HEAVY METAL CONCENTRATIONS IN BROWN PELICANS FROM FLORIDA AND CALIFORNIA

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Abstract. The large nesting population of brown pelicans (*Pelecanus occidentalis*) on Anacapa Island, California, has experienced almost total reproductive failure in 1969, 1970, and 1971, apparently the result of thin, easily crushed eggshells. Comparable populations in Florida are reproducing successfully. The large differences in tissue concentrations of DDT compounds between the two populations stand as the most probable explanation of the California failure. We have investigated the occurrence of nine heavy metals (Ag, Cd, Co, Cr, Cu, Hg, Ni, Pb, and Zn) in the tissues of brown pelicans from Florida and California and in a white pelican (*Pelecanus erythrorhynchos*) from California to determine whether elevated levels of these heavy metals might be partly responsible for the reproductive failure of California pelicans.

Analyses were performed according to established techniques by atomic absorption spectrophotometry.

The concentrations of metals measured in the California birds are about the same or lower than in the pelicans from Florida. The only metal showing a clear difference between the two populations is mercury, which is 3-5 times more concentrated in the Florida birds.

INTRODUCTION

Heavy metals are natural components of marine ecosystems, but their levels may be elevated as a result of increased input into the oceans resulting from man's activities. In some cases the concentrations of certain metals in marine waters have reached levels which caused damage to wildlife populations and created serious human health problems. A large fish kill on the coast of Holland in 1965 was evidently the result of very high copper concentrations resulting from copper sulfate which had been deposited on the shore (Roskam, 1965). Cadmium pollution of a river valley downstream from a zinc mine in Japan has resulted in the painful "itai-itai" disease in the human populations (Yamagata and Shigematsu, 1970). In Minamata Bay in Japan, fifty-three persons were killed, and many more became seriously ill from eating fish with high mercury levels resulting from industrial discharges into the bay (Irukayama, 1966).

Identifying levels in wildlife which are elevated as a result of pollution is difficult, since very few data have been reported concerning the natural (non-pollutant) levels of metals in any species of marine vertebrates. To investigate the extent of heavy metal pollution in northern oceans, Anderlini et al (in press) measured levels of nine metals in four populations of petrels: ashy petrels, Oceanodroma homochroa, from the Farallon Islands of coastal California; Wilson's petrels, Oceanites oceanicus, nesting in two areas of Antarctica and wintering in different areas, one population visiting the North Atlantic and the other visiting the Southern Pacific and Indian Oceans; and snow petrels, Pagodroma nivea, a species confined to the pack-ice region of Antarctica. If concentrations of heavy metals in marine ecosystems near industrial areas have increased as a result of pollution, it can be expected that concentrations of metals at corresponding trophic levels in ecosystems remote from the sources of pollution will be lower. The analysis of these different populations of closely related species would provide a measure of heavy metal pollution in oceans near industrial areas by comparing levels with those present in Antarctic Seas.

The results of this study indicated a tendency toward higher levels of cadmium, chromium, mercury, and nickel in petrels feeding in the northern oceans, compared to those petrels confined to less industrialized southern oceans. The magnitudes of the differences did not seem alarming, however, with levels in the same order of magnitude in all four populations. Copper and zinc, essential elements whose tissue concentrations are probably metabolically regulated, were at similar levels in all populations. Except in the vicinity of outfalls, it does not appear that pollution by these six metals presents an imminent hazard to populations of sea birds off the coast of California.

In the early 1900's nesting colonies of brown pelicans (Pelecanus occidentalis) existed in at least five sites in Southern California, and as recently as 1964 it is estimated that 1000 pairs bred successfully on Anacapa Island (Banks, 1966). The nesting success on Anacapa in 1969 was reported by Risebrough, Sibley, and Kirven (1971) as not more than four young fledged from a minimum of 1272 nests built. This almost total failure, apparently the result of thin, easily crushed eggshells, has continued through the two succeeding nesting seasons.

Results of analyses of 65 eggs from this colony have been reported by Risebrough (in press) with a mean value for total DDT compounds of 1223 parts per million of the lipid weight. This value is extremely high in comparison to measured concentrations in brown pelican eggs from successful nesting colonies in the Gulf of California and in Florida. The mean level of total DDT compounds in 87 eggs from four Florida colonies was only 34 ppm, approximately 36 times lower than the Anacapa level. The concentration of polychlorinated biphenyls (PCB) was also higher in the California eggs, but only by about three times (Schreiber and Risebrough, in press). Coupled with the results of several feeding experiments relating thinning of eggshells to DDT compounds in the diets of birds (Heath et al 1969; Wiemeyer and Porter, 1970; Risebrough and Anderson, in prep.), this evidence seems clearly to implicate the high levels of DDT compounds as the most probably cause of the reproductive failure of the Anacapa pelicans.

