PCB's in Laying Hens

Helene C. Cecil[1/], Joel Bitman[1/], George F. Fries[1/],
L.W. Smith[1/], R.J. Lillie[1/] and Jacqueline Verrett[2/]

1/ ARS, U.S. Department of Agriculture, Beltsville, Md. 20705
2/ FDA, Department of Health, Education & Welfare, Washington, D. C. 20204

INTRODUCTION

Polychlorinated biphenyls (PCB's) are environmental pollutants of industrial origin. The compounds are persistent and are accumulated in animal tissues.

In the past year there have been several instances of contamination of poultry feedstuffs by either 'Aroclor 1242, 1248, or 1254.' Accidental feeding of contaminated feed by commercial chicken breeders has resulted in decreased hatchability in some cases. There have been only a few controlled studies on the effects of PCB's on reproduction in chickens. Scott et al. (1971) reported reduced egg production and hatchability in chickens fed 10 ppm Aroclor 1248. Koplinger et al. (1972) reported reduced egg production, hatchability, and thinner egg shells after feeding 10 ppm Aroclor 1242 or 100 ppm Aroclor 1254.

In the present experiments six different polychlorinated biphenyls, a polychlorinated tripnenyl and a polybrominated biphenyl were fed to White Leghorn hens. Changes in eggshell characteristics, reproductive traits, and residues in eggs and feces were followed during feeding and a subsequent period to measure the clearance route of PCB's from tissues when hens were fed an uncontaminated feed. Feces from these birds were recycled as a protein supplement for lactating cows.

EXPERIMENTAL PROCEDURE

Single Comb White Leghorn pullets were placed in individual cages in a gravity-ventilated, open-front house equipped with windows. The birds were fed a standard breeder diet containing 3.5% calcium and exposed to a 14-hour light regime. At 10 months of age the pullets were distributed into 12 groups of 35 each. One group was continued on the standard breeder diet (control); the other eleven groups were fed the same diet supplemented with 20 ppm Aroclor 1221, 1232, 1268, and 5442; 2 and 20 ppm Aroclor 1242, 1248, and 1254 and 20 ppm polybrominated biphenyl (BP-6). The test substances were dissolved in acetone or benzene and pipetted onto a portion of the basal diet spread out in shallow pans. After evaporation of the solvent, the premix was thoroughly mixed with the remainder of the feed. Diets containing the test substances were prepared every two weeks.

Feed consumption, body weight, mortality, egg production, egg weight, eggshell thickness, fertility, and hatchability were studied. Residues in eggs, feces, and body fat were also followed.

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In the fertility studies, a composite sample of undiluted semen obtained from caged White Leghorn males fed the same diet as the control pullets was used to inseminate the pullets once a week at the rate of 0.05 cc per bird. Two days after insemination, eggs were saved for a 5-day period and set according to hen and group number.

Eggs were weighed, and shell thickness determined weekly for the first 8 weeks and biweekly for the remainder of the experiment. After removal of the egg membranes, eggshell thickness was measured via a micrometer at three places around the equator of each egg.

Residues in the egg contents were determined on pooled samples of 10 eggs/group. Residues in feces were determined on pooled 24 hour collections from 10 birds/group. After mixing in a Waring Blendor, a 1 gm sample was cleaned up using FDA (1968) multipesticide residue methodology. Concentrations of PCB were determined by gas liquid chromatography using electron capture detection (Fries et al., 1972).

Lactating cows will be fed dehydrated feces in a ration mixed with corn meal. Parameters measured will be: milk constituents, milk production, and residues in milk.

RESULTS

Feed consumption, body weights, and mortality. There were no effects of feeding polychlorinated di- or tripnenyls or a polybrominated biphenyl on feed consumption, body weight, or mortality (Table 1).

Table 1. Feed consumption, body weights, and mortality of White Leghorn hens fed 'Aroclors' or a polybrominated biphenyl (PBB) for 8 weeks.

Diet		Feed Consumption	Body Wt. Gain	Mortality
	ppm	g/hen/day	g	%
Control	0	122	75	3
Aroclor 1221	20	123	57	0
" 1232	20	117	45	0
" 1242	2	117	81	0
" 1242	20	114	78	0
" 1248	2	117	61	0
" 1248	20	117	94	6
" 1254	2	122	84	0
" 1254	20	117	134	3
" 1268	20	124	79	0
" 5442	20	121	74	0
PBB	20	116	154	11

Shell thickness and egg weight. Shell thickness and egg weight were unaffected by PCB, PCT, or PBB feeding (Table 2).

