Bull. Environ. Contam. Toxicol. (1985) 34:527–532

Environmental Contamination and Toxicology

Residues of Pesticides and Polychlorinated Biphenyls in Game Animals

H. Brunn,[1,*] H. D. Berlich,[2] and F. J. Müller[2]

[1]Staatliches Veterinäruntersuchungsamt Gießen, Marburger Straße 54, D-6300 Gießen, West Germany and [2]Arbeitskreis Wildbiologie und Jagdwissenschaft an der Justus-Liebig-Universität Gießen, Frankfurter Straße 98, D-6300 Gießen, West Germany

Levels of chlororganic pesticides and polychlorinated biphenyls in the tissues and organs of wildlife reflect the degree to which the environment is contaminated with these substances (Drescher-Kaden et al. 1978). These levels have been determined in fish (Brunn and Manz 1982; Boiselle et al. 1983; Schüler, Brunn and Manz in press) and in mammals (Frese et al. 1978; Tataruch 1980; Holm 1983). There have, however, been no reports on the levels of low-chlorinated biphenyls in wildlife in Western Germany.

The object of the study described below, therefore, was to determine the concentration of these low-chlorinated hydrocarbons in the meat of game animals taken from a defined biotope. These levels were compared to the levels of chlororganic pesticides and high-chlorinated biphenyls which had been determined for the same samples. In addition, concentrations of the various chlororganic compounds were determined in a small population of a migratory bird and these values compared to those of the sedentary species.

MATERIALS AND METHODS

Levels of residues of hexachlorobenzene (HCB), the HCB metabolite, pentachlorobenzene (PChB), α- and β-HCH, Lindan® (γ-HCH), heptachloroepoxide (HCO), p,p'-dichlorodiphenyltrichloroethane (DDT), low-chlorinated biphenyls (of the type marketed as Clophen C® in Western Germany) referred to here as PCB-C and high-chlorinated biphenyls (Clophen A-60®) referred to here as PCB A-60, were determined by gas chromatography in tissues of the following animals: 17 partridges (Perdix perdix L.), 4 pheasants (Phasianus

* Correspondence and reprint requests

colchicus) and 26 hares (Lepus europäus Pall.). These animals represent sedentary populations from a defined biotope. They were all shot on a game preserve of about 4 km^2 located near a ridge of the Franconian Jura about 300 metres above sea level. The area is primarily agricultural (winter crops and grazing meadows) and no industry is present. For purposes of comparison 8 woodcocks (Scolopax rusticola L.), a species of migratory bird, were also examined.

Breast muscles of birds and muscle tissue from forelimbs of hares were used as samples for analysis. Preparation of tissue, gas chromatography and quantification were performed according to Schüler, Brunn and Manz (submitted for publication). A Hewlett Packard 25 m fused silica capillary column (OV 1 crosslinked) was used in place of the SP 2100 column specified. All values were statistically corrected to diminish scattering, dependent upon absolute concentrations as recommended by the West German health authorities (Bundesgesundheitsblatt 1974).

RESULTS AND DISCUSSION

The frequency of occurence of chlorinated hydrocarbons in the animals examined is presented in Table 1. Nearly all samples contained detectable amounts of high- and low-chlorinated biphenyls. All of the pheasants, most of the hares and about half of the partridges were contaminated with DDT. No other remarkable differences were found between the three species. Lindan® (γ-HCH) was detected in 45 % of the combined samples, whereas α- and β-HCH, HCB and PChB residues were relatively rare. This disparity appears to be the result of the different restrictions for use of the various insecticides in the Federal Republic of Germany. Application of γ-HCH is generally permitted with few restrictions, whereas use of mixtures consisting of α-, β-, γ- and δ-HCH as well as HCB has been prohibited since 1977.

Residues of HCO were detectable in 85 % of all samples. This high frequency of occurence indicates that HCO is persistent in the environment since it's application as well as the use of heptachlor have been prohibited since 1980.

The proportion of migratory birds (woodcocks) which were contaminated with HCH and HCB was greater than the proportion of sedentary animals. The frequency of occurence of other contaminants was similar in these two populations. The total number of woodcocks, however, is clearly too small to allow general conclusions to be drawn.

