Interaction of Dieldrin and DDE Residues in Japanese Quail (*Coturnix coturnix japonica*)

by

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Interaction between environmental chemicals is well established (CONNEY and BURNS, 1972). Altered metabolism, storage, and toxicity of pesticides in animals reflect antagonistic and synergistic effects of xenobiotics (CONNEY and BURNS, 1972; CONNEY et al., 1971; MAYER et al., 1972; CHAPMAN and LEIBMAN, 1971; KINOSHITA et al., 1966). An understanding of interactions of organochlorine compounds is of particular interest since residues of some of these chemicals commonly occur in many domestic and wild animals (STICKEL, 1968; MILLER and BERG, 1969; VERMEER and REYNOLDS, 1970).

Studies of metabolism and storage of combinations of organochlorine pesticides have given various results depending upon the compounds and species tested. DDT and dieldrin fed in combination to rats, swine, and fish resulted in less dieldrin storage than when dieldrin was fed alone (STREET et al., 1966). Dieldrin storage was not affected by DDT in chickens (STREET et al., 1966) or guineapigs (WAGSTAFF and STREET, 1971). Female rats administered ^{14}C-dieldrin IP excreted more polar metabolites in feces and urine when they were simultaneously fed a diet containing 50 parts per million (ppm) DDT (STREET and CHADWICK, 1967).

There are reports of increased retention of DDT residues in the presence of cyclodienes. Oral dosage of aldrin to beagle dogs (Canis familiaris) maintained on a fixed intake of DDT caused a sudden rise in the concentrations of DDT, DDD, and DDE in blood and fat (DEICHMANN and MACDONALD, 1971). In rainbow trout, DDT accumulation in pyloric caecae increased when dieldrin was present, but dieldrin accumulation decreased in the presence of DDT (MACEK et al., 1970). Dieldrin was also found to decrease the elimination of DDT.

DDE and dieldrin commonly occur in the tissues of birds, and DDE has caused significant eggshell thinning in laboratory (MCLANE and HALL, 1972; LONGCORE et al., 1971; WIEMEYER and PORTER, 1970) and field (BLUS et al., 1971) studies. Little information exists concerning possible interactions between DDE and other commonly occurring organochlorine pesticide residues. Dieldrin and DDE residue uptake was determined in the tissues (CUMMINGS et al., 1967) and eggs (CUMMINGS et al., 1966) of hens simultaneously fed five organochlorine pesticides (lindane, heptachlor epoxide, dieldrin, endrin, and DDT), but the pesticides were not fed alone so that possible pesticide interactions could not be determined.

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This study was designed to determine whether DDE and dieldrin might interact when fed under chronic conditions to Japanese quail.

MATERIALS AND METHODS

Male Japanese quail (N = 192) were randomly placed into a control and three treatment groups. One group was fed 1 ppm dieldrin (dry weight), a second group 2 ppm DDE, and the third group 1 ppm dieldrin + 2 ppm DDE incorporated into their diets. Feed was prepared by dissolving the pesticides in corn oil equivalent to 1 percent (w/w) of the total diet and mixing into Turkey Maintenance Mash using a D-300T Hobart Mixer. Only corn oil was added to the control diet. Purity of both dieldrin and DDE exceeded 99 percent.

Nine individuals from each of the groups were randomly selected for residue analysis of livers and whole-bodies (minus digestive tract, beak, feet, wings, feathers and skin) after 3, 7, 14, 28, and 56 days on treated diet. Livers and bodies were pooled in groups of three and analyzed for DDE and dieldrin.

WARF Institute extracted and analyzed all samples for pesticide residues. Liver samples were diced and carcasses were ground in a hand meat grinder. Subsamples (20 g for carcasses, 10 g for livers) were mixed with anhydrous Na_2SO_4 and extracted with 70 ml petroleum ether + 170 ml ethyl ether on a Soxhlet extractor. Extracts were concentrated and cleaned up on Florisil columns eluting with 5% ethyl ether in petroleum ether prior to analysis by electron capture gas-liquid chromatography. Instruments and operating conditions were: Barber Colman 5000 with a 4 ft x 3 mm glass column packed with 5% DG 200 on 80/100 GCQ (column temp. 200°C, injector temp. 215°C, detector temp. 245°C, and nitrogen flow 80 ml/min); and Barber Colman 5360 with a 4 ft x 4 mm glass column packed with 5% QF-1 on 80/100 GCQ (column temp. 195°C, injector temp. 215°C, detector temp. 250°C, and nitrogen flow 80 ml/min). Recovery ranges of dieldrin and DDE were 80-102 percent and 103-110 percent, respectively. Residues were not corrected for percent recovery. Data were analyzed using Student's *t* test.