Table 2. Effects of 'Aroclors' and a polybrominated biphenyl (PBB) on egg weight and eggshell thickness of White Leghorn hens.

Diet		Shell Thickness (mm x 10^{-2}) weeks PCB diet					gm Egg Weight weeks PCB diet				
	PPM	0 wks	2 wks	4 wks	6 wks	8 wks	0 wks	2 wks	4 wks	6 wks	8 wks
Control	0	38	37	36	36	36	62	61	61	62	63
Aroclor 1221	20	36	37	37	36	36	62	62	63	64	63
" 1232	20	35	37	36	36	35	61	60	61	62	62
" 1242	2	36	37	35	36	36	59	58	60	61	61
" 1242	20	34	37	36	36	34	60	60	60	62	63
" 1248	2	36	38	36	36	35	62	61	62	64	63
" 1248	20	37	37	36	36	36	60	59	59	60	61
" 1254	2	38	37	36	36	35	60	60	61	62	63
" 1254	20	37	37	36	35	35	61	60	60	62	60
" 2168	20	36	36	37	36	35	62	62	63	61	63
" 5442	20	36	38	36	36	36	62	62	61	63	63
PBB	20	36	38	36	36	35	61	58	60	59	61

Egg production, fertility, hatchability and embryonic abnormalities. During the second month of feeding 20 ppm PCB 1232, 1242, 1248, 1254, and PBB, egg production was 8 to 13% less than control birds (Table 3). Three of these groups (PCB 1232, 1242, and 1248) had a drastic reduction in hatchability. (Table 4). After three weeks of feeding 20 ppm PCB 1232 hatchability was 77% (Control = 92%); with PCB 1242 or 1248 hatchability was reduced to 28% and 18%, respectively. As feeding continued, hatchability fell further and after 9 weeks of feeding hatchability was 45% (PCB 1232), 11% (PCB 1242), 2% (PCB 1248), and 69% (PCB 1254). Fertility of eggs from hens fed these compounds remained high (Table 4). The majority of the hatchability failures occurred during the last two days of incubation (Fig. 1). Many of the chicks were able to pip and partially break the shell but were unable to break the shell completely.

In addition to the hatchability failure, a large number of the embryos suffered teratogenic abnormalities (Tables 5,6). On gross examination 34% of the dead embryos were abnormal. Subcutaneous edema and edemal cysts were found in half of the abnormal embryos. Other teratogenic features were small bodies, skinny legs, rotated ankles and short or crossed beaks. Most of the chicks that hatched appeared normal and no deaths after hatching could be attributed to treatment. However, these chicks did not grow as well as control chicks with 4 weeks body weight gains significantly less. (Table 7)

The detrimental effects of PCBs on hatchability could be reversed by feeding a diet containing no PCBs (Table 4). Two weeks after the birds were fed a diet containing no PCBs, hatchability improved, and after 6 weeks on clean feed, hatchability had returned to 83% of the control. Growth of the chicks that hatched from these eggs also improved. (Table 7).

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Table 3. Effects of 'Aroclors' and a polybrominated biphenyl (PBB) on egg production of White Leghorn hens.

Diet			% Egg Production			
			Months of PCB Diet		Months of Depletion Diet	
			1 Month	2 Months	1 Month	2 Months
		PPM				
Control		0	81	77	78	68
Aroclor	1221	20	81	79	74	76
"	1232	20	78	68*	67*	69
"	1242	2	77	75	72	71
"	1242	20	73	64*	65*	66
"	1248	2	80	75	78	79
"	1248	20	73	64*	63*	68
"	1254	2	80	75	73	72
"	1254	20	74	70*	63*	57
"	1268	20	76	74	70	63
"	5442	20	80	78	64*	67
PBB		20	71	66*	53*	65

Table 4. Effects of 'Aroclors' and a polybrominated biphenyl (PBB) on fertility and hatchability of fertile eggs of White Leghorn hens.

