EFFECTS OF DIETARY p,p′-DDT AND p,p′-DDE ON EGG PRODUCTION AND EGG SHELL CHARACTERISTICS OF JAPANESE QUAIL RECEIVING AN ADEQUATE CALCIUM DIET

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We reported earlier that Japanese quail fed a low (0.56%) calcium diet containing 100 p.p.m. p,p′-DDT laid eggs with thinner shells and less calcium in the shell (Bitman *et al.*, 1969). Since the effect of the DDT might be augmented by the calcium stress during egg laying, the present study follows the effects of DDT and DDE on egg production and egg shell quality in Japanese quail fed an adequate calcium diet.

PROCEDURE

Forty-two virgin Japanese quail, 39 days old were distributed randomly into three groups of fourteen and placed in individual cages on a regime of 14 hours light and 10 hours dark. Feed and water were provided *ad libitum*. The control group received a diet containing 2.7% calcium. Nelson *et al.* (1964) reported 2.5 to 3% calcium to be adequate for breeding Coturnix quail. The groups on p,p′-DDT or p,p′-DDE received the same diet modified by the addition of 100 p.p.m. of the pesticide. Eggs were collected daily during the 74 day experimental period and the presence of broken eggs and the premature extrusion of eggs (yolks) were recorded. Egg shell thickness was measured at three places at the waist of each egg using a micrometer, after removal of the egg membranes. The beta back-scatter method of James and Retzer (1967), for measuring egg shell strength, was also used. Calcium was determined by atomic absorption analysis of solutions obtained by wet-ashing egg shells in concentrated hydrochloric acid.

Statistical comparisons were made using Student's "t" test, with correction for unequal group size.

RESULTS AND DISCUSSION

Birds fed the diets containing 100 p.p.m. p,p′-DDT or p,p′-DDE had a lag in egg production for 3 weeks, suggesting a lag in ovulation in these groups (Fig. 1A and Table 1). After three weeks the treated groups had the same egg production as the controls. There was no effect of either of the pesticides on egg weight (Fig. 1B). The birds on p,p′-DDT and p,p′-DDE diets also produced more broken eggs, 4% as against 2% for the controls (Tables 1 and 2). In the pesticide groups certain quail were responsible for most of the broken eggs. Four of the p,p′-DDE treated birds laid 47 broken eggs or 78% of the total number of broken eggs; 3 quail in the p,p′-DDT treatment laid 37 broken eggs or 80% of all the broken eggs within that group.

The eggs from the DDT birds had less shell calcium than control eggs ($P < 0.05$; Table 3). The eggs from DDE fed birds had a lower calcium which was not statistically significant. Egg shell thickness and beta backscatter were unaffected by the pesticide treatments (Table 3), with no correlation of thinner egg shells with clutch position.

Premature extrusion of the egg was a possible explanation for the higher incidence of broken eggs during pesticide treatment. Therefore, the time of oviposition

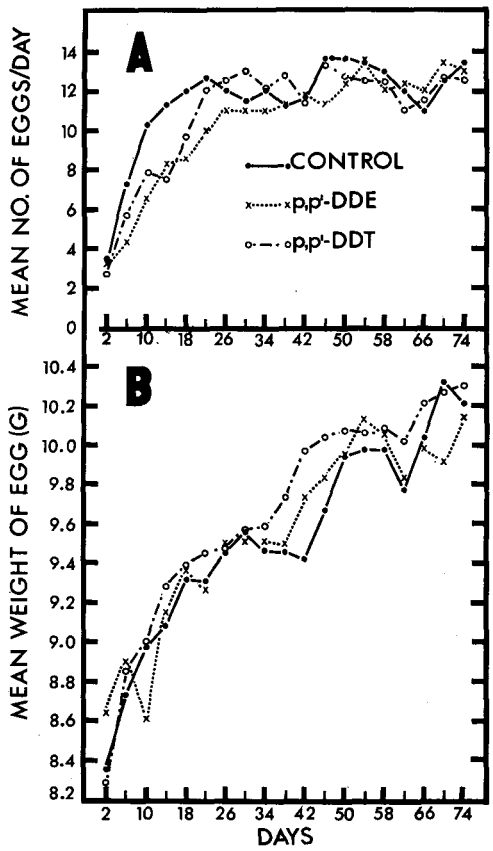

FIG. 1. A. Effect of 100 p.p.m. p,p'-DDT or p,p'-DDE on egg production. Values are the number of eggs per day averaged for 4 days. (●) control; (o) p,p'-DDT; (x) p,p'-DDE. B. Effect of 100 p.p.m. p,p'-DDT or p,p'-DDE on egg weight. Values are egg weights averaged for 4 days. Symbols are as in A.

