ENDRIN DECREASES SCREECH OWL PRODUCTIVITY

W. JAMES FLEMING, M. ANNE ROSS MCLANE, and EU-
GENE CROMARTIE, U.S. Fish and Wildlife Service, Patux-
ent Wildlife Research Center, Laurel, MD 20708.

Although the use of many organochlorine pesticides has been sharply curtailed during the last decade, agricultural needs have generated interest in renewed or continued use of some of these pesticides. Endrin is 1 such pesticide. The U.S. Environmental Protection Agency (1976) issued a Rebuttable Presumption Against Registration notice for endrin in 1976 which resulted in restriction of its uses (U.S. Environmental Protection Agency 1979). In addition, some states severely restricted the use of endrin primarily because of its toxicity to nontarget wildlife and the availability of suitable alternative chemicals (Mungari 1979). However, during the late 1970's, endrin was used to help control grasshoppers in the Midwest (L. C. McEwen, pers. commun.) and rodent pests in orchards in the Northeast (Mungari 1979). Its use in 1981 to control pale western cutworms (Agrotis orthogonia) in wheat fields in Montana caused widespread concern over contamination of waterfowl and game birds.

Endrin is 1 of the most toxic of the organochlorine pesticides; it is ~80 times more toxic than DDT and ~8 times more toxic than dieldrin and aldrin to mallard (Anas platyrhynchos) ducklings (Hill et

J. Wildl. Manage. 46(2):1982
al. 1975). It has been diagnosed as a major factor in the deaths of several white pelicans (Pelecanus erythrorhynchos), a brown pelican (P. occidentalis), and 2 bald eagles (Haliaeetus leucocephalus) (Stickel et al. 1979).

The effects of endrin on avian reproduction have not been adequately studied. Ring-necked pheasants (Phasianus colchicus) and bobwhites (Colinus virginianus) fed 0.13 and 0.33 ppm endrin showed no decrease in productivity; mallard ducks fed 0.67 ppm endrin produced eggs of lower fertility and hatching success, and survival of young seemed depressed (J. W. Spann, unpubl. data). Baldwin et al. (1976) showed that endrin is deposited in the eggs of birds dosed with the pesticide. Brown pelican eggs from Louisiana contained as much as 1.5 ppm endrin (Blus et al. 1979). A red-breasted merganser (Mergus serrator) egg from Wisconsin contained 0.33 ppm endrin (White and Cromartie 1977) and 2 great blue heron (Ardea herodias) eggs from the Tennessee Valley contained 0.1-0.2 ppm endrin (unpubl. data).

Our study is the first on the sublethal impact of endrin on the reproductive performance of a bird of prey. Our objective was to examine the effects of dietary endrin on screech owl (Otus asio) reproduction.

METHODS

Thirty experienced breeding pairs of screech owls from a captive colony at the Patuxent Wildlife Research Center were randomly assigned to outdoor pens. Each pen measured 12.2 x 3 x 2.4 m high and was equipped with a nest box, resting shelter, perch, and a food shelter. For 2 weeks before the study, owls were fed a commercial bird-of-prey diet (Nebraska Brand, North Platte, Nebr.). Water was provided ad libitum.

Fifteen pairs of owls were randomly chosen to receive 0.75 ppm endrin (2.25 ppm dry weight basis) in their feed. The endrin-treated feed was made by mixing endrin in propylene glycol and adding this solution to the bird-of-prey diet at 2% by weight. Actual amounts of endrin in the feed ranged from 0.7 to 0.8 ppm as determined by chemical analysis. Fifteen pairs of owls served as controls and were fed 2% propylene glycol in their diet. Within the limits of sensitivity of the chemical analyses used, endrin was not detectable in the control diet.

The experimental diets were started on 16 February and continued until each pair had completed incubation. The amount of food removed from the feeding tray in each pen was recorded daily. When the eggs in each pen hatched, day-old chicks (Gallus gallus) without endrin added were substituted for experimental diets. Previous experience has shown that young birds of prey do not survive well on the commercial bird-of-prey diet, even when no toxicants are added.

Nest boxes were checked daily until clutches in each pen were complete and females were incubating. Adult pairs were weighed weekly until they began laying eggs. The number of eggs laid and hatched, and the number of young fledged were recorded. Eggs were numbered within each clutch in the order in which they were laid. The 3rd egg from each clutch was removed when the clutch was completed. These eggs plus all eggs that failed to hatch from the endrin group were saved for chemical analyses. Owlets were weighed and tarsus and primary feather lengths were recorded at 4 weeks of age, about the time of fledging.

Eight additional pairs of owls were ran-
domly assigned to either an endrin (6 pairs) or a control group (2 pairs). Diets and other factors were as described above except that pens were smaller and pairs were sacrificed when they completed their clutches. Carcasses and eggs from these birds were analyzed for endrin.

