Starvation-Pesticide Interactions in Juvenile Brown Pelicans[1]

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Mobilization of fat tissue is common in migrating birds and can also occur in response to other factors such as food deprivation. BERNARD (1963) demonstrated sensitization to organochlorine poisoning in house sparrows (Passer domesticus) following starvation, and STICKEL and STICKEL (1969) found that storage of DDT in fat tissue of cowbirds (Molothrus ater) could act as a protective mechanism and that heavier birds survived longer following a lethal dose of DDT.

ECOBICHON and SASCHENBRECKER (1969) demonstrated that food deprivation caused mobilization of fat and DDT residues stored within the depot to other body tissues in white leghorn cockerels. Healthy cockerels could tolerate 0.45 ppm DDT in their diet without signs of toxicity. In a study involving caged robins (Erithacus rubecula), SODERGREN and ULFSTRAND (1972) found that food deprivation caused a decrease in fat, but DDT residue levels in breast muscle increased in terms of both fresh and lipid weight. It was also found that a considerable portion of DDT residue released from fat reserves was relocated to the brain. Homing pigeons administered capsules containing DDT-C^{14} in corn oil followed by food deprivation showed increased amounts of C^{14} in breast muscle (FINDLAY and DEFREITAS 1971). Omental fat pad tissue contained less C^{14} after starvation because of fat pad lipid weight loss, but lipid concentration of C^{14} increased three-fold.

HARVEY (1967) fed DDT-C^{14} to starlings (Sturnus vulgaris) and observed less than 25% absorption in body tissues. He suggested that DDT is steadily removed from the fat and is converted to an excretable metabolite in the liver.

Similar findings on mobilization of body fat during starvation and resultant higher concentrations

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of DDT residues in various tissues have been reported also for mammals (DALE et al. 1962; SCHMIDT and DEDEK 1972).

In 1972, in connection with other studies, an opportunity became available to test the effect of short-term starvation on environmentally acquired chlorinated hydrocarbon residue levels in wild nestling brown pelicans (Pelecanus occidentalis). This paper presents the results of that study.

MATERIALS AND METHODS

Nineteen nestling brown pelicans, approximately nine weeks old, were obtained from a pelican colony at Vero Beach, Florida, by personnel of the Florida Game and Fresh Water Fish Commission. The birds were transported to Gainesville, Florida, where they were divided into two groups of 9 and 10, with each group being housed in a separate pen. They were maintained on a diet of mullet and fed at the rate of 3/4 lb/bird/day for one week to allow adjustment to captivity. Fresh water was available at all times. The birds were then weighed, banded, and each bird received an oral inoculation of 3×10^8 cells of Edwardsiella tarda to insure that all birds had similar infections of this common enteric bacterium of aquatic animals. Beginning on day 8, one group was deprived of food for the remainder of the experiment. Four or five birds from each group were killed on day 7 and the remainder on day 14.

At necropsy samples of brain, liver, muscle, and fat were removed from each bird for chlorinated hydrocarbon residue analyses. Samples were mixed with Na_2SO_4 and extracted with petroleum ether for five hours in a Soxhlet apparatus. The petroleum ether was evaporated, and the residue was partitioned in hexane/acetonitrile for removal of lipids. The sample was further processed by elution through an 8% deactivated florisil column using hexane:benzene, 3:1 (THOMPSON and EMERMAN 1974). The eluate was concentrated for analysis by electron capture gas chromatography which was performed on a Varian 2100 gas chromatograph with the following parameters: column, 6' x 1/4" glass containing 3% OV-101 or 1.5% OV-17/1.95% QF-1 at 200°; injection port, 210°; detector, 215°. Nitrogen carrier flow was 50 ml/min. Tests of statistical significance between DDE levels in both groups at one and two week sampling dates were performed using a t test.

RESULTS AND DISCUSSION

During the course of the experiment, the pelicans in Group I (fed) lost an average of 66 grams per bird, whereas Group 2 (starved) lost an average of 906 grams per bird.

