The Effects of DDT, DDE and Their Sulfonated Derivatives on Eggshell Formation in the Mallard Duck

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The effects of 2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane (DDT) and 2,2 bis-(chlorophenyl)-1,1 dichlorethylene (DDE) on eggshell thickness and weight have been reported for many avian species (COOKE 1973) AND (STICKEL 1973). These effects have been shown to occur both naturally (VERMEER and RISEBROUGH 1972, BLUS, et al 1971 and BLUS et al 1972) and in laboratory experiments (DAVISON and SELL 1974, PORTER and WEIMEYER 1969). Since the vast stockpiles of DDT and DDE constitute a problem from both the aspect of storage and the hazard of environmental pollution; an effort is underway to study the feasibility of detoxifying these insecticides. One of the more promising methods to date has been the treatment of DDT and DDE with sulfuric acid to produce a sulfonated derivative of the parent compound which is water soluble. These sulfonates are being tested for toxicity in a variety of animal systems. This paper reports the results of a study conducted to determine the effects of the sulfonated derivatives of DDT and DDE on eggshell formation in the duck.

Materials and Methods

Young adult mallard ducks (Anas platyrhynchos) were obtained from a local supplier and randomly assigned to cages with 5 hens and 1 drake per cage. The ducks were maintained on commercial poultry-laying mash (Purina Chow) and were allowed to acclimate for a period of 2 months. Egg production was induced by regulating the photoperiod; the ducks were first exposed to 8 hours of light per day for 4 weeks and then 16 hours of light per day for the remainder of the experimental period. Egg production began 3 weeks after 16 hours of light per day was instituted (SPANN 1974).

When peak egg production was reached, the test compounds were added to the poultry laying mash. The eight experimental groups (1 drake and 5 hens each) were given 10 ppm and 50 ppm of DDT, DDE, DDT-SO4 and DDE-SO4 respectively; 4 control groups were maintained on the normal diet. The feed for the test groups was prepared by dissolving the DDT and DDE in acetone, and the sulfonated compounds in distilled water. The feed was mixed in a Hobart food mixer for 20 minutes.

Eggs were collected daily from each group for 30 days and labeled to identify the group and date. The white and yolk were removed from the egg by making a small hole on each side of the

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eggshell and blowing on one side. The eggshells were air dried until measurements were made. Days were pocked at intervals throughout the experimental period and the eggshells collected on those days were measured (total 434 eggs). The measurements made were (1) weight (grams), (2) maximum length and width (cm), and shell thickness (mm); 4 measurements of thickness were made around the girth of the egg with micrometer. The R-value* was determined by dividing the weight by the product of length x width (RATCLIFFE 1967). Statistical analysis of all data was done by Least Squares and Maximum Likelihood General Purpose Program**.

Results

I. Eggshell Measurements

In all statistical analyses performed, no differences were seen between dose levels of the compounds fed; and the 10 and 50 ppm groups are considered together. Figure 1 shows the measurements of eggshell thickness over the 30-day experimental period. There were no statistical differences in mean thickness of the eggshells of controls on the days measured; the mean value was .401 mm. As expected, the thickness of the eggshells from ducks fed DDE was significantly reduced ($p < .01$) for the entire experimental period. The eggshells from the ducks fed DDT remained as thick as controls until day 14, but were significantly thinner ($p < .01$) for the remainder of the experimental period. The ducks fed DDT-SO_4 and DDE-SO_4 produced eggs with shells identical in thickness and were grouped together. It can be seen that the groups fed sulfonates laid eggs which were the same thickness as controls except on day 18; on day 18 there was a significant difference ($p < .01$) in eggshell thickness in comparison to controls. The thickness returned to control levels at day 27 and remained as thick as the eggs of the controls for the remainder of the experiment.

Figure 2 shows the R-values* of eggshell thickness from ducks fed DDT, DDE, sulfaonated derivatives, and control diets. A significant reduction in the R-value for eggshells from ducks fed DDT and DDE is seen when compared to controls. There was no significant difference among the R-values obtained for eggshells from ducks fed DDT-SO_4 and DDE-SO_4 and the eggshells from the controls. The DDT-SO_4 and DDE-SO_4 values did not vary significantly and were considered as one group.