During some of the controversy which has surrounded this problem, it has been suggested that perhaps pollution of California's coastal waters with heavy metals is responsible for the continuing loss of Anacapa's pelicans. In an effort to ascertain the extent of heavy metal pollution in brown pelicans of California, we have investigated the levels of nine heavy metals in tissues of adult birds from California, and for comparison, corresponding data were collected for brown pelicans from a colony in Florida which is reproducing successfully.

Research was supported by National Institute of Health Postdoctoral Fellowship 1-F02-ES51971-01 (Connors) from the National Institute of Environmental Health Sciences; by the Division of Ecology and Systematics of the National Science Foundation, grant GB-11649; and by the International Decade of Oceanic Exploration program of the National Science Foundation, grant GX-28743. We thank George Knauer, Carolyn Connors, and Seddon Bennington for assistance in the laboratory, and Arthur Bischoff and Dick Bauer for assistance in obtaining specimens.

METHODS

Five brown pelicans were obtained in California, all found dead or dying: one adult on Anacapa Island, August 1970; one adult and one first year bird in Monterey County, October 1970; one adult and one second year bird in Los Angeles County, August 1971. Five adult brown pelicans were collected near Tarpon Key and Tampa Bay, Florida, August 1969. In addition, one white pelican (Pelecanus erythrorhynchos) found dead in the Sacramento National Wildlife Refuge, California, in November 1971, was analyzed with the brown pelicans. Five addled eggs of the brown pelican were taken for analysis from Anacapa Island after the breeding season in 1971.

Duplicate samples of liver, breast muscle, and mid-section of one femur were dissected for analysis and prepared according to the procedures described in Anderlini et al (in press). Liver and breast tissue were not available in two of the California brown pelicans when the specimens were received in our laboratory. The entire contents of the eggs (exclusive of shell) were analyzed.

All analyses were performed on a Perkin-Elmer Model #303 Atomic Absorption Spectrophotometer according to standard conditions for Ag, Cd, Co, Cr, Cu, Ni, Pb, and Zn. Analyses for Hg were performed on the same equipment by flameless spectorphotometry following the techniques of Uthe et al (1970) and Stainton (1971).

RESULTS

Table 1 presents a summary of the data obtained for mercury levels in the pelican tissues. Because of the small number of individuals sampled and the uncertainty of the distribution of values in the population, no confidence limits about the mean can be given. The range of values for each category is shown. Duplicate samples of tissue were prepared and analyzed independently, and the two measurements, which were usually in close agreement, were averaged. Thus, the high value of 17.36 ppm mercury in the liver of one Florida brown pelican cannot be considered a spurious result due to contamination during the analysis.

It is clear from these data that the levels of mercury in the sample of the Florida brown pelican population are higher than in the California sample, by 3-5 times. In comparison with levels of mercury in other sea birds, the values in the Florida population are surprisingly high. The maximum concentration of mercury in liver measured in our laboratory for any of 10 ashy petrels, 20 Wilson's petrels, 10 snow petrels and 16 common terns (Sterna hirundo) from Long Island Sound and Lake Ontario was 4.74 ppm. Common terns feeding in polluted Lake St. Clair in Canada have been measured at values as high as 39 ppm mercury in liver (Dustman et al, 1970), but in mercury feeding experiments, red-tailed hawks (Buteo jamaicensis) had only 17-20 ppm mercury in the liver at death (Fimreite and Karstad, 1971). In view of this, a value of 17 ppm in the liver of a Florida brown pelican can be considered potentially dangerous. This population is presently being carefully monitored, however, and no unusual mortality associated with high pollutant levels has been observed (Schreiber and Risebrough, in press). The single white pelican analyzed has values slightly higher than the California brown pelican levels.

None of the other eight metals investigated showed such clear differences in levels between the two brown pelican populations. Tables 2 and 3 present the nickel and chromium results. For each of these metals the liver and breast values are comparable, but the bone values are higher in the Florida population. In view of the small sample size, this should not be considered as indicative of significant differences between the levels in the two populations. The white pelican values are slightly lower than the brown pelican values for both metals.

Concentrations of cadmium, copper, and zinc showed no differences judged significant between the Florida and California populations. The data are summarized in Tables 4, 5, and 6. One individual brown pelican found dead near Monterey Bay had an unusually high level of cadmium in the liver, probably indicating that it had recently been feeding on fish containing a high concentration of this metal. Other west coast pelicans had much lower levels. Petrels from Antarctic and California ocean waters had liver cadmium levels considerably higher than the miximum pelican value (Anderlini et al, in press).

Concentrations of these metals in the white pelican analyzed tend to be comparable or slightly below the mean values for the brown pelicans, except for a very high level of zinc in the liver. Zinc, an essential element, usually shows a narrow Gaussian distribution in a population, probably indicating metabolic control of the concentration. Mean liver levels in populations of common terns, brown pelicans and three species of petrels have ranged from 92 ppm to 176 ppm. Thus, the level of 275 ppm found in this bird is surprising, and may indicate greatly elevated levels in the food of this individual. It will be informative to investigate other white pelicans.