Carcasses for chemical analyses were prepared by removing the feet, beak, distal portions of the wing, intestine, feathers, and skin. The carcasses were then wrapped in aluminum foil and frozen until analyzed. The length and width of each egg were determined; each egg was then opened at the equator and the contents placed into a chemically clean jar (rinsed in acetone and hexane) and frozen. Eggshells were dried for at least 30 days at room temperature, weighed, and thickness measured at the equator (the average of 3 measurements for each egg was used for data analysis). Ratcliffe's thickness index for shell thickness was determined (Ratcliffe 1967).

Samples for organochlorine pesticide analyses were mixed with anhydrous sodium sulfate and extracted for 7 hours with hexane in a soxhlet apparatus (Cro-martie et al. 1975). Samples were cleaned and separated into fractions on a partially deactivated Florisil column. Under this separation scheme, Fraction 3 would contain 12-ketoendrin, Fraction 2 would contain endrin and dieldrin, and Fraction 1 would contain other organochlorine pesticides and PCB's. Fraction 1 was eluted with 1% ethyl ether in hexane, Fraction 2 was eluted with 6% ethyl ether in hexane, and Fraction 3 was eluted with 15% ethyl ether in hexane. The pesticides and PCB's in Florisil Fraction 1 were separated as described by Cro-martie et al. (1975) except that silica gel was substituted because of a lack of SilicAR. To prevent losses of endrin on the silica gel column, it was necessary to first isolate this compound on the Florisil column.

Pesticides were quantified with a gas-liquid chromatograph equipped with an electron-capture detector and a 1.5% SP-2250/1.95% SP-2401 column at 198 °C. The average recovery for endrin, dieldrin, and 12-ketoendrin from fortified mallard carcass and chicken egg samples was 99%.

The lower limits of reportable residues were 0.5 ppm for PCB's and 0.1 ppm for pesticides, except for endrin and 12-ketoendrin which were 0.05 ppm. Residues in 2 samples were confirmed by gas chromatography-mass spectrometry as described by Kaiser et al. (1980).

Data were analyzed by Student's t test, chi-square test, nested analysis of variance, and regression analysis. Hatching and productivity data were adjusted on the basis of the number of eggs remaining after removal of the 3rd egg. With regard to the reproductive variables measured, variances were high resulting in high probabilities of making Type II errors. Therefore we used \( \alpha = 0.1 \) as our significance level to decrease the chance of making a Type II error, but in each instance where \( 0.05 < P \leq 0.1 \), the actual \( P \) value is stated either in a table or in the text.

RESULTS

The owls fed endrin laid fewer eggs/day/laying female during the laying period, had fewer eggs hatch/incubated clutch, and produced fewer fledglings/total number of pairs in the treatment group than did controls (Table 1). Other reproductive variables did not differ.

Endrin residues in eggs from the endrin-treated group ranged from 0.12 to 0.46 ppm (Table 2). Residues in the 3rd egg of each clutch were not correlated
Endrin, a chlorinated hydrocarbon insecticide, was used in a study to determine its effects on the reproductive success of screech owls. The study was conducted in captivity, and screech owls were fed either endrin or a control diet. The test species were fed endrin for 83 days, which resulted in endrin residues in eggs, carcasses, and birds, but not in samples of leaf tissue. The concentration of endrin in samples was quantified with gas chromatography.

### Table 1: Reproductive Success of Captive Screech Owls Fed 3 or 0.75 ppm Endrin. Ranges are in parentheses.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Control Group</th>
<th>Endrin Group</th>
<th>Test of significance</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pairs of breeders</td>
<td>15</td>
<td>15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Females laying eggs</td>
<td>12</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nests incubated</td>
<td>12</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nests with hatchlings</td>
<td>12</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean date of 1st egg (after 2/16)</td>
<td>38 (27-52)</td>
<td>40 (25-55)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs laid</td>
<td>55</td>
<td>43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs incubated/number laid</td>
<td>29/43</td>
<td>16/34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs hatched/number incubated</td>
<td>29/43</td>
<td>16/34</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs hatched/number incubated</td>
<td>29/41</td>
<td>16/30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent eggs hatched/number incubated clutch</td>
<td>72 (40-100)</td>
<td>49 (0-100)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs incubated</td>
<td>7</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cracked eggs</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percent hatchlings surviving to fledging (4 weeks)</td>
<td>97</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total fledglings produced</td>
<td>28</td>
<td>16</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Two-tailed t test.
- The 3rd egg from each clutch was removed for chemical analyses. Hatching success and fledglings produced are calculated on the basis of the adjusted clutch size.
- One-tailed t test.
- Includes cracked, thin-shelled eggs, and eggs found outside and inside the nest boxes; 1 additional egg from the endrin group was cracked by investigators.

