT compounds and of dieldrin than the others (Table 3).

TABLE 3

CHLORINATED HYDROCARBONS, MERCURY, AND LIPID CONTENT OF TISSUES OF COMMON EGRETS FOUND DEAD OR MORIBUND AT THE AUDUBON CANYON RANCH, 1970. CONCENTRATIONS IN PARTS PER MILLION, WET WEIGHT*

Tissue	*Specimen*	*% lipid*	*DDE*	*PCB*	*DDD + DDT*	*Dieldrin*	*Endrin*	*Mercury*
Brain	1	6·1	1·0	3·8	0·003	0·60	<0·10	—
	2	7·7	70·0	15·0	2·2	4·87	0·24	—
	3	6·6	80·5	12·9	4·4	5·08	0·28	—
	4	6·7	93·4	6·3	1·4	6·76	0·10	—
	5	6·8	43·8	10·7	2·4	4·50	0·19	—
	mean	6·8	59·7	9·7	2·1	4·36	<0·18	
Liver	1	5·6	28·4	93·1	3·1	—	—	2·04
	2	1·3	92·5	31·7	4·8	—	—	5·90
	3	4·5	182	20·3	11·1	—	—	7·34
	4	2·6	239	19·3	7·0	—	—	5·62
	5	4·5	79·8	22·4	4·7	—	—	9·48
	mean	3·5	124·3	37·3	6·1	—	—	6·08
Breast muscle	1	2·7	1·1	1·4	0·09	—	—	—
	2	1·7	77·5	20·0	3·3	—	—	—
	3	2·1	84·7	7·4	4·3	—	—	—
	4	2·4	193	12·1	4·4	—	—	—
	5	3·3	113	29·2	6·6	—	—	—
	mean	2·4	93·9	16·0	3·7			

* Dashes indicate not analysed.

The differences cannot be explained by the higher body content of lipid. Birds 2–5 had carcasses ranging from 2·1 to 3·5% in lipid content, and presumably had metabolised much of their body fat after ceasing to feed. They had only one-third to one-half as much body lipid as bird 1. Bird 1 also had proportionally more PCB than DDT compounds, whereas the other four had more DDT residues, predominantly DDE, than PCB.

General significance of residues found

Concentrations of p,p′-DDT + p,p′-DDD in the egret brains did not exceed 4·4 ppm (Table 2). Laboratory studies suggest that 30 ppm of p,p′-DDT + p,p′-DDD in the brain is indicative of poisoning by these compounds (Stickel & Stickel, 1969), but wild birds are subjected to conditions of stress in breeding, migration, and adverse weather that are not encountered by captive birds. In the egret brains, as in most environmental samples, the most abundant DDT compound was DDE.

Concentrations of DDE ranged up to 93 ppm, a figure considerably below the lethal levels of this compound found in the brains of brown-headed cowbirds (*Molothrus ater*) experimentally killed by Stickel *et al.* (1970). The only detailed study to date of the toxicity of PCB (Prestt *et al.*, 1970) has shown that the commercial Aroclor 1254 preparation is only 1/13 as toxic as p,p′-DDT to Bengalese Finches (*Lonchura striata*). Although toxicity of PCB may vary widely from preparation to preparation (Vos & Koeman, 1970) due to the presence of small amounts of very poisonous contaminants, the chlorinated dibenzofurans (Vos *et al.*, 1970), we have no reason to believe that the cause of death of the adult egrets can be attributed to PCB.

Dieldrin concentrations in the brains of these four birds were very high. Laboratory studies, involving Japanese quail (*Coturnix coturnix*), have indicated that brain concentrations of 4 to 5 ppm of dieldrin might be considered lethal levels (Stickel *et al.*, 1969). Dieldrin poisoning was therefore probably a contributory cause of the death of the egrets found dead or moribund. Endrin residues were low in the brain, in the order of 0·1 to 0·3 ppm, but endrin has very high toxicity to birds (Tucker & Crabtree, 1970), and may have been a factor in the deaths.