RESULTS

No dieldrin was detected in livers or whole-body remains of untreated birds analyzed at the beginning (zero days) and termination (56 days) of the experiment. Mean residues of DDE in whole-bodies were 0.01 (SD = 0.00) and 0.02 (SD = 0.00) ppm at zero and 56 days.

Dieldrin and DDE residues exhibited a similar pattern in livers when fed alone (Figure 1). Both compounds reached their highest concentration at 28 days exposure followed by a slight decrease at 56 days. Residues in livers of birds treated with compounds in combination

averaged 4.99 (± 0.42, SD) and 2.75 (± 0.77, SD) ppm for DDE and dieldrin, respectively. When birds were treated with each compound alone, DDE residues reached an average of 4.17 (± 0.97, SD) ppm and dieldrin an average of 2.77 (± 0.42, SD) ppm in livers. After three days treatment, DDE and dieldrin residues were higher in livers of birds treated with both compounds simultaneously than residues in livers of birds treated only with DDE or dieldrin. DDE was significantly higher ($p \leq .05$) when fed in combination with dieldrin than when fed alone (Figure 1).

Dieldrin residues in the whole-body samples (carcass minus liver) increased steadily throughout the treatment period (Figure 2). There was no difference at any time between dieldrin residues in birds exposed to dieldrin alone and in those exposed to dieldrin + DDE.

In birds exposed to DDE, either alone or in combination with dieldrin, the residues of DDE increased similarly for 28 days (Figure 2), but after 56 days, the DDE residue was significantly greater ($p \leq .05$) in the birds fed DDE + dieldrin than in those fed DDE alone. When birds were exposed only to DDE, the residue of DDE plateaued at about 8-9 ppm by 28 days. When the study was terminated the mean DDE residue was 47.9 percent greater in bodies of birds fed diets containing both compounds than in birds fed DDE alone (Figure 2).

DISCUSSION

Japanese quail fed diets containing DDE (2 ppm) and dieldrin (1 ppm) had maximum residues of both compounds in livers by 28 days of exposure (Figure 1). There was a subsequent slight decrease of dieldrin and DDE residues in all treated groups. Both DDE and dieldrin residues in each treatment rose to a concentration (ppm) approximately 2-fold greater than that in the diet. The mean DDE residues in the livers of quail fed both compounds were generally higher than the corresponding residues in birds fed only DDE (Figure 1).

After 3 days of dosage, residues of both DDE and dieldrin were higher in birds fed the compounds in combination than in those fed either DDE or dieldrin alone (Figure 1). The DDE residue was significantly higher ($p \leq .05$), whereas the dieldrin residue was not. The gradual increase of DDE and dieldrin residues fed singly contrasted with the high initial residue (at 3 days) followed by a decrease (at 7 days) when the chemicals were combined. This difference may indicate an absorptive or metabolic interaction during the initial stages of exposure. Meaningful interpretation of such a possibility requires more definitive data.

Residues of dieldrin in the bodies of exposed birds increased throughout the exposure and did not reach equilibrium (Figure 2). This finding differs somewhat from that of CUMMINGS et al., (1967) that dieldrin residues reached a plateau by 45 days in breast muscle and abdominal fat of chickens treated with 0.45 ppm dieldrin in their diet. The dieldrin residues of whole-body samples (Figure 2) indicate that the storage of dieldrin is not affected by the presence of DDE in Japanese quail.