(r = 0.20, P > 0.1) with the length of time birds were on the endrin diet before completion of the clutch. Eggs from control birds did not contain endrin above the limit of detection although DDE and PCB residues were found in most eggs from both control and endrin-treated groups. PCB concentrations in eggs differed (P ≤ 0.05; 2-tailed t test) between the endrin and control groups but DDE concentrations did not (P > 0.1; 2-tailed t test). Neither PCB nor DDE concentrations in eggs was correlated (r = 0.15, and -0.31, respectively; P > 0.1) with endrin residues in eggs from the endrin treatment group.

In the endrin-treated group, hatching success and number of young produced were significantly lower than in the control group. Eggs from endrin-fed birds contained endrin residues at a sensitivity of 0.05 ppm. Residues were quantified with gas chromatography as de-

### Table 2: Endrin, DDE, and PCB Concentrations in Carcasses and Eggs of Screech Owls Fed 0.75 ppm Endrin or a Control Diet as Long as 83 Days.

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Treatment group</th>
<th>Sex</th>
<th>N</th>
<th>Residues (ppm wet weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Endrin</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>t</td>
</tr>
<tr>
<td>Carcass</td>
<td>Control</td>
<td>Male</td>
<td>2</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>Male</td>
<td>2</td>
<td>ND</td>
</tr>
<tr>
<td></td>
<td>Endrin</td>
<td>Male</td>
<td>5</td>
<td>0.36</td>
</tr>
<tr>
<td></td>
<td>Endrin</td>
<td>Female</td>
<td>5</td>
<td>0.55</td>
</tr>
<tr>
<td>Eggs</td>
<td>Control</td>
<td>ND</td>
<td>12</td>
<td>0.12</td>
</tr>
<tr>
<td>Endrin</td>
<td>Male</td>
<td>9</td>
<td>0.28</td>
<td>0.14-0.45</td>
</tr>
<tr>
<td>Endrin</td>
<td>Female</td>
<td>13</td>
<td>0.27</td>
<td>0.12-0.46</td>
</tr>
</tbody>
</table>

- ND = not detected at a sensitivity of 0.05 ppm.
- *Residues in 3rd egg from each clutch.
- †Residues in eggs that did not hatch.

Wildl. Manage. 46(2):1982
Short Communications

were not correlated \((r = -0.35\) and \(-0.45\), respectively; \(P > 0.1\)) with endrin residues in the 3rd egg from each clutch (Fig. 1). Clutches in which the 3rd egg had >0.3 ppm endrin produced 0.67 young/pair \((N = 3)\), which differed \((P = 0.08, 1\text{-tailed } t\) test) from the 2.3 young per pair \((N = 6)\) produced by clutches in which endrin residues were ≤0.3 ppm. Hatching success of clutches with the 3rd egg having >0.3 ppm was less than that of clutches with <0.3 ppm \((P = 0.04, \chi^2\) test). Endrin concentrations in the 3rd egg from each clutch did not differ \((P > 0.1, 2\text{-tailed } t\) test) from those of unhatched eggs in the endrin-treatment group. Most unhatched, uncracked eggs from both the endrin-treated and control groups were addled and showed no signs of development.

Neither egg shells of the 3rd egg of each clutch nor shells of unhatched eggs were thinned by the endrin diets as compared to controls \((P > 0.1, 1\text{-tailed } t\) test). Shell thickness of all unhatched and 3rd eggs from the endrin-treated group was not correlated \((r = 0.20, P > 0.1)\) with endrin residues in the egg contents. Analysis of data based on Ratcliffe’s thickness index rather than on shell thickness measurements produced similar findings.

Food removal from feeding stations, an index to food consumption, did not differ \((P > 0.1, 2\text{-tailed } t\) test) between the endrin-treated and control groups. Changes in weights of adult pairs of treated and control birds that had not begun to lay eggs after 4 weeks on experimental diets were not different \((P > 0.1, 2\text{-tailed } t\) test). Body weights and tarsus lengths of 4-week-old fledglings in the control and endrin-treated groups were not different \((P > 0.1, \text{nested ANOVA})\), but primary lengths were different \((P = 0.06, \text{nested ANOVA})\; x = 77.6 \pm 4.8\,\text{mm}, 80.7 \pm 6\,\text{mm}) for the control and endrin-treated groups, respectively.