Another parameter which also varied significantly was eggshell weight. The weights of eggshells of ducks fed DDT and DDE followed the same pattern as the thicknesses. There were no significant

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$$*R = \frac{\text{Weight}}{\text{Length x Width}}$$

** Walter R. Harrey, Ohio State University, 1969.

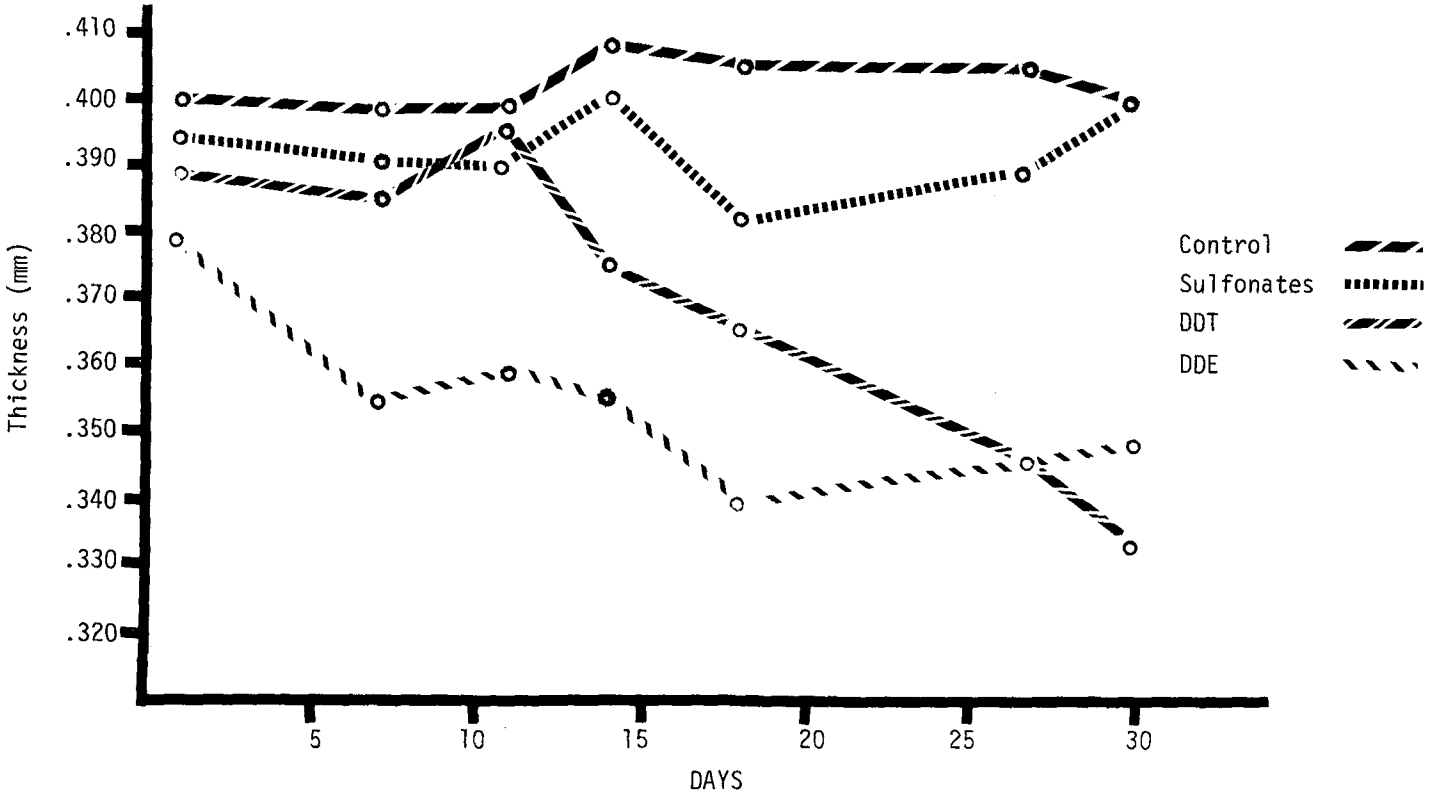

FIGURE 1. Mean eggshell thicknesses from ducks fed DDT, DDE, sulfonates, and control diets

