Behavior of Mallard Ducklings From Parents Fed 3 ppm DDE

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DDE is a widespread environmental pollutant. Several investigators have examined the effects of DDE or the parent compound, DDT, on the behavior of birds. JAMES and DAVIS (1965) found that bobwhite quail (*Colinus virginianus*) fed a dietary concentration of 20 ppm DDT made more errors in discrimination testing in an operant conditioning chamber than did controls. JEFFERIES (1967, 1971) reported that there was a significant delay in ovulation related to the dose rate of DDT and DDE in Bengalese finches (*Lonchura striata*); the same studies also noted abnormal aggressive behavior toward mates and young chicks in birds fed diets containing 32 ppm DDT or 38 ppm DDE. Delayed egg-laying has been reported for ring doves (*Streptopelia risoria*) fed diets containing 10 ppm DDT (PEAKALL 1970) or 40 ppm DDE (HAEGELE and HUDSON 1973). KREITZER and HEINZ (1974) found no effect of a dietary concentration of 50 ppm DDE on avoidance behavior of coturnix quail (*Coturnix coturnix*) and KARLSSON et al. (1974) reported that a diet containing 10.5 µg DDT each day had no effect on locomotory activity of redstarts (*Phoenicurus phoenicurus*).

In the present study, mallard ducks (*Anas platyrhynchos*) were fed a control diet or a diet containing 3 ppm DDE; the purpose of the study was to determine any effects of the parentally administered DDE on approach and avoidance behavior of offspring.

Methods

One male and 4 female 10-month-old mallard ducks were randomized to each of four 1.53-m x 3.05-m pens. The birds were from the Patuxent Wildlife Research Center's captive flock, which was several generations removed from the wild. Water and commercial duck breeder mash were provided ad libitum. Treatment diets were randomly assigned to pens in January. The ducks in 2 pens were fed a diet that contained 3 ppm p,p'-DDE. The DDE was dissolved in propylene glycol and then mixed into the feed in the ratio of 1 part propylene glycol-DDE mixture to 99 parts feed. Control feed, containing 1% pure propylene glycol, was fed to the ducks in the other 2 pens. A concentration of 3 ppm DDE in dry duck mash is equivalent to about 0.6 ppm DDE in a natural succulent duck diet according to a conversion factor calculated by HEINZ (1975).

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Starting in April, eggs were collected each day for 78 days and were stored at 13° C. Eggs were periodically set in an incubator kept at 37.5° C and about 80% relative humidity. Four randomly selected eggs from each pen of ducks being fed DDE were frozen and later analyzed for DDE by WARF Institute, Inc. A pool of 4 randomly selected control eggs from each control pen was also analyzed for DDE. A 20-gram portion of homogenized egg or pool of eggs was mixed with sodium sulphate and air dried for 72 hours, extracted for 8 hours in a Soxhlet apparatus with ethyl ether and petroleum ether (70:170), and eluted through a florisil column twice with ethyl ether and petroleum ether (5:95 and 15:85). Analysis was by gas chromatography, using a Barber Coleman Pesticide Analyzer Model 5000. A 6-foot x 3-mm glass column was packed with 5% DC-200 on 80/100 mesh Gas Chrom Q; temperatures were: column = 200° C, injector = 220° C, detector = 235° C. The carrier gas was nitrogen at a flow rate of 80 ml/minute.

Details of the test apparatuses and testing procedures used for measuring approach and avoidance behavior and the methods of data analysis are similar to those described by HEINZ (1975). Abbreviated descriptions follow. Approach behavior was tested when ducklings were a minimum of 8 hours old after hatching and were between the developmental ages (age measured from the onset of incubation) of 26 days, 0 hours and 26 days, 11 hours. The apparatus used to test approach behavior consisted of 10 identical runways, each with a holding area and a treadle at the opposite end of the runway. One duckling was placed in the holding area of each runway, and after 1 minute, the holding area of each runway was opened, a loudspeaker over each treadle began emitting a tape-recorded maternal mallard call, and the ducklings were free to move about in the runways in response to the call for 10 minutes. An event recorder recorded the latency of approach (the amount of time it took a bird to walk onto the treadle), the number of reversals (the number of times each duckling walked onto and off the treadle), the percentage of time each bird spent on the treadle after its initial approach, and the number of times each bird jumped upward from the treadle toward the loudspeaker.

Chi-square tests were used to compare controls with ducklings from parents fed DDE in the proportions of each group that approached or failed to approach the maternal call and in the proportions that spent or did not spend 100% of their time on the treadle after approaching the call. Ducklings in each group that did approach the call were compared with t-tests on $\log_{10}$ transformations of the latency of approach and $\log_{10}$ $(x + 1)$ transformations of the number of jumps toward the loudspeaker. Controls and ducklings in the DDE treatment that spent less than 100% of their time on the treadle were compared with t-tests on $\log_{10}$ transformations of the number of reversals and angular transformations of the percentage time spent on the treadle after initial approach.

After approach-behavior testing, ducklings were placed, 16 to a pen, in heated brooders. Avoidance behavior was tested when the birds were between the developmental ages of 27 days, 1 hour and 27 days, 7 hours. The apparatus used to measure avoidance behavior consisted of 16 identical runways. Each runway had a holding area, beyond which was 2 m of open runway. A revolving black and white axle with plastic blades that raked against the wire front of the holding area was used to frighten the ducklings. One minute after a duckling had been placed in each of the 16 holding areas, the holding areas were opened and the axle began revolving. Two seconds after the test started, a picture was taken from above the apparatus, recording the distance each duckling had traveled from the frightening stimulus.

