# Retention and Excretion of Polybrominated Biphenyls by Hens

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Polybrominated biphenyls (PBB) are industrial compounds used as flame retardants in thermal plastics. They have received little attention as potential environmental or food contaminants. Recently, PBBs accidentally used in place of magnesium oxide in dairy cattle feeds adversely effected the health and productivity of the cows (JACKSON and HALBERT, 1974). PBB residues in milk and meat were more than 100 times the action levels subsequently established for PBBs.

Although poultry feeds were not originally involved in the accidental substitution, they became involved by cross contamination in mixing plants and, possibly, through the recycling of rendered products before the problem was identified. Thus, some knowledge of the residue behavior and the biological effects of the PBBs in hens is important.

The chemically related polychlorinated biphenyls (PCB) can severely reduce hen productivity and egg hatchability. PBB affected hens less severely than did equal intakes of some PCBs (LILLIE et al., 1974; CECIL et al., 1974) In this paper, we present the data on residue accumulation and elimination by the hens fed PBB in these studies.

## MATERIALS AND METHODS

Thirty-five individually caged White Leghorn hens were fed a diet containing 20 ppm PBB[1] The PBB diet was fed for 63 days, and the hens were observed for an additional 49 days after PBB was removed from the diet. Details of the hens' feeding and management were presented previously (LILLIE et al., 1974).

Ten randomly selected eggs were composited and analyzed weekly. Total excreta for a 24-hr period from 10 hens was composited and analyzed once a week during the study. Five hens were killed at 63 days and five at 112 days. Individual body fat samples and the last-laid eggs of these hens were analyzed for PBB residues.

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[1]BP-6, Michigan Chemical Co. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Dept. of Agriculture or an endorsement over other products not mentioned.



Bulletin of Environmental Contamination & Toxicology,
Vol. 15, No. 3 

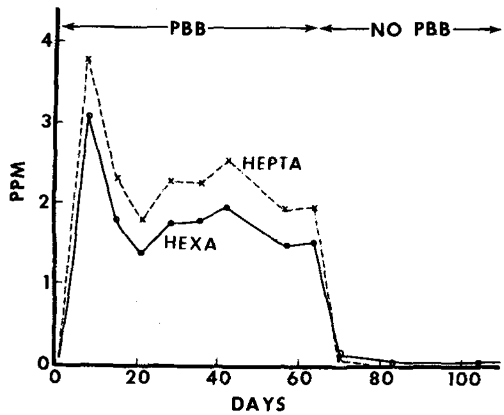


Fig. 1. Concentration of PBB residues in wet excreta of hens fed a diet containing 20 ppm PBB for 63 days. Each point represents a one-day composite of 10 hens.

The standard pesticide multi-residue analytical methods were used, with a slight modification. The clean-up and gas chromatographic methods and their modifications were described, and quantitation was discussed by FRIES and MARROW (1975).

RESULTS AND DISCUSSION

The PBBs are complex mixtures of chemical analogs, but only one hexa component and one hepta[2] component occur in sufficient quantities to allow routine quantitation (FRIES and MARROW, 1975). We have quantitated these two components as if each was fed at a rate of 20 ppm in the diet. This method of quantitation is not completely realistic. However, it facilitates comparision of the behavior of the two compounds and is consistent with regulatory practice in which quantitation is based on the hexa analog.

Concentrations of PBB residues in the excreta are shown in Fig. 1. After an initial rise and decline, the levels remained fairly constant during the feeding of PBB at about 2 ppm on a wet basis. When feeding stopped, the residues dropped to a negligible level (<0.1 ppm). The average excretion of hexa was 9% of intake whereas that of hepta was 15% while PBB was fed. These results indicate that the less brominated component is more readily absorbed from the gastrointestinal tract.

Residues in whole eggs approached a stable level within 21 days after feeding began, and the hexa and hepta concentrations

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[2]Mass spectrometric evidence indicates that this component is actually an unresolved mixture of hepta and octa (FRIES and MARROW, 1975). For simplicity it will be referred to as hepta in this paper.

