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Enzymatic Changes in the Oviduct Associated with DDE-induced Eggshell Thinning in the Kestrel, *Falco sparverius*

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There is a wide range of sensitivity to DDE-induced eggshell thinning within the order Aves. PEAKALL (1975) has proposed three categories, insensitive, moderately sensitive and highly sensitive species. In a previous paper (MILLER et al. 1976) we reported enzymatic changes in the oviduct associated with eggshell thinning in a moderately sensitive species, the Pekin Duck (Anas platyrhynchos) and found that these changes did not occur in an insensitive species, the chicken (Gallus gallus). In this paper, we report the enzymatic changes associated with marked eggshell thinning in a highly sensitive species, the American Kestrel (Falco sparverius).

MATERIALS AND METHODS

Breeding pairs of kestrels were maintained at the Macdonald Raptor Research Center (BIRD 1982). Each pair was forced to renest by removal of the first clutch to induce laying of a replacement clutch (BIRD & LAGUE 1982). The length and breadth of each egg was measured to the nearest 0.1 mm, then the eggs were frozen and cut around the equator. The eggshells were washed with water and dried to constant weight at 45°C. The eggshell index was obtained by dividing the weight (mg) by the product of the length (mm) and breadth (mm) (RATCLIFFE 1967). At the completion of laying the first clutch of eggs, DDE was administered daily via their food to 8 pairs of kestrels and an additional 8 pairs served as controls. The DDE was administered by injecting DDE dissolved in corn oil into dead day-old cockerels so that the final concentration was 20 ppm on a fresh weight basis. The calculated dietary intake was 6 mgDDE/kg body weight/day. The female kestrels were killed by decapitation during the laying of the second clutch, usually between the second and third egg. The oviduct was removed immediately and after rinsing with ice cold 0.25 M sucrose, the mucosa was scraped and the scrapings homogenized with 0.25 M sucrose (10% weight per volume). Aliquots were frozen rapidly using dry ice and acetone, freeze-dried at -20°C for 48 hrs and stored at -70°C. ATPase activity was measured by a modification of Bonting's method (MILLER et al. 1976), carbonic anhydrase activity by the method of MAREN (1960) and protein by the procedure of LOWRY et al. (1951).

Table 1. Effect of DDE feeding on kestrel eggshell thickness, blood calcium and enzyme activity in the shell gland.

	Control[1]	DDE-treated
Shell thickness index[2]	0.990±0.046 (35)	0.728±0.050 (15)**
Ca-ATPase[3]	29.71 ±2.05 (8)	20.28 ±1.73 (8)*
Mg-ATPase[3]	32.20 ±3.08 (8)	26.31 ±2.11 (8)
Na,K-ATPase[3]	5.08 ±1.02 (8)	4.29 ±0.90 (8)
HCO_3-ATPase[3]	7.01 ±1.32 (8)	11.81 ±3.11 (8)
Carbonic anhydrase[4]	23.56 ±3.56 (8)	18.98 ±2.42 (8)*
Blood calcium (mg/100 ml)	19.41 ±0.50 (8)	19.67 ±0.44 (8)

[1] Mean with standard error, sample size in brackets

[2] Weight of eggshell (mg)/length (mm) x breadth (mm) (RATCLIFFE 1967)

[3] µmol P_i released per mg protein per hour

[4] Enzyme units per mg protein

* Significant at 0.01

** Significant at 0.001

RESULTS AND DISCUSSION

Eggshell thinning of 26% was achieved by exposure to DDE diet (Table 1); the time on diet averaged 14 days. The two enzymes whose activities were significantly reduced, Ca-ATPase and carbonic anhydrase, are the same as found previously for the Pekin Duck (MILLER et al. 1976). The lack of any effect on the circulating levels of calcium supports the hypothesis proposed earlier (PEAKALL et al. 1975) that DDE-induced eggshell thinning results from changes within the shell gland, rather than in the supply of calcium to the gland.

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REFERENCES

BIRD, D.M. Nature 299, 300 (1982).

BIRD, D.M. and P.C. LAGUË. Can. J. Zool. 60 (1982).

LOWRY, O.H., N.J. ROSEBROUGH, A.L. FARR and R.J. RANDALL. J. Biol. Chem. 193, 265 (1951).

MAREN, T.H. J. Pharmac. Exp. Ther. 130, 26 (1960).

MILLER, D.S., W.B. KINTER and D.B. PEAKALL. Nature 259, 122 (1976).

PEAKALL, D.B. In Environmental Dynamics of Pesticides. Ed. R. Haque and V.H. Freed, pp. 343-360 (1975).

PEAKALL, D.B., D.S. MILLER and W.B. KINTER. Environ. Pollut. 9, 289 (1975).

RATCLIFFE, D.A. Nature 215, 208 (1967).

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