Diet			% Fertile Eggs			% Hatchability of fertile eggs					
			Weeks of PCB diet			Weeks of PCB diet			Weeks of Depletion diet		
			3 wk	6 wk	9 wk	3 wk	6 wk	9 wk	2 wk	4 wk	6 wk
		PPM									
Control		0	91	91	90	92	90	95	96	92	90
Aroclor	1221	20	93	93	94	94	93	93	90	90	87
"	1232	20	90	91	86	77*	45*	45*	89	77*	76*
"	1242	2	87	91	92	91	93	88	91	90	88
"	1242	20	95	90	95	28*	21*	11*	57*	75*	78*
"	1248	2	90	97	96	88	95	96	93	90	96
"	1248	20	74	86	95	18*	6*	2*	22*	48*	72*
"	1254	2	91	89	90	91	88	84	93	85	84
"	1254	20	92	90	96	90	81	69*	83	73*	77*
"	1268	20	92	88	89	89	94	95	81	77	84
"	5442	20	93	94	93	97	94	94	90	89	88
PBB		20	98	87	92	90	98	92	90	89	85

Table 5. Embryonic death and embryonic development of eggs from White Leghorn chickens fed 'Aroclors' for 5 to 9 weeks.

	% Unhatched	% Abnormal
Control	3	2
20 ppm PCB 1232	39	12
20 ppm PCB 1242	75	27
20 ppm PCB 1248	76	26
20 ppm PCB 1254	18	5

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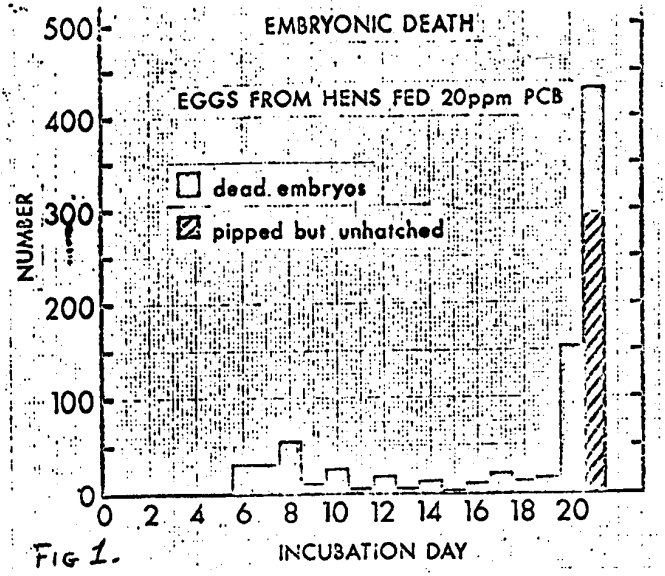

FIG 1.

Table 6. Abnormalities in dead embryos of eggs from White Leghorn fed 20 ppm 'Aroclor' 1232, 1242, 1248 or 1254 for 5 to 9 weeks.

	Number	%
Dead Embryos	843	100
Abnormal Embryos	286	34
Abnormalities	394	100
Edema	198	50
Unabsorbed Yolk	49	12
Small body	34	9
External hemorrhage	30	8
Skinny Legs	28	7
Rotated Ankle	12	3
Short or Crossed Beak	11	3
Others	32	8

Table 7. Four-week body weight gain of chicks hatched from eggs of hens fed PCBs.

			gm Body Weight Gain				
				Weeks depletion diet			
Diet		PPM	6-9 wks PCB	1	2	3	4
Control		0	163	136	140	134	141
Aroclor	1232	20	138*	126	139	127	128
	1242	20	115*	96*	116*	104*	131
	1248	20	109*	98*	98*	114*	116*
	1254	20	141*	118*	126	124	126

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Table 8. PCB residues in eggs and fat of White Leghorn hens after 9 weeks PCB feeding and a subsequent 6 week period of uncontaminated feed.