TABLE 1

Average p,p'-DDE Residues (ppm) in Tissues of Nestling Brown Pelicans Subjected to Starvation for One and Two Week Periods

	Group Number	
	1 (fed)	2 (starved)
1 week		
Brain	.03 ± .01[a]	.03 ± .01
Liver	.06 ± .03	.06 ± .01
Muscle	.24 ± .07	.34 ± .10
Fat	1.72 ± .31	3.28 ± .75[c]
2 weeks		
Brain	.02 ± .002	.04 ± .01[b]
Liver	.04 ± .005	.08 ± .02
Muscle	.24 ± .04	.32 ± .11
Fat	1.94 ± .37	3.09 ± .24[b]

[a] ± values are Standard Error

[b] ± Significantly different (p=.05) residue than fed.

[c] ± Significantly different (p=.01) residue than fed.

Table 1 shows average p,p'-DDE residues contained in tissues from the two groups of birds. The most prominent effect of starvation was the increased concentration of residues in fat tissue. The starved group had significantly higher p,p'-DDE residues in fat tissues at one and two week samplings. Other tissues did not show consistently significant differences between fed and starved birds, with the exception of brain levels in group 2 at 2 weeks. Residues of

p,p'-DDD and p,p'-DDT quantitated were less than those of p,p'-DDE but followed similar concentration patterns in the various tissues. Trace amounts of PCB were noted in tissue samples but were not quantitated. It should be noted that residues present were those found as a result of environmental exposure prior to initiation of the experiment or from the fish that were fed during the experiment and some variation among birds existed. However, if significant residues were present in fish given to birds in Group 1 during the experimental period, it might have resulted in higher residues in the group, not similar or lower residues. The data indicate that during starvation, DDE residues are increased on a ppm basis, but since it is not known what proportion loss of fat contributed to overall weight loss, no judgment can be assessed on the actual DDE change during starvation. It did not appear that when fat was mobilized during periods of lowered food intake, that insecticide residues were mobilized proportionately.

These observations may be of significance in understanding the effects of persistent pesticides such as chlorinated hydrocarbons in pelican populations. The pelicans used in this experiment were 9-week-old nestlings that would soon leave their nests and begin obtaining their own food. Up until that time they had been provided food by their parents, food consisting of several species of fish which would have been the source of the chlorinated hydrocarbon residues. At about 50 days of age, nestling pelicans achieve an asymptotic weight considerably above that of adult birds and then lose approximately 500 gms prior to fledging; weights at fledging are higher than the usual weight of adults (SCHREIBER 1975). This adaptation provides an energy reserve to be utilized by the young pelicans as they learn to feed themselves. During this learning process the pelican loses weight and this weight loss may be due to mobilization of fat. In the process of this mobilization, chlorinated hydrocarbons may relocate to the brain as observed in starved robins (SODERGREN and ULFSTRAND 1972). This in turn could result in pathogenic effects on pelicans if the levels of chlorinated hydrocarbons were high. This effect was not seen in the present experiment, but results might have been different under longer conditions of starvation stress, or under conditions with higher pesticide levels in the birds, or both. In a study of a die-off of common murres (Uria aalge), SCOTT et al. (1975) reported a reduction in body weight and

mobilization of fat in dead and healthy birds related to environmental stress such as pesticides or a failure in the local food supply. There was evidence of pesticide involvement. However, they stated that pesticides could not be causally linked to the die-off. In Florida, the residue levels of chlorinated hydrocarbons have been found to be quite low (THOMPSON 1975) and such an effect might not occur unless environmental levels of DDT or other pesticides were to increase. In other parts of the world, where DDT is still widely used, such an effect might occur in pelicans or other fish-eating birds.

SUMMARY

Nineteen 9-week-old brown pelicans (Pelecanus occidentalis), obtained from a colony in Vero Beach, Florida, containing environmentally acquired p,p'-DDE residues, were subjected to a food deprivation experiment. Samples of brain, liver, muscle, and fat taken after one and two week periods of starvation indicated that starved birds contained significantly greater residue levels in fat compared to non-starved controls. Such differences were not observed in residues in the other tissues. The significance of these findings is discussed in relation to the biology of brown pelicans.

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