Ohio Cooperative Wildlife Research Unit

The Ohio Division of Wildlife
The Ohio State University
U. S Bureau of Sport Fisheries and Wildlife
Wildlife Management Institute
Cooperating

EFFECTS OF PCBs ON RING DOVE

(STREPTOPELIA RISORIA)

COURTSHIP BEHAVIOR

A Thesis

Presented in Partial Fullfillment of the Requirements

for the Degree Master of Science

by

Reynaud Michael Farve, B.Sc.

The Ohio State University
1978

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INTRODUCTION

Polychlorinated biphenyls (PCBs) are chemically stable chlorinated hydrocarbons. They are chemically inert, are not hydrolized by water, and are resistant to alkalies, acids, and other corrosive chemicals. Little is known about their biological decomposition, but they are believed to be more stable than DDT and its metabolites. These characteristics, combined with their fat soluble properties, give PCBs the necessary physical and chemical characteristics for biological magnification (Peakall 1975).

As evidence concerning the detrimental effects of PCBs on the environment mounted, Montsanto Chemical Company (the sole U.S. producer) voluntarily restricted their sales in 1970. PCBs had been used for plasticizers, surface coatings, and adhesives. Currently, they are sold to electrical industries for use in closed systems such as a dielectric fluid in transformers and capacitators (Peakall 1975). The U.S. Environmental Protection Agency on January 19, 1977 issued its final regulations which prohibit discharge of PCBs into waterways. Also, the Toxic Substances Control Act has prohibited the manufacture of PCBs after January 1, 1979, and distribution after June 1, 1979. Meanwhile, the effects of this long-lived chemical on the enviromnent are expected to be felt for years to come.

PCBs have been documented as influencing several aspects of behavior in birds. The behavior of Pheasant (Phasianus colchicus) chicks, from hens given 50 mg PCB weekly, on a visual cliff was significantly different from that of chicks in other dosage groups (Dahlgren and Linder 1971). Kreitzer and Heinz (1974) found that the avoidance of Coturnix Quail (Colinus coturnix) chicks to a moving

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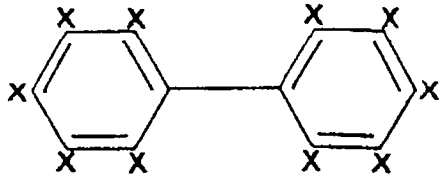
silhouette was depressed by treatment with PCBs. Robins (Erithacus rubecula) treated with PCBs were observed to have a higher average activity than controls (Ulfstrand et al 1971). Peakall and Peakall (1973) found an increased mortality of young Ring Doves (Streptopelia risoria) due to a decreased nest attentiveness and increased activity by adults treated with PCBs.

PCBs containing certain percentages of chlorine are reported to have estrogenic effects in rats (Rattus rattus) (Bitman and Cecil 1970) and anti-androgenic effects in cockerels (Gallus gallus) (Platonow and Funnel 1971). PCBs also have been shown to be powerful inducers of hepatic enzymes which degrade estradiol in Kestrels (Falco sparverius) (Lincer and Peakall 1970) and in pigeons (Columba livia) (Risebrough et al. 1968). Hepatic enzyme induction is believed to be the result of the structural similarities of PCBs and estrogens (synthetic and natural) (Fig. 1). If PCBs do in fact induce degradation of estrogen, one might expect behavior patterns that are influenced by estrogen also to be affected by PCBs.

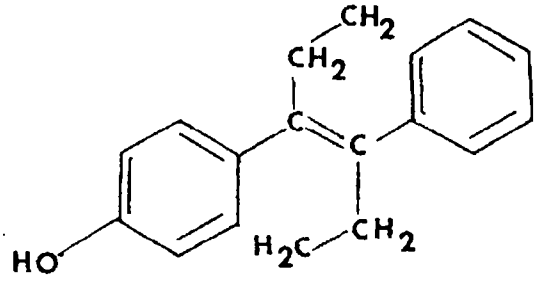
The purpose of this study was: (1) to determine if sublethal doses of PCBs could affect the hormonal balance of birds such that fixed action patterns might be altered (in form or frequency), especially estrogen influenced behaivors, and (2) to note if this alteration significantly affected egg laying or latency to egg laying. Since birds in the wild are often subjected to environmental stress, doves also were tested under food stress conditions. Keith (1978) noted that DDE and a food stress acted synergistically to affect the behavior and reproductive success in Ring Doves.

The Ring Dove was chosen for this experiment for several reasons.

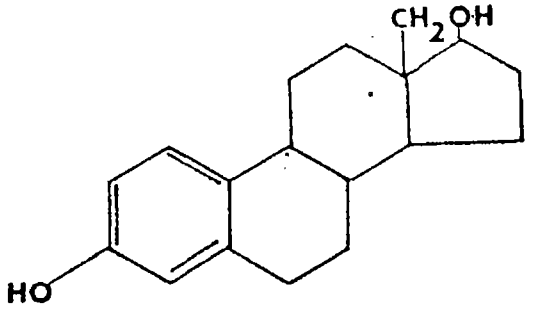
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PCB



DIETHYLSTIBESTROL



ESTRADIOL - 17β

Fig. 1. Chemical structure of polychlorinated biphenyls (PCBs), a synthetic estrogen (diethylstibestrol), and a natural estrogen (estradiol-17 B). "X" indicates possible sites of chlorine attachment.