Very few mercury concentrations have so far been reported in Californian wildlife, and it is not therefore possible to conclude that the mercury concentrations listed in Table 3 are higher than in other local fish-eating birds. Mercury residues in seed-eating birds and their predators in Alberta, where mercury compounds have been used in seed dressings, were higher than in individuals of the same species from Saskatchewan (Fimreite *et al.*, 1970). Most of the mercury concentrations found in livers of the Alberta birds were below 2 ppm lower than any of the concentrations we report here. Population declines of the white-tailed eagle (*Haliaetus albicilla*) in Sweden have been attributed to mercury (Borg *et al.*, 1969). Of eight eagles analysed in 1964, the four highest mercury concentrations found in the livers were 9, 12, 15, and 60 ppm (Borg *et al.*, 1969). Analyses of six livers of white-tailed eagles found dead in Finland showed mercury concentrations of 4·6, 12·2, 19·0, 19·8, 24·7, and 27·1 ppm (Henriksson *et al.*, 1966). The five higher concentrations were assumed to have contributed to the birds' deaths. Our results involve somewhat lower concentrations in the egrets of Audubon Canyon Ranch, but suggest that mercury contamination is already a significant environmental problem in California. Effects upon reproductive success of mercury-contaminated populations might also be expected (Borg *et al.*, 1969; Fimreite *et al.*, 1970), but some apparent interspecific variation in these has already been reported (Vermeer, in press).

Sources of residues

The ratio of the concentrations of DDE or of total DDT to PCB is frequently characteristic of ecosystems and, under certain circumstances, can be used to determine whether individual birds have been resident in a particular ecosystem

(Risebrough *et al.*, 1968). It is therefore probable that bird 1 had acquired its body burden of residues in a region such as Bolinas Lagoon where PCB was more abundant than DDE and where environmental contamination levels were lower than in the regions recently inhabited by birds 2–5.

The low residue concentrations in the fish analysed from Bolinas Lagoon suggest that the birds with high concentrations of DDT (Nos. 2–5) acquired these residues in the wintering ranges. The DDT:PCB ratios in both adult and nestling egrets also support this hypothesis. In the marine ecosystems of southern California, which are heavily contaminated with DDE, the ratio of DDE to PCB approximates those found in several of the egret samples, especially those with the highest concentrations of residues (Risebrough and F. Gress, pers. comm.). A few great blue herons each year spend the winter at Bolinas Lagoon. We believe that the majority of the herons winter farther north than the egrets. Egrets are commonly seen in large numbers in winter in southern California's Imperial Valley, a region of intensive pesticide usage. The great blue heron in which no PCB was detected (Table 2) had evidently come from an area with very low PCB contamination. Great blue herons sometimes take terrestrial food as well as aquatic organisms (Palmer, 1962). Although the majority of great blue herons appeared to be feeding on aquatic organisms from Bolinas Lagoon, regurgitated pellets containing small mammal bones and fur have been found on the floor of the heronry at Audubon Canyon Ranch and appear to have come from great blue heron nests. Common egrets prey principally upon aquatic organisms, mostly fish (Palmer, 1962), and Bolinas Lagoon is their chief feeding area in the vicinity of the Audubon Canyon Ranch.

We feel that the differences in eggshell-thinning, egg breakage, and adult and nestling residue levels between these two species are primarily related to differences in intake levels as determined by winter feeding areas. Summer feeding habits and physiological differences in uptake of pesticides may also be related, but have not been noted in this study.

We have no information that might indicate the sources of dieldrin, and it is important to determine where dieldrin is still being used in California or persisting in its ecosystems. Endrin is still being used to treat conifer seeds as protection against seed-eating mice in forest regions, but it is not at all clear that this use is the principle source of the endrin found in the egrets.

The sources of mercury contamination are also unknown, and it is clearly important to determine them.

Population trends

In spite of lowered reproductive success of the egrets, there has been no decrease in numbers of breeding pairs of either egrets or herons at the Audubon Canyon Ranch between 1967 and 1970 (further details to be published later by Mrs Pratt). The California Department of Fish and Game conducted a state-wide heron rookery survey in 1969 and 1970 and found a decrease of 12·5% in the number of active nests of common egrets between 1969 and 1970 while active nests of great blue herons showed a 1·8% increase (California Department of Fish and Game, 1970). The decrease in numbers of breeding egrets might represent a normal fluctuation rather than a symptom of a widespread population decrease.

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