

APPENDIX H

Regulatory Action on PCBs

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Shrimp are very sensitive to PCBs and most will die as a result of 20-day exposure to a concentration of 5 parts per billion. PCBs also inhibit shell growth of oysters. Crabs are less sensitive; all accumulate residues to many times the concentrations in the water, and a test with crabs showed that they lost the residues very slowly.

Growth of certain species of marine diatoms was experimentally inhibited by PCBs, but algae were not affected.

The small marine crustacean, Gammarus, is sensitive to PCBs in concentrations of thousandths to tenths of a part per billion.

Exposure to 5 parts per billion of Aroclor 1254 caused mortality of two species of fish in 14-45 days. Onset of death was delayed and was accompanied by fungus-like lesions.

Rainbow trout were quickly killed by polychlorinated terphenyls at 10 parts per billion under normal oxygen conditions and at 2 parts per billion with reduced oxygen.

Metabolic changes of PCBs have been suggested by environmental observations of different isomeric patterns in animals of different trophic levels. Quantitative differences also are pronounced, with magnifications of hundreds to thousands of times.

Laboratory studies have shown no metabolic changes of PCBs by crabs and shrimps, minimal changes by fish, and pronounced changes by birds.

PCBs induce microsomal enzyme activity in birds. Exposure to PCBs increased the susceptibility of mallard ducklings to duck hepatitis virus.

Offspring of pheasants whose parents received high dosages of PCBs made poor choices in visual cliff tests. Egg production and hatching after pipping also were affected. Migratory restlessness was increased in English robins exposed to PCBs.

Long-term studies of the reproductive effects of Aroclor 1254 on mallards and bobwhite quail and of Aroclor 1254 plus DDE on quail showed no significant differences from controls. In studies of chickens, however, egg production and hatchability were impaired by high doses of Aroclor 1254 and by low doses of Aroclor 1242.

Statistical evaluations of the role that different chemicals may play in thinning eggshells of brown pelicans showed that DDE residues correlate better with shell thinning than do residues of dieldrin or PCBs, confirming observations with cormorants and white pelicans.

IV. CONCLUSIONS

PCBs are man-made biologically active substances that are dispersed throughout the environment and stored in the tissues of animals. They are lethally toxic to fish and aquatic invertebrates in concentrations measured

Mallard ducklings demonstrated the possibility of interacting effects between PCBs and disease organisms (Friend and Trainer, 28). Thirty-five to 44 percent of the 10-day-old ducklings exposed for 10 days to a dietary dosage of 25, 50, or 100 parts per million of Aroclor 1254 died upon subsequent exposure to duck hepatitis virus in contrast to only 14 percent of the birds exposed only to the virus.

Swedish robins (Erithacus rubecula) given 5 micrograms of Clophen A50, for 11-13 days showed a greater migratory restlessness than controls (Ulfstrand and Södergren, 29).

Pheasant hens absorbed 94 percent of the Aroclor 1254 given as a single capsule dose, a very efficient entry of this chemical into the system (Dahlgren, et al., 30). Residues in muscle declined 82 percent in 28 days after dosage. Residue were excreted in both eggs and feces.

Residues in the milk of cattle inadvertently exposed to PCBs declined at the rate of 1.3 percent per day when uncontaminated feed was restored (Fries, et al., 31). The rate of loss of DDE residues was identical. PCBs in milk fat decreased from 12.6 parts per million to 5.8 parts per million in about 3 weeks and to 2.1 parts per million in about 4 months.

A cow given 10 mg/kg of Aroclor 1254 in a single dose released an average of 3.9 parts per million into the whole milk during the next 4 days' milking. A dosage of 100 mg/kg produced 36 parts per million in the milk of another cow (Platonow, et al., 32). The gas chromatographic pattern of the Aroclors in the milk was very similar to that of the fed compound.

B. REPRODUCTION

Pheasants given a capsule dose of 50 mg of Aroclor 1254 weekly for 17 weeks produced fewer eggs than controls, and a higher percentage of chicks pipped the shell but did not hatch (Dahlgren and Linder, 33). Chicks that hatched weighed less and survived more poorly than controls. Eggshell thickness was not affected. In behavioral tests of the offspring on a visual cliff, more of the chicks from the dosed parents made the undesirable choice of jumping to the deep side, or made no choice, in the 5-minute test period. None of these effects occurred among the groups whose female parents were dosed with 12.5 mg.