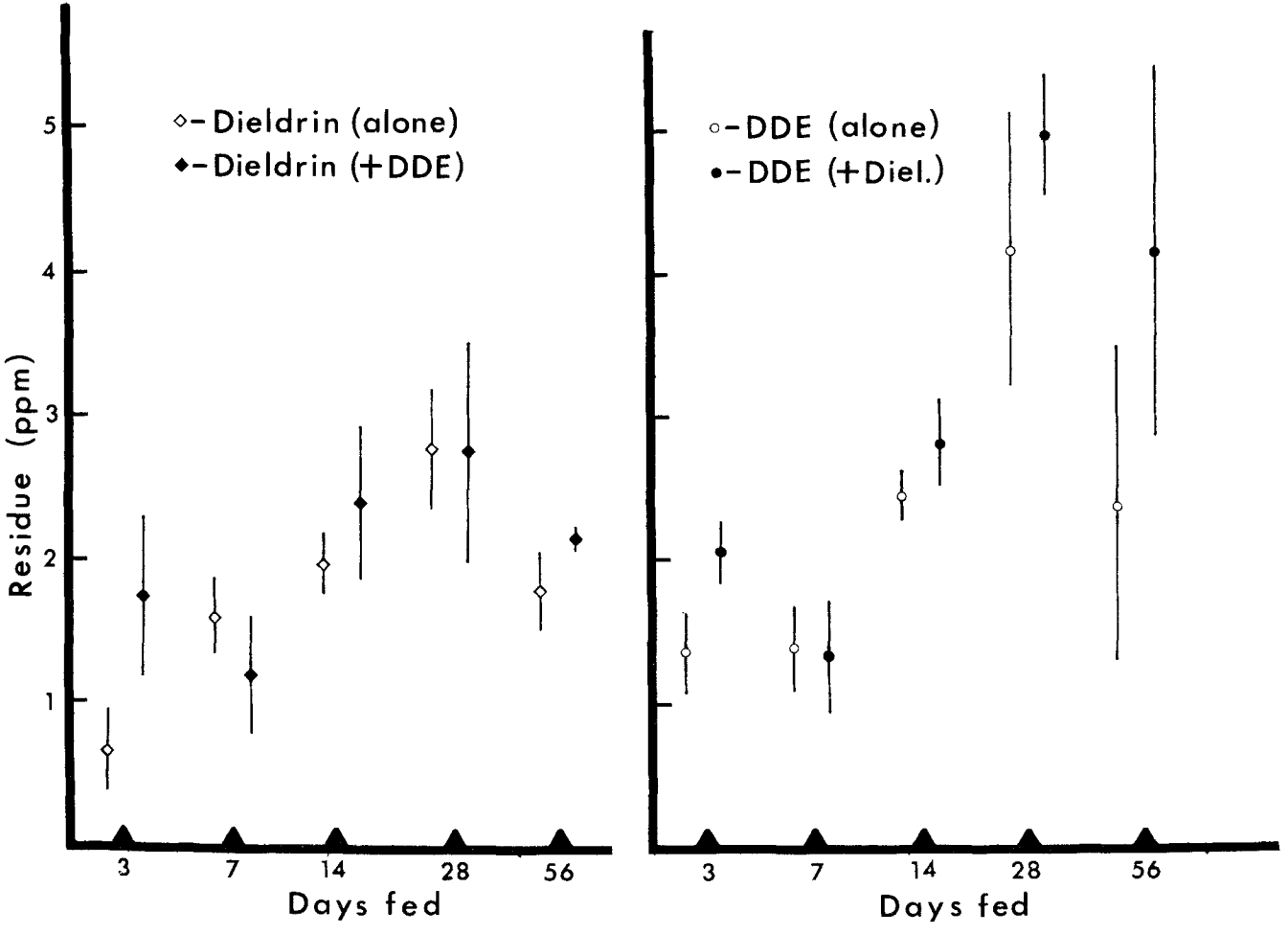

Figure 1. Pesticide residues (ppm, wet wt.) in livers of Japanese quail fed DDE (2 ppm) and dieldrin (1 ppm) separately and together. Circles and diamonds represent mean values and lines represent standard deviation.