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These birds are excellent laboratory animals, because they can be housed in a small area and can be observed easily without interfering with their normal breeding behavior. Also, the normal reproductive behavior cycle has been well documented (Craig 1909, Lehrman 1964, White 1975). The most important reason, however, was that behavior and hormone relationships have been studied intensively in this species. Estrogen is known to influence nest soliciting (nest cooing and wing flipping), gathering nest material, and nest building (Cheng 1973a, b, Hutchison 1970, Lehrman 1958, Vowles and Harwood 1966). Testosterone is known to influence male behavior patterns (chasing and bow cooing) (Erickson et al. 1967, Erickson and Lehrman 1964). Incubation is influenced by progesterone, but testosterone, estrogen and prolactin also play roles in the initiation and maintenance of this behavior pattern (Lehrman 1958, Lehrman and Brody 1961, Stern 1974, Stern and Lehrman 1969).

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METHODS AND MATERIALS

Subjects, Housing, and Maintenance

The subjects were 27 sexually mature Ring Doves. Each had at least one successful breeding experience consisting of nest building, egg laying, and raising squabs to 21 days of age. Birds were sexed by observing their behavior, and males were color banded when they performed bow cooing.

The doves were held in three different kinds of cages during the experiment. Breeding cages, constructed of 1.3 cm wire mesh, were 91 X 61 X 61 cm and contained 2 perches. Long leaf pine (Pinus palustris) needles were provided for nest building. Experimental cages were of the same kind, except perches were not provided. Each cage was lined with an 8-cm-high strip of pegboard, and hard cardboard cylinders (4.4 cm high, 8 cm in diameter) were provided to hold the pine needle nesting material which was color coded for each day. Isolation cages were 46.5 X 28 X 20 cm aluminum compartments. Experimental and isolation cages allowed for visual (but not auditory) isolation of pairs and individuals, respectively.

The birds were housed in a laboratory where the lighting and temperature could be controlled. The doves were kept on a 14 h light and 10 h dark (on at 0600 h and off at 2000 h) photoperiod with fluorescent lighting throughout the study. The temperature in the laboratory was maintained at 65°-75°F (18.3°-23.9°C) except when the energy crisis in the winter of 1977 caused temperatures to fall to 55°F (12.8°C) (from 9 to 22 January).

The birds were fed Purina pigeon chow. The pretreatment diet consisted of 2 parts corn oil mixed with 98 parts feed and was provided

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ad libitum. The treatment diet consisted of a mixture of 98 parts feed and 2 parts corn oil plus 25 ppm Aroclor 1254 (25 mg Aroclor/ 1 kg feed mixture) and was provided ad libitum. After 18 weeks on the ad libitum PCB diet, 6 pairs of treatment doves plus 4 pairs of untreated birds were subjected to a food stress consisting of a 10 percent food reduction.

Male and female doves randomly selected from the pretreatment, experimental, and treatment, food-stressed groups were sacrificed and analyzed for PCB residues. The amount of residue in fat tissue was determined by the Consumer Laboratory of the Ohio Department of Agriculture according to procedures described by Webb and McCall (1973).

Experimental Design

Courtship observations were made at three periods during the feeding experiment. Eight pairs were observed during the pretreatment period and again after 15 weeks of PCB treatment. This time period was used because female doves accumulated maximum amounts of PCBs in their eggs after a 15-week diet of 10 ppm Aroclor 1254 (Lincer and Peakall 1973). Observations of the food-stressed doves started 2 weeks after the start of food reduction. Each bird was visually isolated 3 weeks before observation. They were paired with unfamiliar doves, to eliminate variation in courtship pattern frequency due to recognition of previous mates (Erickson and Morris 1972), the night (usually 2000 h) before the observation started. Behavior patterns were recorded from 0800 to 1000 h daily for a period of 2 weeks. Each cage was observed during alternate 10-min periods until all 4 pairs had been observed for a total of 30 min each. I made no attempt to conceal myself from the birds, as my presence seemed not to affect

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their performance. After the 2-week observation period the birds were visually isolated.

Since only 4 pairs of birds could be observed satisfactorily per observation period, the treatment groups were divided into 2 sub-groups of four pairs each. A separate cage containing untreated doves was also set up with each sub-group to act as controls during the experiment. In the food-stress experiments, two sub-groups of 5 pairs (3 treated and 2 controls) of birds were observed.

Either the number of performances or the amount of time spent in a particular pattern was recorded on a data sheet. The numbers of charges, bow coos, perch coos, heteropreening, nest coos, billings, sex crouches, copulations, and times flying in the cage were counted. The behavior patterns of sitting quietly, self preening, wing flipping, pacing, feeding, and drinking were timed. A description of these behavior patterns appears in Miller and Miller (1958).

The following nest oriented activities were also quantified:

1) nest building - the amount of time a bird spent adjusting and/or weaving needles in the construction of a nest.

2) handle material - the number of times a bird picked a needle entirely off the cage floor or removed one from the needle container and subsequently dropped it.

3) material to nest - the number of pine needles brought to the nest site and used in nest construction during the observation period each day. Material handled in

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this way was not recorded under "handle material."

4) sit in nest - the amount of time a bird spent sitting quietly in the nest (completely constructed or not) when eggs were not present.

5) incubating - the time a bird spent sitting on eggs.

6) material removed - the number of pine needles removed from the container per day.

7) material found in the nest - at the end of the 2 weeks of observation, the nest was removed, and the number and color of needles were recorded. This procedure gave daily information on the number of needles used in the final construction of the nest.

Billing, sex crouching, copulation, feeding and drinking, and perch cooing were not analyzed, since they occurred too infrequently during the observation periods.