Mallards fed a dietary dosage of 25 parts per million of PCBs from about 11 weeks before their first breeding season and through their second year laid eggs with shells of normal thickness (Heath, et al., 1). The number of eggs laid, hatchability, and survival of young did not differ significantly from the untreated controls. In another test, mallard ducks fed 10 or 500 parts per million of Aroclor 1254 in the diet for about 5 weeks laid eggs with normally thick shells. Bobwhite quail fed diets containing 50 parts per million of PCBs, or 30 parts per million of DDE, or a combination of 25 parts per million of PCBs plus 15 parts per million of DDE for about 11 weeks before their first breeding season reproduced as well as controls.

Ring doves (Streptopelia risoria) fed 10 parts per million of Aroclor 1254 for 6 months laid eggs no lighter than those laid by control birds. (Peakall, 34). Fourteen birds fed 10 parts per million of PCBs before and after dosage and nine birds injected intraperitoneally with 160 mg/kg 1-4 days before egg laying confirmed the lack of effect of PCBs on shell weight.

faster than those with more chlorines, so that the latter were subject to greater increase in the food chain (Jensen, et al., 19).

In two simple food chains, fish to eagles (Haliaeetus albicilla) and fish and mussels (Mytilus edulis) to seals (Phoca vitulina and Pusa hispida), concentrations increased hundreds to thousands of times from prey to predator (Jensen, et al., 19). Fish contained hundredths to tenths of parts per million; fresh mussels contained hundredths of parts per million; seal blubber contained 5-21 parts per million; and the muscle of the white-tailed eagle contained 150-240 parts per million.

In Great Britain, birds that feed on birds or mammals contained the highest concentrations of PCBs, those that have a mixed diet contained the next highest, and those that feed on insects had the lowest (Prestit, et al., 3). The fish-eating herons from the southeast of England contained higher residues of PCBs than birds of any other area.

Many species of California birds contained hundredths to tenths of parts per million of PCBs; peregrines (Falco peregrinus) contained greater amounts, one as high as 98 parts per million in muscle (Risebrough, et al., 20), while fish in the same area contained only thousandths of parts per million.

Residues of PCBs in the industrially polluted Escambia Bay increased in the expected order. Water contained a maximum of 275 parts per billion, and sediment a maximum of 486 parts per million. Oysters (Crassostrea virginica) contained 2-3 parts per million, shrimp (Penaeus duorarum) 1.5-2.5 parts per million, blue crabs (Callinectes sapidus) 1-7 parts per million, and pinfish 6-12 parts per million (Duke, et al., 15).

Subsequent samplings from three stations in the Bay showed little change in concentrations of PCBs in sediments even after 9 months (Nimmo, et al., 21). Experiments were then undertaken that showed that shrimps (Penaeus duorarum) and fiddler crabs (Uca minax) could accumulate Aroclor 1254 from the sediments. Relationships between concentration of PCBs in sediment and concentration in crabs and shrimps were variable. The maximum accumulation was from sandy silt containing 61 parts per million (dry weight) of Aroclor 1254; fiddler crabs accumulated 80 parts per million (wet weight) in their bodies; shrimp accumulated 240 parts per million (wet weight) in the hepatopancreas. Some PCBs were present in the water and a portion of the accumulation could have been from that source. The ratio of individual PCB isomers maintained integrity in the sediments and tissues of test animals throughout the investigation, indicating no pronounced metabolic changes of the PCBs.

Spot (Leiostomus xanthurus) exposed to 1 part per billion of Aroclor 1254 for 56 days attained maximum concentrations in 14-28 days, although absolute amounts continued to increase as the fish grew (Hansen, et al., 17). Maximum concentration in whole spot was 37,000 times that in the test water. These results were very similar to those for DDT reported earlier from the same laboratory. The PCBs were lost slowly from the tissues of spot after they were placed in clean flowing water. After 84 days of flushing, the concentration had dropped 73 percent and the absolute amount had dropped 61 percent. Isomers of Aroclor 1254, with the exception of one peak, maintained their integrity in spot.

1. Residues in Birds Killed by PCBs. Chickens killed by PCB dosage in the studies of (Vos and Koeman, 8) generally contained from 120 to 420 parts per million in the brains, but the overall range was from 40 to 700 parts per million. Residues in livers were 120 to 2,900 parts per million.

Coturnix quail poisoned by PCBs (Phenoclor DP6) contained residues of 342-1710 (av. 1158) parts per million in the brain and 1079-8350 (av. 3280) parts per million in the liver (Koeman, 11). Bangales finches killed by PCBs had residues of 70 to 697 parts per million in the livers; those sacrificed at the end of the experiment contained 3 to 634 parts per million (Prestt, et al., 8). Residues in brains were somewhat lower; the proportional amount in the brain in comparison with the amount in the liver averaged higher in the birds that died than in those that were sacrificed.