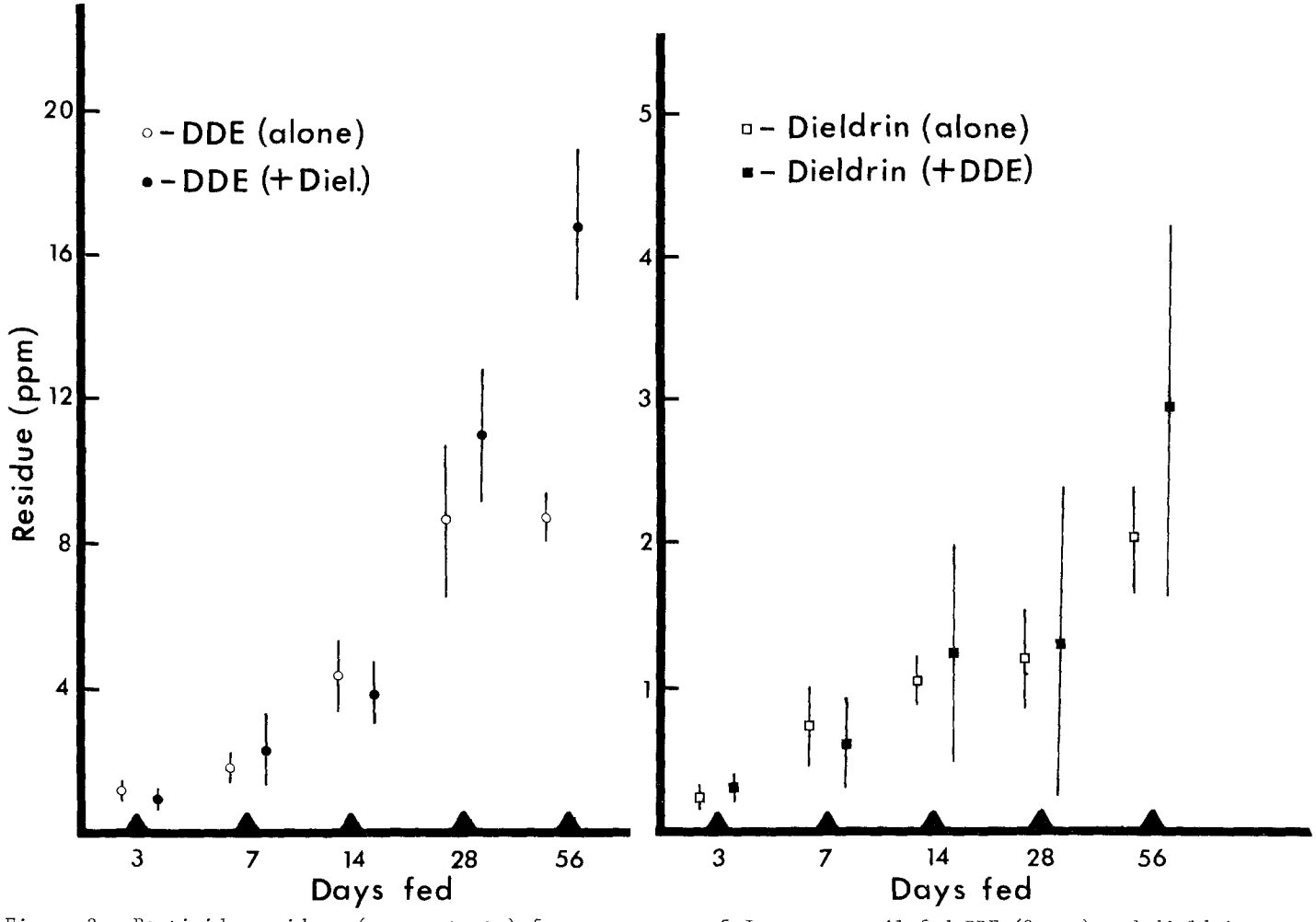

Figure 2. Pesticide residues (ppm, wet wt.) from carcasses of Japanese quail fed DDE (2 ppm) and dieldrin (1 ppm) separately and together. Circles and squares represent mean values and lines represent standard deviation.

DDE residues in the bodies of quail fed both compounds continued to increase throughout the exposure. In contrast, the residues leveled off when only DDE was fed. The continued increase of DDE residues when DDE and dieldrin were fed in combination indicates an interaction in which dieldrin promotes an increased uptake and/or retention of DDE. The mechanism and extent to which this phenomenon occurs should be further tested with different combinations and concentrations of pesticides and in other species of birds.

The possibility that DDE residues may increase in the presence of other organochlorines, such as dieldrin, is of particular biological importance. Should this residue relationship occur in wildlife under natural situations, subsequent biological effects, such as eggshell thinning, could result. The basic understanding of interactions of environmental pollutants in terms of resulting residues and biological effects is poorly understood and requires further, more intensive study.

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