Data Analysis

Behavior pattern frequency data were tested by two-way analysis of variance. Frequency data were compared at two index points, days after pairing (pairing-days) and days relative to the first egg (egg-days), in the observation period. In the pairing-days arrangement, all observations were analyzed except those on nest centered patterns (nest building, material to nest, material found in nest, and incubation),

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which were ignored for non-laying pairs. Pairing-days arrangement was used to compare the total number of courtship performances in relation to pairing between groups. Only those pairs that laid eggs were included in egg-days analysis. This arrangement compares the behavior pattern frequency for both groups at the egg laying index point. Thus only a few days before and after egg laying, not the entire observation period, were used in the egg-day comparison.

To determine how PCBs were affecting the timing of estrogen influenced patterns, I plotted the mean values of these patterns for pretreatment and treatment birds against egg-days. The observed values were fitted to a polynomial curve of the seventh degree ($Y=A_0 +A_1x+ A_2x^2 +A_3x^3 + \ldots .A_7x^7$). The seventh degree equation was used to allow for the maximum degrees of freedom for statistical comparisons to be made and to allow for the maximum number of patterns to fit the model. The fitted regression curves for the two groups could be tested to reveal whether the curves in fact represented the same underlying regression curve. If both estimated curves for the two treatment groups fit the original means, they were tested by the comparison of two regression lines test (Neter and Wasserman 1974:160). If one curve fit adequately but not the other, Scheffe's procedure of simultaneous prediction intervals was used to compare the curve that fit against the values of the other treatment group (Neter and Wasserman 1974:154). If both curves gave poor fits, they could not be statistically compared.

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RESULTS

PCB Treatment

Doves randomly sampled from the PCB treatment groups accumulated higher levels of PCBs in their fat tissue than those sampled from the pretreatment group (Table 1). Therefore, all doves in the treatment group were considered to have accumulated high amounts of PCBs.

Egg laying was affected by PCB treatment and food stress. PCB treatment tended to delay the onset of egg laying (Table 2). The food stress delayed the onset of egg laying (Table 3, $P=0.06$, Fisher's exact probability); however, the combined effect of food stress and PCB treatment did not increase the delay in egg laying (Tables 2 and 4, $P > 0.1$, Fisher's exact probability).

There appeared to be no difference in the form in which behavior patterns were performed. Thus only the performance frequency was analyzed in detail.

Estrogen-influenced behavior patterns. - The total performance (pairing-days) of estrogen influenced behavior patterns was not reduced in either males or females, but there was a greater length of time between peak male nest soliciting (nest cooing and wing flipping) and egg laying in treatment birds (Figs. 2 and 3, $P < 0.001$). The treatment males did not persist with these courtship patterns and thus the shape of the pretreatment and treatment curves are similar. The timing differences in performance are the result of the late egg laying by treatment females. Treatment males paired with females that failed to lay eggs continued courting the female throughout the observation period. No difference in the intervals from peak material gathering to egg laying was detected between the two treatment groups (Fig. 4,

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Table 1

The Amount of PCBs in Ring Dove Fat Samples

Bird #	Sex	Treatment group	PCB (ppm)
24	female	pretreatment	1.5
25	male	pretreatment	4.4
16	female	treatment	662.0
15	male	treatment	470.0
17	female	treatment,food-stressed	634.0
32	male	treatment,food-stressed	549.0
35	female	treatment,food-stressed	1068.0
34	male	treatment,food-stressed	1304.0

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Table 2

Mean Number of Days after Pairing Until the Onset of Egg Laying

Treatment group	Number of females (layers/non-layers)	Egg laying onset day ($\bar{X} \pm 2$ S.E.)
pretreatment	8/0	7.3± 0.6
control during exp.	4/0	6.3± 0.5
treatment	7/1	8.6± 1.4
control, food-stressed	2/2	10.0± 2.0
treatment, food-stressed	3/3	10.0± 2.9

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Table 3

The Effect of Food Stress (10 percent reduction in food intake) on the Onset of Egg Laying (Fisher's exact probability, P = 0.06)

	Pretreatment females (N=8)	Control, food stressed pairs (N=4)	Total
Early egg (day 6-8 after pairing)	7	0	7
Late egg (day 9+)	1	2	3
Total	8	2	10

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Table 4

The Effect of Feeding 25 ppm Aroclor 1254 to Birds Placed Under a Food Stress (10 percent reduction in food intake) on the Onset of Egg Laying (Fisher's exact probability, $P > 0.1$)

	Control, food-stressed pairs (N=4)	Treated, food-stressed pairs (N=6)	Total
Early egg (day 6-8 after pairing)	0	1	1
Late egg (day 9+)	2	2	4
Total	2	3	5