Only 1 of the 8 pairs of owls used for carcass residue determinations laid any eggs. This pair was in the endrin-treated group and was sacrificed after 52 days on the endrin diet. The other 7 pairs of owls were sacrificed after 83 days on the test diets. Endrin concentrations in the carcasses of owls from the endrin-treated group ranged from 0.13 to 0.80 ppm. Endrin concentrations in females were not different \((P > 0.1, 2\text{-tailed } t\) test) from those in males (Table 2). The endrin concentration in the female that laid eggs \((#20)\) was in the middle of the range of endrin residues for the endrin-dosed females that did not lay eggs. Endrin in the 4 eggs of #20 ranged from 0.16 to 0.22 ppm indicating a low variability of residues within the clutch. Endrin was not detected in the carcasses of the 2 pairs of control owls. Low concentrations of DDE and PCB’s were present in carcasses of both control and endrin-treated groups (Table 2); concentrations of PCB’s differed \((P = 0.09, 2\text{-tailed } t\) test) in these groups but DDE did not \((P > 0.1, 2-\)
DISCUSSION

Screech owls fed 0.75 ppm endrin produced 43% fewer fledged owlets than controls. Hatching success appeared to be the main reproductive variable affected by endrin. However, the collective effects of endrin on other reproductive variables may have contributed to the overall net loss of productivity. Endrin residues in eggs were not associated with eggshell thinning and therefore the decrease in hatching success was not due to the shell thinning phenomenon that has been described for DDE. The absence of detectable embryo development in the unhatched, uncracked eggs seems to indicate a problem with egg fertility or with early embryo survival. It is not clear that this is related to the endrin treatment because unhatched control eggs also exhibited this characteristic. The PCB concentrations in the endrin-treated group were greater than in the control group. However, these PCB concentrations in eggs and adult owls were several times less than those found in a study in which screech owls were fed PCB's without adverse reproductive effects (McLane and Hughes 1980). PCB absorption and/or storage may have been enhanced by endrin but this relationship is not clear because of the poor correlation of PCB and endrin residues.

Endrin residues in the 3rd egg from each clutch were not correlated with hatching success, although, except for 1 clutch, there was a trend toward lower hatching success in clutches with higher residues. An arbitrary division of clutches in the endrin group revealed that the number of young produced from clutches having ≤0.3 ppm endrin in the eggs was 3.4 times greater than the number produced from clutches having >0.3 ppm endrin in the eggs. We emphasize that the 0.3 ppm level was not derived statistically and that an actual affect level may be higher or lower. However, the 0.3 ppm level appears to be a good preliminary level to use in evaluating the impact of endrin on screech owls in the wild. Blus (pers. commun.) and Blus et al. (1979) estimated that ~0.5 ppm endrin in the eggs of brown pelicans was the critical level which, if exceeded, caused reproductive impairment. Survival of young screech owls was not affected by the endrin treatment of adults.

We conclude that 0.75 ppm endrin in the diets of screech owls during the reproductive season caused a net decrease in screech owl productivity. A preliminary estimate of harmful endrin concentrations in screech owl eggs is 0.3 ppm or more. Sensitivities of other avian species to endrin may vary. Additional work needs to be conducted before a complete evaluation of endrin's effects on avian reproduction can be made.

Acknowledgments.—We acknowledge the help of D. H. Clearwater and D. A. Berry in conducting the experiment and C. M. Bunck for statistical advice. E. H. Dustman and H. M. Ohlendorf provided helpful reviews of the manuscript. P. S. McDonald typed the manuscript.

LITERATURE CITED


EFFECTS OF ALPHA-CHLORALOSE DRUGGING ON BLOOD CONSTITUENTS IN THE EASTERN WILD TURKEY

MARK A. DONAHUE, MICHAEL E. LISANO, and JAMES E. KENNAMER
Department of Zoology-Entomology and Auburn University Agricultural Experiment Station, Auburn University, AL 36849.

Measurement of physiological parameters of eastern wild turkeys (Meleagris gallopavo silvestris) may be a useful tool in determining the success with which this species deals with its environment. However, measurement of physiological parameters can be biased by capture techniques. Duncan (1974) suggested that handling may be one of the greatest stressors encountered by the domestic fowl. It would be expected that this effect could be similar in wild birds. Thus, it is necessary to have knowledge of the physiological consequences of a capture technique. To date, physiological data from wild turkeys have been obtained from killed, trapped, or pen-reared birds.

Two methods of trapping are most frequently used with wild turkeys: projected nets and orally administered hypnotic drugs. Whatley et al. (1977) reported that capture with rocket nets causes significant increases in plasma corticosterone levels, which is an indicator of stress in wild turkeys. The effect of this stress varies, making it difficult to predict the magnitude of the effect from one bird to the next. Drugging may be a more feasible capture method if it does not cause significant physiological consequences.

One drug commonly used to capture wild turkeys is alpha-chloralose (Williams et al. 1970). This drug has been tested extensively and its hypnotic effects are well documented. It has a long

---


Received 7 July 1981. Accepted 13 October 1981.