

A Suggestion of Synergistic effects of DDE and Aroclor 1254 on Reproduction of the American Kestrel *Falco sparverius*

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ABSTRACT

Most laboratory toxicological studies have been undertaken with only one compound, administered at several doses. Environmental studies routinely report mixtures of contaminants in food webs, but synergistic effects have rarely been looked for. American Kestrels fed a combination of DDE and PCBs had a higher rate of egg breakage and a lower rate of pipping and hatching than did Kestrels exposed to DDE or PCBs alone. Although small sample sizes preclude rigorous statistical analysis, these results provide support for the hypothesis that PCBs also had a significant role in the population declines of several species of birds of prey.

METHODS

American Kestrels, *Falco sparverius*, were obtained from nest-boxes in the Ithaca, New York, area and by trapping during fall migration. Individual juxtaposed cages, with plywood walls between, measured approximately 3 m x 6 m, with a sloping roof providing a height of 4-5.5 m. Each cage contained one male and one female. Day-old cockerels were provided once a day. Eggs were collected five days after the last egg of a clutch was laid. For artificial incubation, eggs were transferred to a still-air incubator (Schano 1969); temperature at the top of the eggs was maintained between 35.5° and 36.3° C. Eggs were turned approximately 180 degrees once every six hours. Concentrated mixtures of DDE, Aroclor 1254, or a combination were made up in a small volume of acetone to which sesame oil was added. These solutions were gently heated to evaporate the acetone and then brought up to the desired volumes. Dead cockerels were injected in the breast region with 0.2 ml of the oil, providing dietary concentrations of 3 ppm DDE, 10 ppm Aroclor, or 3 ppm DDE + 10 ppm Aroclor 1254. Feeding on the dosed food began in March and was continued until late August. Eggs and eggshells were weighed on a Mettler balance to the nearest 0.001 g. Shells were measured for breadth and length to the nearest 0.1 mm with a Mitutoyo No. 505-633 caliper. After careful washing and draining, shell thickness was measured to the nearest 0.005 mm at the equator (four locations) with an Ames No. 255 ME thickness gauge. Determinations of Ratcliffe's index were made by dividing the weight of the dried eggshell (mg) by the length and breadth in millimeters (Ratcliffe 1970).

RESULTS

Eggshell Thickness. Ratcliffe's index was 13% and 16% lower in the groups fed DDE and DDE+PCB, respectively, than the index of the control group (Table 1; $P < 0.001$; 't' test); the difference between the two treatment groups was not significant ($P > 0.1$, 2-sided 't' test). Thickness index of the PCB group was 6.2% higher than that of the controls but the requirement of the 't' test for equal variances appears not to be met; $F = 2.56$, $P < 0.05$, (Table 1). The higher mean thickness of the PCB group may not therefore be significant.

Table 1. Changes in Ratcliffe's thickness index and shell thickness in eggs of Kestrels fed 3 ppm DDE, 10 ppm PCBs, 3 ppm DDE + 10 ppm PCBs, and a control diet.

	Control	DDE	PCBs	DDE+PCBs
Ratcliffe's index				
N	15	17	18	12
Mean, S.D.	0.920 .050	0.799* .054	0.977 .080	0.770* .045
Thickness				
N	15	18	14	15
Mean, S.D.	0.171 .013	0.145* .009	0.176 .015	0.139* .008

* Significantly different from control, $P < 0.001$

Breakage. No egg breakage occurred in the control (N=3), DDE (N=5), PCB (N=5; one nest had breakage attributable to other causes), but broken eggs were found in each of the DDE+PCB nests (N=5). This distribution has a very low probability (< 0.005) from a Chi-square analysis, but the low number of samples in the control group precludes a rigorous application of this test.

Artificial Incubation. Incubation conditions were imperfect, as indicated by the low rate of pipping and hatching of the control eggs (Table 2). However, none of the eggs of the DDE+PCB group hatched. No statistical significance can be attached to this observation because of the low hatching rate of the controls and the relatively small sample sizes, but a synergistic effect of DDE and PCB on hatchability is suggested.

Table 2. Pipping and hatching rates of artificially-incubated Kestrel eggs.

Diet	Eggs incubated	Eggs pipped	Eggs hatched
Control	11	6	4
DDE	20	6	5
PCBs	11	2	2
DDE+PCBs	7	0	—

DISCUSSION

In wild raptors, PCBs have almost always been associated with DDE and with lesser amounts of other organochlorines (i.e. Lincer 1972; Lincer & Clark 1978; Risebrough *et al.* 1968; Fiuczynski & Wendland 1968; Prestt *et al.* 1970; Peakall & Lincer 1970). Most laboratory studies of effects of PCBs on avian reproduction, however, have not addressed synergistic effects with other environmental chemicals. Risebrough & Anderson (1975) found that Mallards, *Anas platyrhynchos*, fed a combination of DDE and Aroclor 1254 produced fewer eggs than ducks on control, DDE, or PCB diets and also showed a higher incidence of egg eating. Thickness index of eggs of the DDE+PCB group was lower than that of the DDE group, but the differences were not statistically significant.

It is apparent that the role synergistic effects of DDE and PCBs may have had in the population declines of several raptor species in the 1950s-1970s has not been adequately addressed with the appropriate follow-up experiments; the data presented here suggest that it may have been significant.

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