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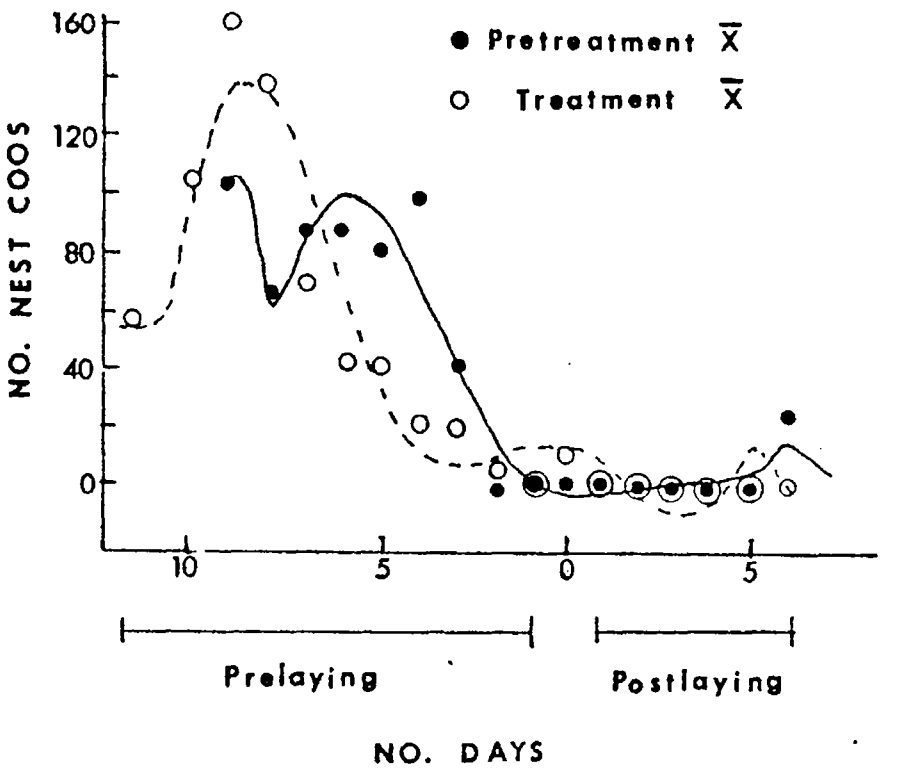


Fig. 2. The mean number of nest coos per 30-min observation period by pretreatment (—) and treatment (--) males relative to the day the first egg was observed.

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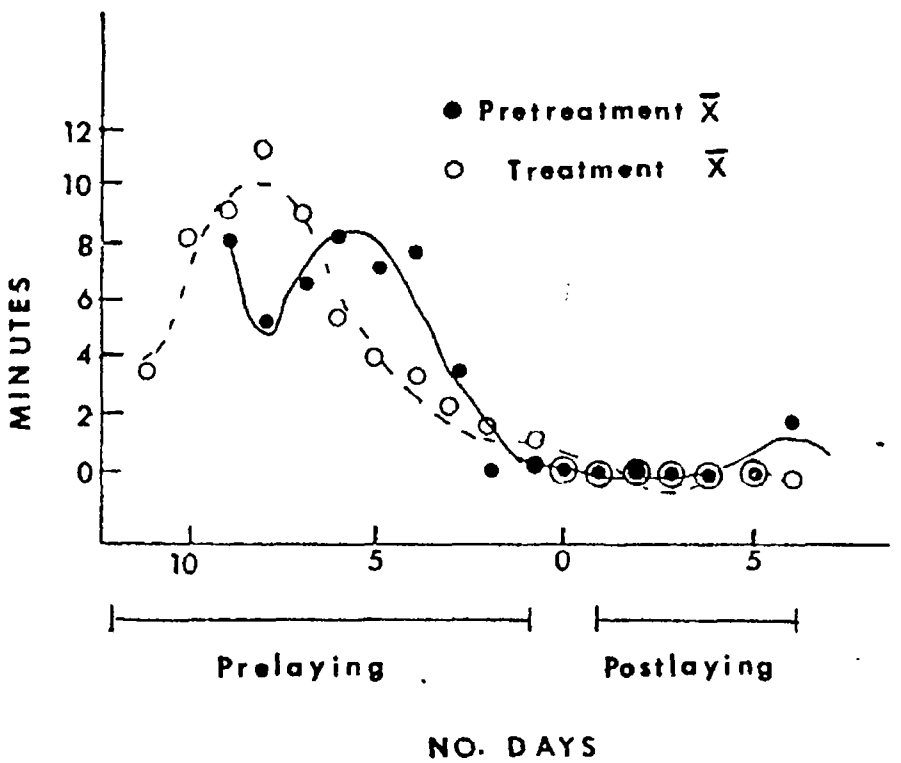


Fig. 3. The mean time in min spent wing flipping per 30-min observation period by pretreatment (—) and treatment (--) males relative to the day the first egg was observed.

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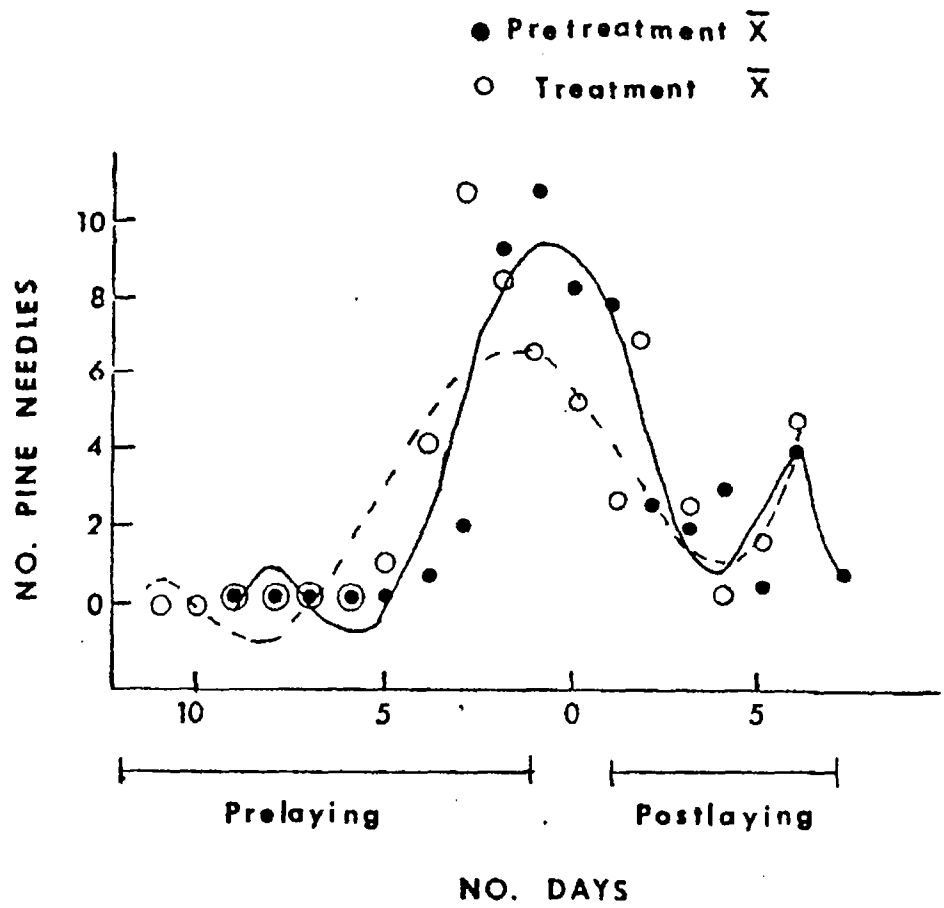