Diet		ppm PCB residues				
		9 wks PCB feeding		6 wks Depletion Diet	
	ppm	Egg	Fat	Egg	Fat
Aroclor 1221	20	0.5	24.0	0.7	8.1
" 1232	20	2.4	45.7	2.0	23.9
" 1242	2	0.5	16.7	0.5	4.3
" 1242	20	13.9	96.3	2.8	26.4
" 1248	2	1.0	20.7	0.7	3.8
" 1248	20	9.3	89.7	3.0	39.8
" 1254	2	0.9	14.2	0.4	7.2
" 1254	20	12.4	124.4	7.2	91.8
" 1268	20	21.5	52.4	1.8	43.6

Residues. The feces residues, accounting for less than 10% of the amount fed were essentially unaltered. However, with egg and body fat samples many of the less chlorinated componets were removed by metabolism. Thus, the residues of 'Aroclor 1221' were greatly altered while the residues of 'Aroclor 1268' were essentially unaltered. In general the level of PCB in body fat at 9 weeks increased with increasing chlorination of the formulation fed (Table 8). Since the less chlorinated compounds are more suseptible to metabolism this result would not be unexpected.

The residue level in eggs paralelled the level in body fat. The exception was 'Aroclor 1268' where the level in eggs was relatively higher than expected. This would be either a compensating or causative mechanism for the low body fat retention. The depletion of residues after PCB feeding stops depends on metabolism, level of production and changes in body composition. While depletion occurred with all compounds a thorough analysis of all factors has not been made.

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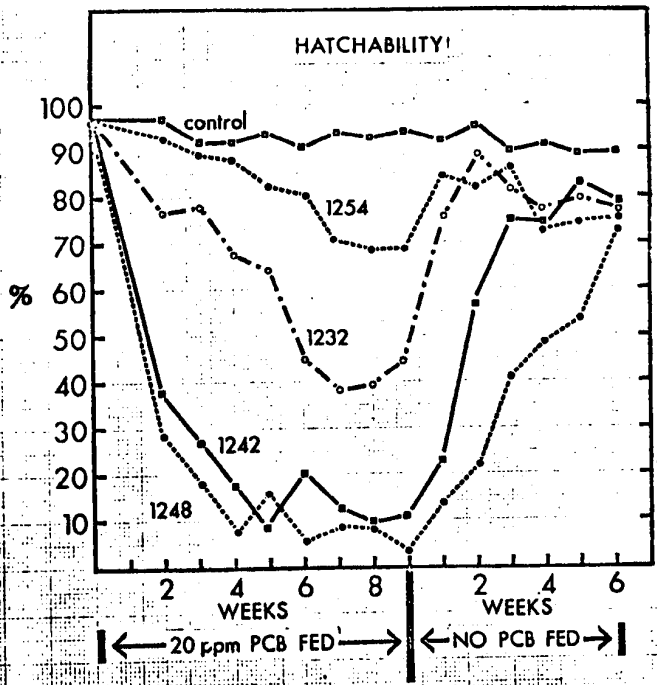
HATCHABILITY
100
90
80
70
%
60
50
40
30
20
10
control
1254
1232
1242
1248
2
4
6
8
2
4
6
WEEKS
WEEKS
20 ppm PCB FED
NO PCB FED

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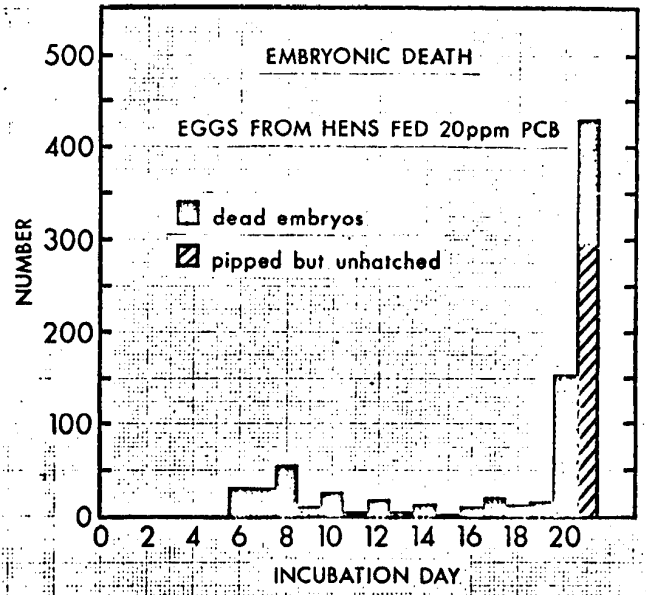
EMBRYONIC DEATH
EGGS FROM HENS FED 20ppm PCB
dead embryos
pipped but unhatched
NUMBER
500
400
300
200
100
0
0 2 4 6 8 10 12 14 16 18 20
INCUBATION DAY

MONS 043949