A bald eagle found sick in the field contained high residues of both DDE and PCBs in its brain, suggesting that PCBs may have contributed to its death. Residues of DDE in the brain were 385 parts per million, which is within the lethal range for DDE (Stickel et al., 12). However, the brain also contained 230 parts per million of PCBs, 6 parts per million of DDD, 2.2 parts per million of dieldrin, and 0.4 parts per million of heptachlor epoxide.

B. INSECTS

The toxicity of PCBs to insects also is related to the chlorine content, but in the reverse order to the result with birds. PCBs with lower amounts of chlorine were more toxic to flies than PCBs with higher chlorine content, and the toxicity of mixtures with more than 48 percent chlorine was very low (Lichtenstein et al., 11). Toxicity of dieldrin and DDT was enhanced beyond an additive effect by the addition of the lower chlorinated PCBs.

Topical applications of Aroclor 1254 to a grasshopper (Clorthippus brunneus) produced delayed mortality that occurred at the time of molt (Moriarty, 14).

C. FISH AND AQUATIC INVERTEBRATES

Shrimp (Panaeus duorarum) are sensitive to low concentrations of PCBs (Duke, et al., 15). All individuals died as a result of a 48-hour exposure to flowing seawater containing 100 parts per billion of Aroclor 1254; 80 percent died in 24 hours. These shrimp accumulated 3.9 parts per million in their tissues. Shrimp exposed to 10 parts per billion did not die, but accumulated 1.3 parts per million of PCBs in their tissues.

Seventy-two percent of the juvenile shrimp died from a 20-day exposure to 5 parts per billion of Aroclor 1254 and the tissues accumulated 16 parts per million. Crabs (Callinectes sapidus) were less sensitive, but accumulated an average of 23 parts per million in a 4-week exposure at 5 parts per billion and still contained 22 parts per million after a week in clean water and 11 parts per million after 4 weeks in clean water.

The small crustacean, (Gammarus oceanicus) had a lethal threshold in 30-day tests between 0.001 and 0.01 parts per billion in colloidal solution and between

APPENDIX G

Biological Data On PCBs In Animals Other Than Man

Polychlorinated biphenyls have become ubiquitous in the world ecosystem in quantities similar to those of DDE. Their presence has caused concern and stimulated research to evaluate their role in the biosphere.

The significance of PCBs to wild animals depends upon both their lethal toxicity and their sublethal physiological effects. These are the subjects of the present paper. Coordinate knowledge of level of exposure, as shown by frequency and levels of occurrence of PCBs in the environment, is essential to complete the understanding. These are summarized elsewhere in this report.

I. TOXICITY

Outright mortality of wild animals can affect populations, particularly those of long-lived species. Measurements of direct toxicity are therefore important first steps in evaluation of a chemical. Other laboratory studies also are needed for proper interpretation of field observations. These include studies to diagnose cause of death by behavior of poisoned animals, tissue changes, and concentrations of chemical in critical tissues.

A. BIRDS

The toxicities of different PCBs to pheasants (Phasianus colchicus), mallards (Anas platyrhynchos), bobwhite quail (Colinus virginianus), and coturnix quail (Coturnix coturnix) were compared with the toxicities of DDT, dieldrin, and other insecticides (Heath, et al., 1). Tests of six PCB mixtures, containing 32 to 62 percent chlorine, showed that the toxicity increased with the percentage of chlorine. In general, toxicities were similar to those of DDE. There were some differences in sensitivity of the species. Bobwhite were most sensitive, followed in turn by pheasants, mallards, and coturnix quail. Bobwhite were 3-4 times as sensitive as coturnix. Special tests with coturnix quail showed that the toxic effects of DDE and Aroclor 1254 were additive but not synergistic.

In other studies, Aroclor 1254 was approximately as toxic as DDE to four species of blackbirds: grackles (Quiscalus quiscula), cowbirds (Molothrus ater), starlings (Sturnus vulgaris), and redwings (Agelaius phoeniceus) (Dustman, et al., 2). Redwings were somewhat more susceptible to DDE than to PCBs. Signs of poisoning were sluggishness with slight tremors of moderate amplitude, much as with chemicals of the DDT group. Internally, livers frequently had hemorrhagic streaks or spots, and the gastrointestinal tract commonly contained blackish fluid, but these signs were not sufficiently consistent for distinctive diagnosis.

Aroclor 1254 was approximately 1/13 as toxic as DDT to Bengalese finches (Lonchura striata) (Prestt, et al., 3). Tremoring and other signs were similar to those observed among blackbirds; the finches had enlarged kidneys and some had hydropericardium.

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