Fig. 4. The mean number of pine needles brought to the nest site by pretreatment (—) and treatment (--) males relative to the day the first egg was observed.

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$P > 0.05$).

Treatment females tended to bring more material to the nest shortly before and after egg laying (Table 5 and Fig. 5) than pretreatment females. The polynomial curve shows that pretreatment females tended to bring more material to the nest after egg laying, and treatment birds tended to peak in this activity around egg laying, thereby making the timing of material gathering significantly different between the two groups ($P < 0.005$). Since no differences were detected in the initiation of nest material gathering after pairing, the difference appears to be due to the delay in egg laying by treatment females.

The correlation of onsets in early wing flipping and early egg laying observed by White (1975) was affected by PCB treatment. In my study, pretreatment females that began wing flipping early in the cycle tended to lay eggs earlier than females that were late in performing this pattern (Table 6, $P=0.07$, Fisher's exact probability). However, no relationship between the onsets of wing flipping and egg laying was observed after birds were on the diet for 15 weeks (Table 7, $P > 0.1$, Fisher's exact probability).

Treatment pairs removed more needles per day during the entire observation period (pairing-days), as well as immediately before and after egg laying (egg-days) (Table 5). Treatment pairs tended to remove needles from the container for a longer period before egg laying, but this timing difference was not statistically significant (Fig. 6, $P > 0.05$). Although treatment pairs removed more needles and tended to do so earlier than pretreatment pairs, there was no difference in the number of needles found in the nest (Fig. 7, $P > 0.05$). Thus the larger number of needles removed by treatment pairs was not added to the nest.

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Table 5

Analysis of Variance of the Behavior Pattern Performance Frequency of Pretreatment (PT) and Treatment (T) Males and Females

Sex	Index[1]	Behavior Pattern	F	P	(PT-T)[2]
male	pairing-day	self preen	4.4	0.04	+
pair	egg-day	needles removed/ day	7.3	0.007	-
	pairing-day	needles removed/ day	3.6	0.06	-
female	pairing-day	sit quiet	4.0	0.05	+
	egg-day	material to nest	2.6	0.1	-
	egg-day	self preen	7.6	0.007	+
	egg-day	sit quiet	2.9	0.09	+

[1] Data arranged with respect to days after pairing (pairing-day) or relative to the day the first egg was observed (egg-day).

[2] The mean value of all observations of one group was subtracted from the mean value of all observations of the second group. The sign of the difference indicates which group performed more frequently.

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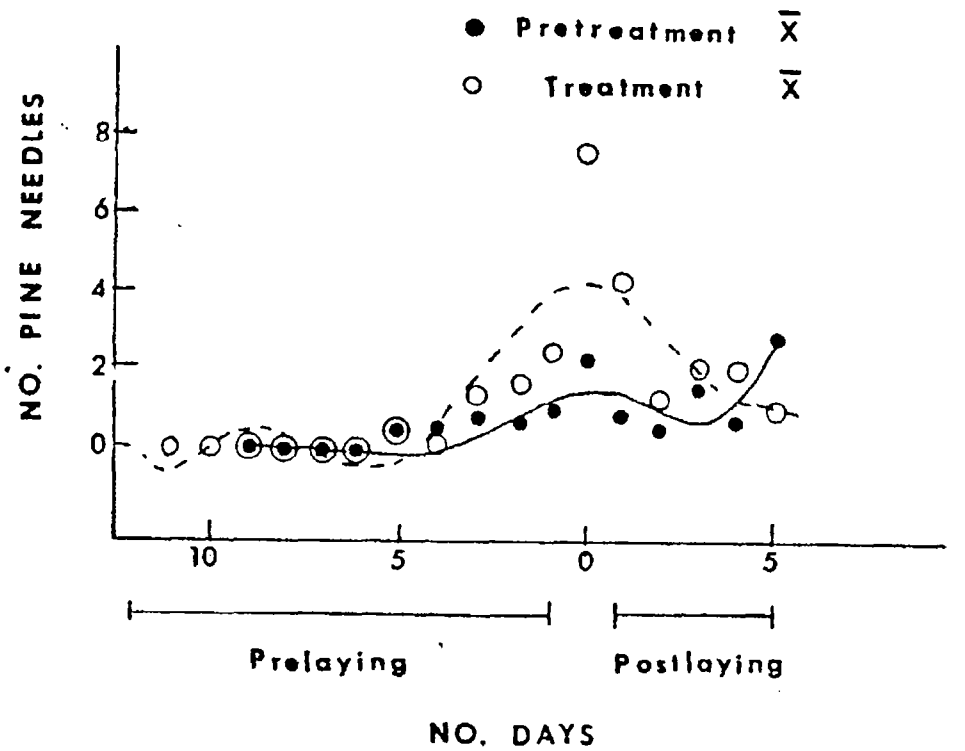


Fig. 5. The mean number of pine needles brought to the nest site per 30-min observation period by pretreatment (—) and treatment (---) females relative to the day the first egg was observed.

