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DDE Residues and Eggshell Thickness of Ring-necked Pheasant Eggs from the Texas High Plains

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The Southern High Plains of Texas is one of the most intensely irrigated and cultivated regions of the United States, with cotton and cereal grains being the predominant crops (Bolen and Guthery 1982). The region contains about 17,000 to 18,000 playa lakes (Bolen and Guthery 1982), which are undrained, circular basins composed of Randall clay soils that accumulate surface run-off and can trap and concentrate pollutants from adjacent agricultural lands. The basins support a variety of plant and animal life (Bolen and Guthery 1982, Guthery et al. 1982), which could be exposed to abnormally high amounts of pollutants. Yet, there is little documentation available on environmental contaminants in these basins and their possible effects on wild populations.

Although p,p'-DDE has been implicated in eggshell thinning in fish-eating and predatory birds (Anderson et al. 1969, Fyfe et al. 1969, Blus et al. 1979, Enderson et al. 1982), its effects on avian species at lower trophic levels have not been well documented. In a controlled study, Haseltine et al. (1974) noted declines in eggshell thickness in mallards (Anas platyrhynchos) and ring doves (Streptopelia risoria) when fed 10 ppm p,p'-DDE. Peakall (1973) found that eggshell thinning started as early as the second day after mallards were fed 40 ppm p,p'-DDE daily. Haseltine et al. (1981) detected residues of p,p'-DDE in 80% and 95% of gadwall (Anas strepera) and mallard eggs, respectively, collected in Wisconsin. Greenburg and Edwards (1970) detected DDT and its metabolites in 119 of 120 ring-necked pheasant (Phasianus colchicus) eggs collected in east-central Illinois. Hunt (1966) found DDT residues to average 741 ppm in ring-necked pheasants from a rice-growing region near Richvale, California.

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The objectives of our study were to (1) determine residue levels of organochlorine pesticides in ring-necked pheasant eggs collected from different habitat types within the Southern High Plains of Texas, (2) determine eggshell thickness of ring-necked pheasant eggs from the different habitat types, and (3) determine the relationship between residue levels and eggshell thickness for ring-necked pheasant eggs in this region.

MATERIALS AND METHODS

Eggs were collected during May, June, and July, 1980 as part of a nesting study in Castro County, Texas (Taylor 1980). Only one egg was taken from each nest located. Eggs were collected from four habitat types: alfalfa fields, wheat fields, oat fields, and playa lake basins. Egg contents were homogenized and placed in individually labeled glass jars and frozen until analysis. Mean eggshell thickness was determined from measurements at three locations along the mid-line perpendicular to the long axis of the egg using a micrometer (Taylor 1980).

Egg contents were prepared for gas chromatographic analysis using the micro-method described by Watts (1980). Fraction one from the florisil fractionation was collected and analyzed. Analyses were conducted on a Perkin Elmer Model 3920b gas chromatograph equipped with an electron capture detector (^{63}Ni). Instrumentation and operating conditions were as follows: (1) the column consisted of a 182.9 x 0.6 cm glass column packed with 1.5% OV-17/1.95% OV210 on 100/120 chromosorb W HP (Supelco Inc.); (2) the carrier gas was 95% argon and 5% methane at 60 ml/min; and (3) the instrument temperatures were 210°C, 200°C, 235°C, and 275°C for the injector, column, interface, and detector, respectively. Nanogen pesticide standards were used for peak identification and quantitation; aldrin was used as an internal standard. All residues were expressed in parts per million (ppm) wet weight, with no attempt to convert residue values to total egg volume.

One-way analysis of variance was used to detect differences in residues or eggshell thickness among habitat types. Duncan's new multiple range test was used for mean separation. Correlations between pesticide residues and eggshell thickness were determined by Spearman's coefficient of rank correlations (Steel and Torrie 1980). The Statistical Analysis System (SAS) was used for data analysis (Ray 1982). Significant or significantly refer to statistical significance of $\underline{P} < 0.05$.

RESULTS AND DISCUSSION

Sixty-one eggs were collected and analyzed in this study. Despite equal efforts among habitat types to locate nests, most eggs were collected from wheat fields and alfalfa fields (Table 1).

Table 1. *p,p'*-DDE residues and eggshell thickness of ring-necked pheasant eggs collected from different habitat types in Castro County, Texas.

Habitat type	N	*p,p'*-DDE residue (ppm)		Eggshell thickness (mm)	
		$\bar{x}$	SE	$\bar{x}$	SE
Wheat fields	14	0.045^{a}	0.020	0.263^{a}	0.005
Alfalfa fields	37	0.063^{ab}	0.009	0.266^{a}	0.003
Playa basins	6	0.128^{bc}	0.026	0.239^{b}	0.010
Oat fields	4	0.175^{c}	0.061	0.243^{b}	0.002

[abc] Means in the same column with dissimilar letters are different ($P < 0.05$; Duncan's new multiple range test).

Residues of heptachlor epoxide and *p,p'*-DDE were detected. Heptachlor epoxide was observed in only one egg (0.04 ppm) that had been collected in an alfalfa field. *p,p'*-DDE was detected in 96.7% of the eggs. Residues ranged from non-detectable to 0.3 ppm, with an average of 0.07 ± 0.01 (SE) ppm. Greenburg and Edwards (1970) determined insecticide residues in ring-necked pheasant eggs from east-central Illinois, and found average *p,p'*-DDE residues of 0.15 ± 0.02 ppm ($N = 120$), which is much higher than our observed residue values. This disparity may be related to exposure differences between the two studies. Prior to 1974, pesticide applicators were not required to keep accurate records (U.S. Code of Federal Regulations 1983), and higher than recommended application rates may have been used. Also, our study was initiated 7 years after use of DDT was restricted in the United States (Ware 1978). Greenburg and Edwards (1970) conducted their study at a time when the use of DDT had not been restricted.

Significant differences existed for *p,p'*-DDE residues and eggshell thickness among the different habitat types (Table 1). Residues in eggs collected from oat fields were significantly greater than in eggs from wheat fields and alfalfa fields, but were not different from those collected from playa basins (Table 1). In addition, eggshells of eggs collected from oat fields and playa basins were significantly thinner than for eggs from wheat and alfalfa fields (Table 1). Thus, eggs with higher *p,p'*-DDE residues had thinner eggshells. This relationship also was demonstrated by a significant negative correlation ($r = -0.36$) between eggshell thickness and *p,p'*-DDE residues.

Haseltine et al. (1974) reported no effect of p,p'-DDE on eggshell thickness in captive ring-necked pheasants, whereas we observed a significant negative relationship between p,p'-DDE residues and eggshell thickness in free-ranging ring-necked pheasants. Physiologically, organochlorine pesticides affect the egg-laying and nesting cycles of some birds by increasing metabolism of estrogens and thus causing an endocrine imbalance (Peakall 1970), and by interfering with calcium ATPase and thereby affecting eggshell formation (Miller 1975). It is possible that the negative relationship we observed between p,p'-DDE and eggshell thickness may not reflect a direct effect of p,p'-DDE on eggshell formation. Ring-necked pheasants consume less food when it is contaminated with pesticides (Bennett and Prince 1981), which could indirectly affect formation of the eggshell by nutritional pathways. Local physiographic or nutritional differences among the four habitats also may have affected eggshell formation nutritionally.

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