The avoidance response of each duckling was categorized as not avoiding the stimulus, running up to 10 cm, or running more than 10 cm. A chi-square test was computed to compare the proportions of controls and ducklings from parents fed DDE that fell into each of the 3 avoidance response categories. For all ducklings that ran more than 10 cm, controls were compared with ducklings from parents fed DDE by computing a t-test on $\log_{10}$ transformations of the distance traveled from the frightening stimulus.

Results

The 2 pools of control eggs contained 0.021 and 0.028 ppm DDE. The 8 eggs from hens fed 3 ppm DDE contained 5.8 $\pm$ 0.32 ppm DDE (mean $\pm$ S. E.) on a wet-weight basis; the range was 4.28-7.23 ppm.

In tests of approach behavior, a greater proportion of control ducklings failed to approach the tape-recorded maternal call within 10 minutes compared to ducklings from parents fed DDE, and a smaller proportion of controls spent 100% of their time on the treadle after their initial approach to the maternal call (Table 1).

TABLE 1

Approach responses by control ducklings and ducklings from parents fed 3 ppm DDE

Group	Percentage that approached maternal call	Percentage that spent 100% of their time near call after initial approach
Control	95.3 (148)†	6.4 (141)
3 ppm DDE	100* (156)	15.4* (156)

† Number of ducklings in sample.

* Significantly different ($P < 0.05$) from controls in chi-square tests based on the numbers of birds in each group approaching vs. not approaching call or the numbers spending 100% vs. less than 100% of their time on the treadle near the call.

Statistical analyses based on data for those ducklings that approached the call showed no significant differences between the treatments in latency of approach or number of jumps toward the loudspeaker per 100 seconds time spent on the treadle (Table 2). Based on data for ducklings that spent less than 100% of their time on the treadle, there were no significant differences between controls and ducklings from parents fed DDE in the number of reversals made or in the percentage time spent on the treadle after initial approach (Table 2).

TABLE 2

Approach responses of ducklings that approached a tape-recorded maternal call within 10 minutes (mean* with 95% confidence limits in parentheses and sample size in brackets)

Group	Latency of approach (seconds)	Number of reversals	Percentage time spent on treadle after initial approach	Number of jumps per 100 seconds on treadle
Control	28 (24-32) [141]	16 (14-18) [132]	66 (61-71) [132]	8 (7-10) [141]
3 ppm DDE	24 (20-27) [156]	17 (15-20) [132]	66 (61-71) [132]	9 (7-10) [156]

* The means for latency of approach, number of reversals, and number of jumps per 100 seconds on treadle are geometric means; the mean for percentage time spent on treadle after initial approach has been retransformed from the angular transformation mean.

In avoidance behavior tests, there was no significant difference between treatments in the proportions of birds that traveled 0, 1-10, or greater than 10 cm from the frightening stimulus (Table 3).

TABLE 3

Avoidance responses of control ducklings and ducklings from parents fed 3 ppm DDE

Group	N	Percentage of ducklings that traveled: 0 cm	1-10 cm	>10 cm
Control	168	36.3	21.4	42.3
3 ppm DDE	175	35.4	28.0	36.6

However, among those ducklings that traveled farther than 10 cm, control ducklings traveled farther from the frightening stimulus than did ducklings whose parents were fed a diet containing 3 ppm DDE (Table 4).

TABLE 4

Avoidance responses of ducklings that traveled more than 10 cm from the frightening stimulus (geometric mean with 95% confidence limits in parentheses)

Group	N	Distance traveled (cm)
Control	71	30 (26-34)
3 ppm DDE	64	24* (21-27)

* Significantly different from controls, $P < 0.05$.

Discussion

Some of the DDE that mallard hens received in their diet passed to their young via the egg and resulted in abnormal behavior. Ducklings whose parents were fed DDE were hyper-responsive to tape-recorded maternal calls as evidenced by the greater proportions that approached the maternal call and remained on the treadle under the loudspeaker emitting the call. Ducklings from parents fed DDE were less responsive than were controls to the frightening stimulus used in avoidance behavior tests; this can be seen in the lesser distances the ducklings in the DDE group traveled from the stimulus.

In the wild, the eggs of many species of birds have been found to contain levels of DDE that sometimes have exceeded the average of 5.8 ppm in the mallard eggs of the present study. These species include the black duck (*A. rubripes*) (LONGCORE and MULHERN 1973), double-crested cormorant (*Phalacrocorax auritus*) (ZITKO and CHOI 1972), brown pelican (*Pelecanus occidentalis*) (BLUS et al. 1974), and bald eagle (*Haliaeetus leucocephalus*) (WIEMEYER et al. 1972). KEITH and GRUCHY (1972) reviewed reports of DDE in the eggs of fish-eating birds and seabirds; many of these species sometimes had levels of DDE exceeding 5.8 ppm.

The amount of DDE in eggs that would be necessary to cause behavioral aberrations in young probably would vary from species to species; many species might not be as sensitive behaviorally to DDE as are mallards. However, given the high levels of DDE reported in the eggs of many species in the wild, it is possible that DDE could alter the behavior of the young of some species toward parental calls or danger, or might affect other behaviors.

Summary

Mallard ducks fed a diet containing 3 ppm DDE (equal to about 0.6 ppm in a natural succulent diet) laid eggs that contained an average of 5.8 ppm DDE; ducklings that hatched from these eggs differed from controls in behavioral tests designed to measure responses to a maternal call and to a frightening stimulus. In response to the maternal call, ducklings from parents fed DDE were hyper-responsive; compared to controls, a greater percentage approached the call and a greater percentage of those that approached remained near the call for the remainder of the test. In a test of avoidance behavior, ducklings whose parents were fed DDE traveled shorter distances from the frightening stimulus than did controls.

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