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Table 6

The Relationship Between the Onsets of Wing Flipping and Egg Laying in Pretreatment Females (N=8) (Fisher's exact probability, P = 0.07)

	Early onset (day 0-3 after pairing)	Late onset (day 4-7)	Total
Early egg (day 6-7 after pairing)	4	0	4
Late egg (day 8+)	1	3	4
Total	5	3	8

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Table 7

The Relationship Between the Onsets of Wing Flipping and Egg Laying in Females (N=8) Fed 25 ppm Aroclor 1254 (Fisher's exact probability, $P > 0.1$)

	Early onset (day 0-3 after pairing)	Late onset (day 4-7)	Total
Early egg (day 6-7 after pairing)	2	1	3
Late egg (day 8+)	3	1	4
Total	5	2	7

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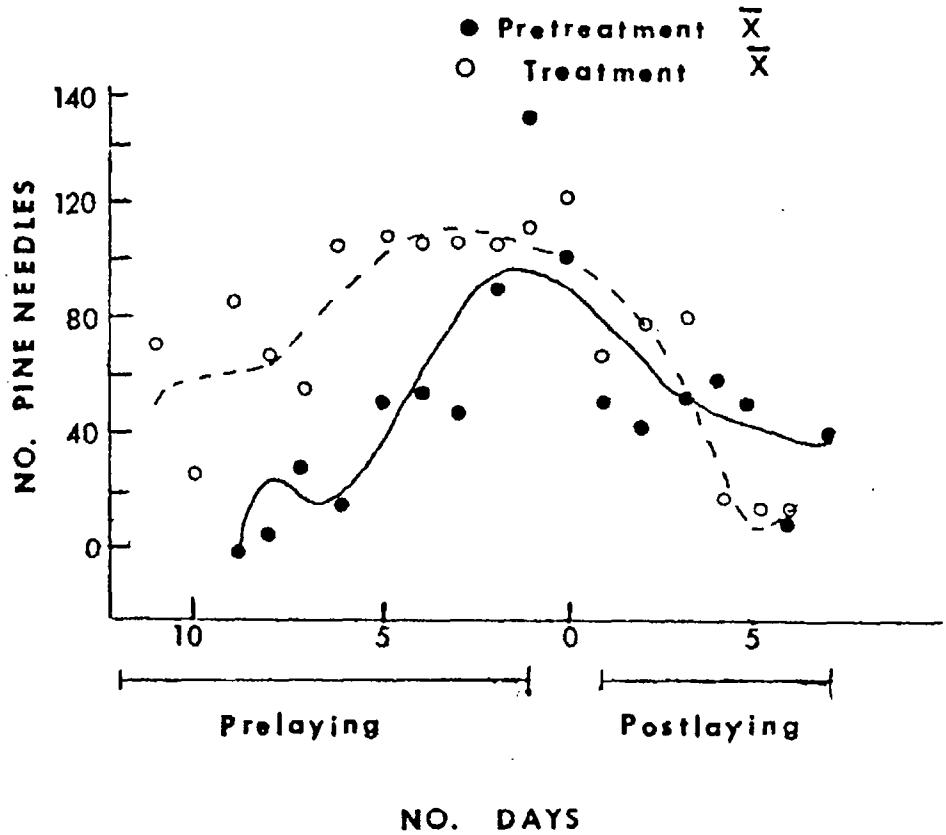


Fig. 6. The mean number of pine needles removed from the container per day by pretreatment (—) and treatment (--) doves relative to the day the first egg was observed.

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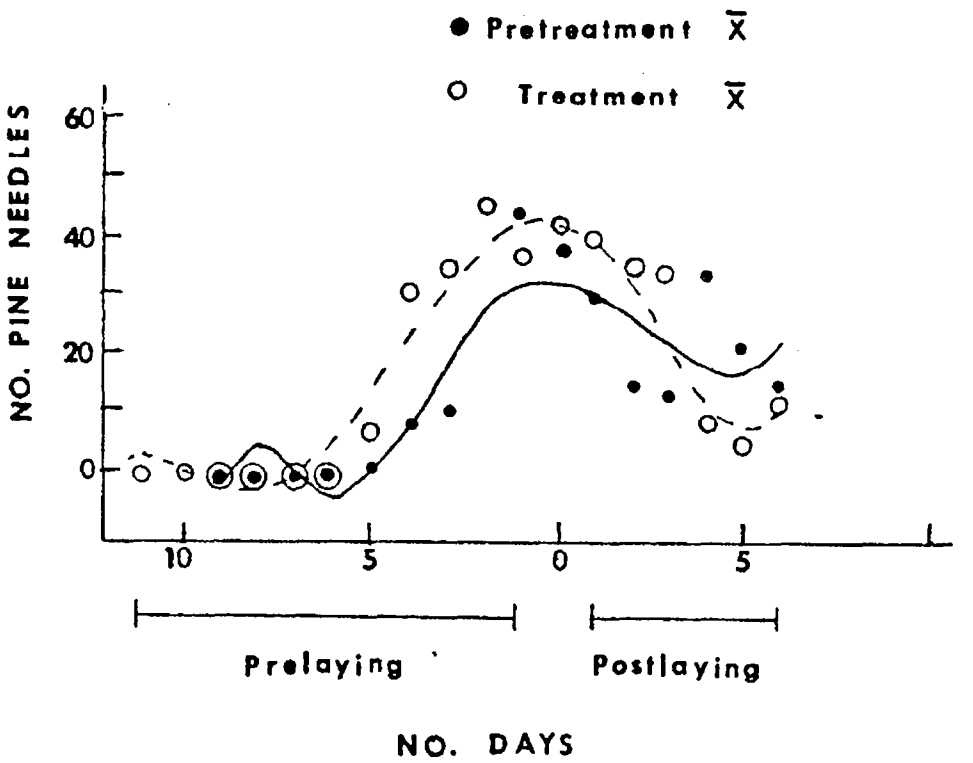