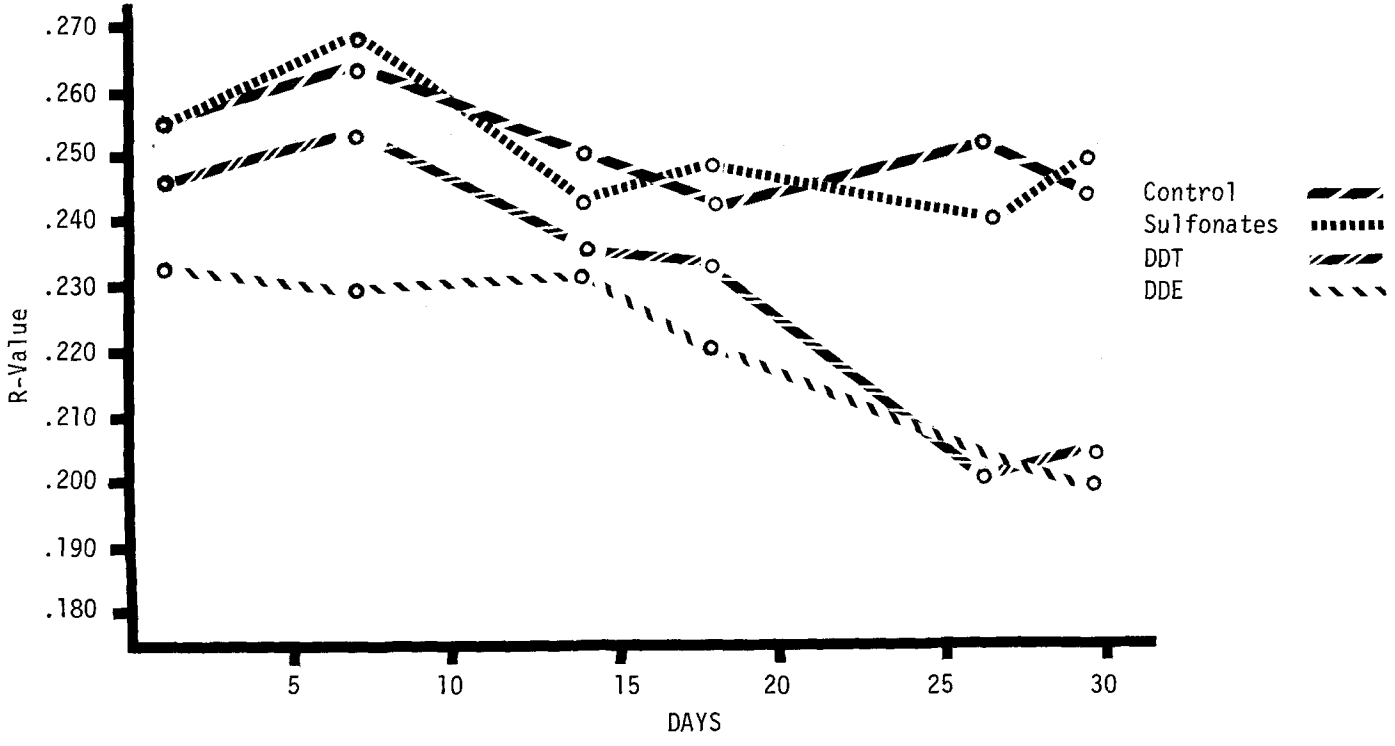

FIGURE 2. Mean R-values for eggshells from ducks fed DDT, DDE, sulfonates and control diets

differences in weight among the groups of ducks fed DDT-SO_4, DDE-SO_4 and the controls

Significant differences were also seen in the lengths and widths of eggshells from the ducks fed DDE-SO_4 and DDT. These differences were compensated for by using R-values. The purpose of the R-value is to correlate eggshell weight with size. As eggshell size may be related to other factors than the toxic effects of the compounds, this value gives an indication of weight in comparison to the overall size.

Discussion

The results of this experiment show that while DDT and DDE fed to mallard ducks at levels of 10 ppm and 50 ppm cause significant alterations in eggshell measurements such as thickness, weight, and in R-values, their sulfonated derivatives do not share these characteristics. While the sulfonated compounds cause a reduction of thickness at day 18, this decreased thickness is not as severe as that caused by DDT or DDE and is a transitory effect. The R-values show that DDT and DDE are potent agents in causing a reduction of the weight-to-size ratio of eggshells, but the sulfonated compounds cause no significant change when compared to controls. Our results show the sulfonated products of DDT and DDE to be less toxic to birds during egg production. Further studies with other animal systems are necessary to more fully characterize the toxicity of these compounds.

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