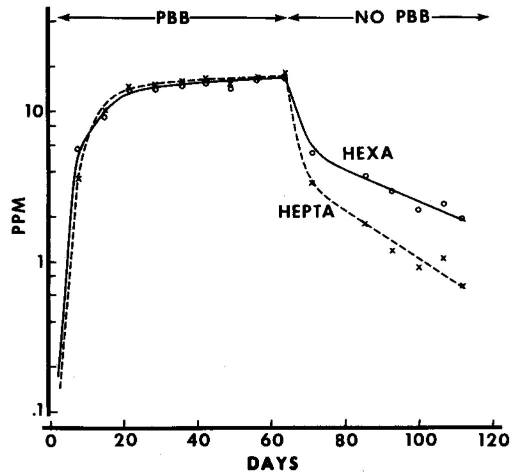


Fig. 2. Concentration of PBB residues in eggs of hens fed a diet containing 20 ppm PBB for 63 days. Each point represents a composite of 10 eggs.

were almost identical (Fig. 2). When feeding stopped, both components initially declined rapidly, then more slowly after 14 days. The half-life was about 28 days for hexa and 20 days for hepta. After 49 days, the levels were approximately 10% of the values when feeding stopped.

The mean levels of PBB residues in egg and body fat of the individual hens killed at 63 and 112 days are presented in Table 1. At 63 days the levels of both hexa and hepta components in eggs were approximately the same as the level in the diet. This finding closely agrees with results for DDT and related compounds in hens

TABLE 1

Concentration of PBB in eggs and body fat of hens fed diets containing 20 ppm PBB for 63 days and no PBB for 49 days thereafter.

| Sample | Days | Concentration, ppm[1] | |
|---|---|---|---|
| | | Hexa | Hepta |
| Eggs | 63 | 20.0 ± 1.7 | 21.1 ± 1.5 |
| | 112 | 2.5 ± 0.3 | 0.9 ± 0.1 |
| Body fat | 63 | 79.8 ± 11.1 | 31.4 ± 10.5 |
| | 112 | 68.9 ± 12.2 | 25.1 ± 12.4 |

[1]Each value is the mean and standard deviation of five observations.

and other birds (CECIL et al., 1972). The relative retention of hexa and hepta in body fat differed significantly: The level of hexa concentration was about 4 times that of the diet, whereas the hepta concentration was only about 1.5 times that of the diet. When PBB was removed from the diet, the levels declined more slowly in body fat than in eggs.

Because body fat was sampled at only one time while PBB was fed, we could not determine whether the values represented steady state. The PBB values after 63 days were much lower than the steady-state value found for DDT, which was 13 times the diet level (CECIL et al., 1972). Residues of the 54% chlorine PCB in parallel studies were about 6 times the diet level at 63 days (FRIES et al., 1973). In contrast, residues of the 68% chlorine PCB were only 1.5 times the diet level. The degrees of halogenation of these two PCBs bracket the degree of halogenation of PBB. Thus, we can reasonably assume that the steady-state level of PBB would be lower than the levels for typical chlorinated hydrocarbons.

An estimate of the 63-day PBB balance is presented in Table 2. Several assumptions had to be made in order to prepare this balance. The more important assumptions were that the average egg contents weighed 50 g and that the hen's body contained 10% fat.

These estimates are crude and account for only 70% of the ingested PBB; however, two valid conclusions can be drawn. First, elimination of PBB through the egg is more important than elimination through the excreta or retention in body fat. Second, the hepta component is more readily eliminated in the excreta and less readily stored in fat than hexa.

The differences in behavior of the two components are consistent with the hypothesis that the hexa component is more readily transferred across biological membranes. A reduction in transfer with increasing halogenation appears to be fairly general. We obtained comparable results with hexabromobiphenyl in cows (FRIES and MARROW, 1975) and the more highly chlorinated PCBs in hens (FRIES et al., 1973) and cows (SMITH et al., 1975). The phenomenon is of more scientific than practical significance for PBBs because the hepta component is only a small part of the total material.

TABLE 2

Estimated recovery of PBB from hens fed diets containing 20 ppm PBB for 63 days.

| Component | PBB recovered, % | | | |
|---|---|---|---|---|
| | Excreta | Eggs | Body Fat | Total |
| Hexa | 9 | 45 | 11 | 65 |
| Hepta | 15 | 50 | 5 | 70 |

## Conclusions

The retention and elimination of PBB by hens are qualitatively similar to those of PCBs and chlorinated hydrocarbon pesticides. Steady-state level in eggs was about the same as the level in the diet, and after 63 days the level in body fat was about 4 times the level in diet.

The FDA action levels for PBB are 0.05 ppm in eggs and 0.3 ppm in fat. Residues in meat and eggs should not exceed the action levels if the diet level is below 0.05 ppm. Feed consumption and egg production decrease slightly when we fed 20 ppm (LILLIE et al., 1974), but effects would not likely be detectable if the diet contained only 0.05 ppm.

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