Fig. 7. The mean number of pine needles found in the nest of pretreatment (—) and treatment (---) doves relative to the day the first egg was observed.

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Other hormonally influenced behavior patterns. - No statistically significant differences were observed in the performance of bow cooing and chasing (by males) or incubation by pretreatment and treatment males and females.

Activity. - Treatment birds tended to be more active than pretreatment males and females. Pretreatment birds spent more time quietly preening themselves and pretreatment females spent more time sitting quietly than treatment females (Table 5).

PCB Treatment and Food Reduction

Estrogen-influenced behavior patterns. - A food stress combined with PCB treatment significantly reduced the total frequency of nest cooing in males. There was no difference in the performance of nest cooing by pretreatment and control, food-stressed males or by treatment and treatment, food-stressed males. However, pretreatment males, as well as control, food-stressed males, did significantly more nest cooing than treatment, food-stressed males (Tables 8 and 9). Thus a food stress plus PCB treatment reduced nest cooing in males, whereas treatment of food stress alone did not.

PCB treatment and a food stress also affected nest building activities. Pretreatment and treatment males handled more material than did treatment, food-stressed males (Tables 9 and 10). Both the control, food-stressed and treatment pairs removed more needles per day than treatment, food-stressed pairs (Tables 8 and 10). No significant differences could be detected between pretreatment and control, food-stressed pairs or treatment, food-stressed pairs. Also there was no significant difference in the amount of material found in the nest of pretreatment and control, food-stressed pairs. However,

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Table 8

Analysis of Variance of the Behavior Pattern Performance Frequency of Control, Food-Stressed (CFS) and Treatment, Food-Stressed (TFS) Males

Index[1]	Behavior Pattern	F	P	(CFS-TFS)[2]
pairing-day	nest coo	10.4	0.002	+
	needles removed/day[3]	10.3	0.002	+
	needles found in nest[3]	4.9	0.03	+
	self preen	10.4	0.002	-
	pacing	4.9	0.03	+
egg-day	needles found in nest[3]	7.6	0.01	+

[1] Data arranged with respect to days after pairing (pairing-day) or relative to the day the first egg was observed (egg-day).

[2] The mean value of all observations of one group was subtracted from the mean value of all observations of the second group. The sign of the difference indicates which group performed more frequently.

[3] Performed jointly by male and female.

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Table 9

Analysis of Variance of the Behavior Pattern Performance Frequency of Pretreatment (PT) and Treatment, Food-Stressed (TFS) Males with Respect to Days after Pairing

Behavior Pattern	F	P	(PT-TFS)[1]
nest coo	7.5	0.007	+
handle material	7.4	0.008	+
material to nest	3.4	0.07	+
needles found in nest [2]	3.7	0.06	+
pacing	3.4	0.07	+

[1] The mean value of all observations of one group was subtracted from the mean value of all observations of the second group. The sign of the difference indicates which group performed more frequently.

[2] Performed jointly by male and female.

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Table 10

Analysis of Variance of the Behavior Pattern Performance Frequency of Treatment (T) and Treatment, Food-Stressed (TFS) Males with Respect to Days after Pairing

Behavior Pattern	F	P	(T-TFS)[1]
handle material	10.6	0.001	+
needles removed/day[2]	13.9	0.0003	+
needles found in nest[2]	4.5	0.04	+
pacing	8.2	0.005	+

[1] The mean value of all observations of one group was subtracted from the mean value of all observations of the second group. The sign of the difference indicates which group performed more frequently.

[2] Performed jointly by male and female.

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pretreatment, treatment, and control, food-stressed pairs all had more material in their nests than did treatment, food-stressed pairs (Tables 8,9, and 10).

Other hormonally influenced behavior patterns. - No significant differences could be detected in the performance of these patterns in either males or females.

Activity. - Untreated birds placed on a food stress tended to be less active than pretreatment birds. These control, food-stressed males tended to spend more time sitting quietly than pretreatment males, but pretreatment males did more pacing relative to egg-days (Table 11). Control, food-stressed males did less self-preening than pretreatment males and less than treatment, food-stressed males (Tables 8 and 11). The combination of a food stress and PCB treatment caused males to be less active. Treatment males and control, food stressed males did more pacing than treated, food-stressed males (Tables 8 and 10).

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Table 11

Analysis of Variance of the Behavior Pattern Performance Frequency of Pretreatment (PT) and Control, Food-Stressed (CFS) Males

Index[1]	Behavior Pattern	F	P	(PT-CFS)[2]
pairing-day	self preen	7.0	0.01	+
	sit quiet	4.9	0.03	-
egg-day	self preen	2.7	0.1	+
	sit quiet	3.1	0.08	-
	pacing	5.8	0.02	+

[1] Data arranged with respect to days after pairing (pairing-day) or relative to the day the first egg was observed (egg-day).