was recorded and the length of time from ovulation to oviposition was calculated. All birds were very regular in the length of time between successive ovipositions and

TABLE 1.—*Egg production and % broken eggs of Japanese quail fed 100 p.p.m. p,p'-DDT or p,p'-DDE*

Treatment	% Egg Production			
	1st month	2nd month	3rd month	4th month
Control	76	91	91	86
100 p.p.m. p,p'-DDT	65	86	91	86
100 p.p.m. p,p'-DDE	58[a]	85	91	85
	% Broken Eggs			
Control	2.8	1.1	1.8	1.6
100 p.p.m. p,p'-DDT	2.5	3.1	4.5	4.9
100 p.p.m. p,p'-DDE	4.7	3.5	4.1	6.6

[a] $P < 0.001$.

the pesticides did not affect oviposition. Since the lengths of time that the egg shell was being formed was unaffected by the pesticides, a decrease in the carbonic anhydrase activity of the shell gland is the probable mechanism causing defective egg shell formation (Bitman *et al.*, 1970).

The effects of DDT on egg shell formation are not as dramatic in Japanese quail fed an adequate calcium diet as in quail fed a low calcium diet. However, the trends are the same. DDT elicited a comparable lag in egg production in Japanese quail fed either a low calcium diet (Bitman *et al.*, 1969) or an adequate calcium diet. Jefferies (1967) has reported a delay in ovulation produced by p,p'-DDT in the Bengalese finch. After treatment for 24 days, egg production was the same as controls for all pesticide groups irrespective of the calcium level in the diet. Smith *et al.* (1969) has also reported no effect of comparable levels of DDT on egg production or fertility and hatchability in Japanese quail. Dietary levels of calcium do affect the susceptibility of Japanese quail to lay more yolks and broken eggs in

TABLE 2.—*Number of yolks, membranes and broken eggs laid by Japanese quail fed 100 p.p.m. p,p'-DDT or p,p'-DDE*

Treatment	Total Number Eggs	Number Yolks	Number Membranes	Total Broken	% Broken	Quail Classified as	
						Resistant	Susceptible
Control	1273	2	19	22	1.7	13	0
100 p.p.m. p,p'-DDT	1230	0	42	46	3.7	10	3
100 p.p.m. p,p'-DDE	1392	16	37	60	4.3	10	4

TABLE 3.—*Egg shell calcium, thickness and beta backscatter of Japanese quail fed 100 p.p.m. p,p'-DDT or p,p'-DDE*

Treatment	Shell calcium (%±SE)	Egg shell thickness (inches×10^{-4})±SE	Beta backscatter (CPM×10^{3})±SE
Control	2.46±0.03	8.0±0.1	219±0.8
100 p.p.m. p,p'-DDT	2.34±0.04[a]	8.0±0.1	217±0.7
100 p.p.m. p,p'-DDE	2.37±0.05	7.8±0.2	217±1.1

[a] Treated *vs.* control, $p<0.05$.

response to DDT. When birds were fed low levels of calcium with DDT added, more than 50% of the birds laid broken eggs (Bitman *et al.*, 1969), whereas only 3 out of 14 did on an adequate calcium diet. The increase in numbers of yolks laid when DDT was added to a low calcium diet was much greater than when DDT was added to an adequate calcium diet. DDE also induced a lag in egg production in Japanese quail and these quail laid more broken eggs than the controls.

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FAMILY VARIATION OF FOUR YEAR OLD WHITE PLYMOUTH ROCK MALES TO HEAT STRESS

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Wilson *et al.* (1966) listed a literature review showing the differences between breeds in their ability to withstand heat stress. Their research also indicated a significant difference in survival time between families of 4 week old Leghorn chicks subjected to 40.83°C. 75% RH. The literature review of Boone (1968) showed breed and inbred line differences in semen quality. His research also showed highly significant family differences in semen quality in one year old males. However, family differences in semen quality of old chicken males undergoing heat stress has not been shown.

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MATERIALS AND METHODS

Twenty-one, 4 year old Clemson Strain W.P.R. males were used in this trial. These males were from a closed flock of 12 years