Table 1 Frequency of occurence of pesticides and polychlorinated biphenyls in the different species examined

Species	Number of animals investigated	HCB	PChB	α- and β-HCH	Lindan	HCO	DDT	PCB-C	PCB A-60
Partridges	17	3	0	0	6	12	8	15	17
Pheasants	4	2	0	0	3	4	4	3	4
Hares	26	6	1	3	12	24	24	22	26
$\sum$	47	11 (23 %)	1 (4 %)	3 (13 %)	21 (45 %)	40 (85 %)	36 (77 %)	40 (85 %)	47 (100 %)
Woodcocks	8	7	2	4	7	8	8	8	8

$\sum$ indicates the sum of all partridges, pheasants and hares

Table 2 Concentrations of pesticides and polychlorinated biphenyls

Species	HCB		PChB		α- and β-HCH		Lindan	
Partridges	0.002	-	-	-	-	-	0.052§	-
Pheasants	0.003	-	-	-	-	-	0.155	-
Hares	0.004	-	-	-	0.190	-	0.121	-
$\bar{x}$	0.003	-	-	-	0.063	-	0.109	-
Woodcocks	0.018	-	0.015	-	0.109	-	0.032	-

Species	HCO		DDT		PCB-C		PCB A-60	
Partridges	0.265§	-	0.160§	-	7.873§	0.039	0.767§	0.001
Pheasants	0.543	-	0.527	-	6.358	0.027	4.902	0.007
Hares	3.595	0.009	0.668	-	8.514	0.021	2.012	0.003
$\bar{x}$	1.530	0.003	0.502	-	7.582	0.029	2.617	0.003
Woodcocks	0.239	0.001	2.165+	0.027+	3.645	0.047	1.864	0.017

Concentrations (mg/kg) of pesticides and polychlorinated biphenyls in fat (left) and based on body weight (right) of the animals analysed. -, value < 0,001 mg/kg. $\bar{x}$, mean value of the sum of the data obtained from partridges, pheasants and hares together. §, n = 16. One animal, which was very lean and showed concentration of DDT in fat 10-fold higher than the average, was not taken into account. +, n = 7; the value of one animal which was appearently poisened by DDT (content in fat nearly 600 mg/kg), was not taken into account.

Average-concentration levels of the various residues in the different species are presented in Table 2. Values for pesticide concentration all fall below the tolerance levels prescribed for Western Germany. The highest pesticide concentrations, in particular HCO, were present in hares. Partridges contained the lowest levels of chlorinated hydrocarbons, with the exception of PCB-C. PCB-C levels were much higher in all samples than were PCB A-60 levels. This result was surprising since the former compounds were assumed to be less persistent in the environment than the latter. The data presented here indicate that this assumption may be inaccurate. Environmental contamination with low-chlorinated biphenyls appears to be a more serious problem than contamination with high-chlorinated compounds. The discrepancy between levels of low- and high-chlorinated biphenyls was smaller in woodcocks than in sedentary species

(Table 2). This difference appears to be the result of the migratory behavior of woodcocks as does the disproportionately high concentration of DDT in these birds. In contrast to neighboring countries, the Federal Republic of Germany has prohibited the use of DDT since 1972.

The data presented above show that levels of polychlorinated biphenyls in game animals by far exceed levels of commonly used pesticides. These results agree with those obtained from terrestrial animals in a similar non-industrial biotope as reported by Drescher-Kaden et al. (1978) as well as from fish and animal products (Brunn 1982; Stojanowić et al. 1983; Schüler, Brunn and Manz in press).

Clearly, the most striking aspect of the results presented here are the unexpectedly high levels of PCB-C in all of the animals examined. This observation indicates that environmental contamination by residues of low-chlorinated biphenyls may be of considerable significance in the future.

Acknowledgements. The authors greatfully acknowledge the skilful technical assistance of Mrs. S. Weber and Mr. Th. Bayer.

REFERENCES

Anonymous (1974) Untersuchungsmethoden zur Bestimmung der Rückstände von Chlorkohlenwasserstoff-Pestiziden in oder auf Lebensmitteln tierischer Herkunft. Bundesgesundheitsbl 18:269-276

Boiselle C, Benner M, Hildebrandt G (1983) Chlorkohlenwasserstoffe in Zandern aus der Unterhavel und ihre Bewertung. Arch Lebensmittelhyg 34:71-76

Brunn H, Manz D (1982) Contamination of native fish stock by hexachlorobenzene and polychlorinated biphenyl residues. Bull Environ Contam Toxicol 28:599-604

Drescher-Kaden U, Hutterer R, v Lehmann E (1978) Rückstände von Organohalogenverbindungen in Kleinsäugern verschiedener Lebensweise aus dem Rheinland. Decheniana (Bonn) 131:266-273

Frese E, Brömel J, Zettl K (1978) Untersuchungen über Rückstandsbelastung einheimischer Wildarten durch einige chlorierte Kohlenwasserstoffe. Fleischw 58:1691-1694

Holm J (1983) Verunreinigungen beim Wild. Lecture Seminar Umwelthygiene WHO-Zentrum der Tierärztlichen Hochschule Hannover 25 Febr

Stojanowić V, Brunn H, Flemmig R (1983) Untersuchungen auf chlorierte Kohlenwasserstoffe in Haar- und Federwild im Rah-

men der amtlichen Lebensmittelüberwachung. Arch Lebensmittelhyg 34:142-144
Tataruch F (1980) Belastung von Wildtieren mit Umweltschadstoffen. Wiener Tierärztl Mschr 67:300
Received April 14, 1984; accepted June 12, 1984.