[2] The mean value of all observations of one group was subtracted from the mean value of all observations of the second group. The sign of the difference indicates which group performed more frequently.

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DISCUSSION

PCB treatment caused physiological changes that culminated in the delay of egg laying observed in the study. This delay has also been observed in other studies with Ring Doves treated with another chlorinated hydrocarbon, DDE. Both Peakall (1970) and Haegele and Hudson (1973) observed an increase in the latency of egg laying in Ring Doves treated with DDE. Haegele and Hudson (1977) showed that males treated with DDE had lower courtship intensities and postulated this as the reason for delayed egg laying. Peakall (1970), on the other hand, beleived the delay in egg laying was the result of an increased degradation of estrogens by PCB induced hepatic enzymes.

The delay in egg laying in this study could not be linked with a change in the male's performance of courtship. PCB treatment neither reduced the frequency nor delayed the initiation of male courtship. Hutchison and Lovari (1976) showed that increased male aggressiveness delayed egg laying in the female, but I detected no increase in aggressive behavior by treatment males. Therefore, there was no indication of a change in the male behaivor associated with the delay in egg laying by females.

Female courtship behavior has been shown to be closely related to circulating estrogen levels (Korenbrot et al. 1974), with concentrations increasing during courtship, peaking around egg laying, and diminishing by incubation. Estrogen has also been shown to be responsible for oviduct development (Lehrman and Brody 1957). The development of the oviduct starts after initial stimuli are received by the female from the

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mate and is augmented by the presence of nesting material (Barfield 1971, Cheng 1974, Lehrman 1965, Lehrman et al. 1961a, b). Once initiated, female oviduct development will continue and culminate in egg laying even if the male is not allowed to copulate or if the male is removed after being paired for only 3 days (Craig 1911, Lehrman et al. 1961b).

The delay in egg laying of treated females resulted in a greater length of time between the peak of male nest soliciting and egg laying in treated birds, when compared to pretreatment birds. This increased interval is probably the result of a delay in the buildup of estrogen concentrations in the females. Initially, estrogen may have been degraded by hepatic enzymes induced by PCBs as shown in the pigeon (Risenbrough et al. 1968) and other birds and mammals (Chen and DuBois 1973, Lincer and Peakall 1970, Nowicki and Norman 1972). Decreased estrogen levels may have caused a delay in oviduct development and resulted in a delay in egg laying. Kosutzy et al. (1977) noted a lower oviduct weight, as well as a decrease in biological response to estradiol, in the F_1 generation of chickens from hens exposed to PCBs. Estrogen degradation also may have been responsible for the disruption of the early wing flipping and early egg laying relationship in treatment females. However, estrogen degradation does not explain the results of nest material gathering by pretreatment and experimental females.

Estrogen concentrations must have eventually come up to par, because of almost all treated females eventually laid eggs. Also, males with females that did not lay eggs continued to court females throughout the observation period. Yet males paired with females that

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eventually laid eggs stopped courting before egg laying, indicating that the females were showing some courting response. The highest concentration of estrogen in the female occurs during the period of nest building (Korenbrot et al. 1974). The female, by her behavior, stimulates the male to bring material to the nest site (Martinez-Vargas and Erickson, 1973). Since there was no difference in intervals between peaks of bringing material to the female for nest building and egg laying, estrogen concentrations must have been similar between pretreatment and treatment females at this time in the courtship. Therefore, a high PCB level in the female at pairing could probably slow the increase in estrogen level by inducing the degradation of a portion of the estrogen produced. Since circulating estrogen is not believed to be associated with male courtship (Korenbrot et al. 1974), this may be why PCB treatment did not affect male behavior.

Care should be taken in the interpretation of data obtained from the food-stress groups, because unequal sample sizes were used in the comparison. Nevertheless, reduction of food by 10 percent, apparently increased the latency to egg laying and decreased egg production. There was no detectable affect on courtship behavior or nest building activities. Keith (1978) also noted similar effects of a food stress, except that he obtained reduced scores in the courtship period (i.e. before incubation) for food stress-doves.

The combination of a food-stress and PCB treatment tended to reduce nest cooing in males, nest building activities of pairs, the number of eggs produced by females (as well as delay egg laying), and the activity of birds. This combination could thereby drastically

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reduce the reproductive potential of the birds.

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SUMMARY

Ring Doves were fed a diet containing 25 ppm PCBs (Aroclor 1254) for 22 weeks. Eight pairs of these birds were observed during a 2 week period immediately before the start of the treatment diet and for 2 weeks starting after 15 weeks on the diet. After 18 weeks on the treated food, 6 pairs were subjected to a food stress (10 percent reduction in food intake) and observed for a third two week period starting after 20 weeks on the treated diet. Doves on an untreated diet were also observed during the 15 week observation period and were also subjected to the same food reduction and observed at the 20 week period.

There were no differences in the form of courtship behavior patterns or the total number of courtship performances by either sex, between pretreatment birds and birds treated for 15 weeks. However, a high PCB level in the female at pairing delayed egg laying. The delay in egg laying increased the amount of time between the peak in male nest soliciting (nest cooing and wing flipping) and egg laying. These results were attributed to a degradation of estrogen by PCB induced hepatic enzymes. Both a food stress and PCB treatment delayed egg laying. In combination, they decreased the amount of nest cooing by males and the size and quality of nests.

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