In Table 7 the results of analyses for silver, cobalt, and lead are presented. Only the bone samples had concentrations great enough for measurement, and the values listed should be regarded as maximum values. All samples were treated equivalently, so comparisons are valid, but because of a large, not precisely determined background correction (especially for cobalt and lead), these values should not be considered as accurate estimates of the actual concentrations. Improvements in the methodology used will provide more accurate determinations in the future. No appreciable differences in concentrations of these metals are noted.

Results of the analyses of the brown pelican eggs are included in Table 8. Concentrations of the metals in eggs tend to be low compared to adult body tissue levels, and by the methodology employed in these analyses, accurate concentration determinations could be made only for chromium, copper, mercury, and zinc.

DISCUSSION

In conclusion, the possibility that elevated levels of any of these nine metals in the coastal waters of Southern California might account for the overwhelming reproductive failure of brown pelicans in that area seems to be ruled out by these data. The concentrations of metals in California birds appear to be about the same or lower than in brown pelicans from the Florida colony which is reproducing satisfactorily. The only metal showing a clear difference in levels between the Florida and California populations is mercury, which, in the samples analyzed in this study, is 3-5 times more concentrated in the Florida birds.

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Table 1. **Mercury concentrations in tissues of pelicans, parts per million wet weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Liver	Breast	Bone
Brown Pelican Florida	9.74 (5) 5.14-17.36	1.85 (5) 1.04-2.27	.278 (5) .148-.407
Brown Pelican California	1.54 (3) 1.20-1.88	.66 (3) .26-.89	.095 (5) .064-.134
White Pelican California	4.13 (1)	1.04 (1)	.064 (1)

Table 2. **Nickel concentrations in tissues of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Liver	Breast	Bone
Brown Pelican Florida	< 2.0	4.41 (5) 3.73-5.25	20.3 (5) 14.6-26.0
Brown Pelican California	< 2.0	3.08 (3) 1.85-4.00	10.8 (5) 8.9-13.7
White Pelican California	--	1.60 (1)	7.70 (1)

Table 3. **Chromium concentrations in tissues of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Liver	Breast	Bone
Brown Pelican Florida	.92 (5) .80-1.20	4.01 (5) 2.65-4.71	15.40 (5) 8.82-22.89
Brown Pelican California	1.37 (3) .70-1.80	3.57 (3) 1.45-6.27	6.03 (5) 4.65-8.68
White Pelican California	.70 (1)	1.19 (1)	3.83 (5)

Table 4. **Cadmium concentrations in tissues of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species, locality	Liver	Breast	Bone
Brown Pelican Florida	1.80 (5) 1.32-2.39	.275 (5) .252-.324	1.66 (5) 1.38-1.86
Brown Pelican California	4.97 (3) .62-13.62	.392 (3) .242-.644	1.52 (5) 1.08-1.96
White Pelican California	1.69 (1)	.194 (1)	1.19 (1)

Table 5. **Copper concentrations in tissues of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Liver	Breast	Bone
Brown Pelican Florida	**26.3 (5) 18.6-48.0**	**17.4 (5) 14.2-23.0**	**2.78 (5) 0.30-6.20**
Brown Pelican California	**50.5 (3) 17.8-98.0**	**19.0 (3) 16.8-21.0**	**2.88 (5) 1.60-3.80**
White Pelican California	**20.1 (1)**	**24.0 (1)**	**2.40 (1)**

Table 6. **Zinc concentrations in tissues of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Liver	Breast	Bone
Brown Pelican Florida	**120.9 (5) 107.3-144.9**	**57.8 (5) 47.2-69.9**	**157.4 (5) 140.3-172.6**
Brown Pelican California	**124.1 (3) 79.6-171.7**	**70.2 (3) 52.6-99.9**	**128.5 (5) 104.1-162.1**
White Pelican California	**274.8 (1)**	**65.0 (1)**	**95.1 (1)**

Table 7. **Maximum concentrations of silver, cobalt and lead in femurs of pelicans, parts per million dry weight. Arithmetic means, number of individuals analyzed, and range of values.**

Species locality	Ag	Co	Pb
Brown Pelican Florida	2.51 (5) 2.03 3.12	6.08 (5) 4.77-7.28	23.1 (5) 20.4-26.4
Brown Pelican California	2.32 (5) 1.95-2.75	5.73 (5) 4.73-6.90	23.1 (5) 19.2-26.9
White Pelican California	1.92 (1)	4.48 (1)	16.3 (1)

Table 8. **Concentrations of metals in contents of five eggs of Brown Pelicans from Anacapa Island, California, parts per million dry weight (Hg in ppm wet weight). Arithmetic means with range of values. Concentrations of Ag, Cd, Co, Ni, and Pb were less than 1 ppm.**

Cr	Cu	Hg	Zn
1.04 .57-1.51	7.66 7.04-8.85	.083 .051-.145	45.9 39.9-49.4