REPORT

RESIDUES OF POLYCHLORINATED BIPHENYLS IN CATTLE

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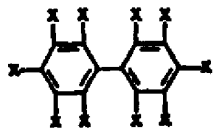
Introduction

Polychlorinated biphenyls (PCB) are a mixture of closely related chlorinated aromatic hydrocarbons. Their general formula is



where x indicates the possible positions for chlorine atoms. Thus PCB could exist, at least theoretically, as 114 possible variants, assuming that the compounds contain three to seven chlorine atoms and the number of chlorine substitutions on each of the two benzene rings differs by no more than one (3).

PCB are commonly used in the manufacture of many plastics, paints, resins, lubricants, hydraulic fluids, etc. for the improvement of chemical and water resistances, flexibility, adhesion properties, etc. (1, 2). They find application also for purposes such as dust prevention and vapour suppression. These two latter properties confer to PCB an up to ten-fold increase of kill-life if they are used in pesticide formulations (1) and an increase in the toxicity of DDT and dieldrin in particular (7).

PCB are extracted from biological material through the same procedure as chlorinated pesticides and possess similar electron absorbing properties. Since PCB possess structural and physico-chemical similarities to the DDT pesticide group, gas-liquid chromatograms of some PCB demonstrate a striking resemblance to the chromatograms obtained from wildlife samples which supposedly contained chlorinated pesticides (3, 12). These properties of PCB contribute to their interference with the analysis of the organochlorine pesticides, DDT and their metabolites in particular (3, 11, 12).

PCB have been implicated as environmental contaminants of wildlife and fish in Europe (5, 6) and North America (3, 13) and they now appear to be part of the global ecosystem (13). It has been reported that in pigeons, PCB are powerful inducers of hepatic enzymes which degrade estradiol (13) and possess an anti-androgenic-like effect in cockerels (10).

Studies on the effects of PCB in rats and guinea-pigs showed liver injury (9). Hydropericardium and abdominal edema were reported as being the predominant lesions caused by PCB in chickens (4, 8, 16) and Japanese quail (6). To the best of our knowledge no report is available as to the effects and toxicity of PCB in large domestic animals.

The present report deals with the occurrence of PCB residues in the milk of an exposed bovine, and in some tissues and urine from two steers, one of which died from undetermined causes.

History

A fruit farmer in the Niagara district of Ontario, who kept a milk cow and two steers, was referred to the Laboratory of Toxicology because of the death of one of the steers.

He suspected that a stream had become polluted by farmers who habitually filled their spray tanks at a bridge immediately upstream from his farm. Evidence for this was provided by the fact that a considerable number of empty spray-chemical bags littered the banks and the stream itself at this point. These bags had contained many different insecticides and herbicides. According to the farmer, the steer which died had shown muscular tremors and inability to rise. It also had a temperature of 105° but, following treatment with tetracycline, this had returned to normal by the next day. Prior to death, the muscular tremors became more pronounced and were complemented by spasmodic twitching.

No post-mortem examination was performed. However, the farmer supplied us with a sample of fat, muscle and urine from the dead steer as well as milk from the cow. His main interest was to determine whether or not the milk was fit for human consumption. Two weeks and also one month after the receipt of

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the first samples, the farmer supplied the laboratory with additional samples of milk for analysis. Three months after the incident, the other steer, which had shown no clinical signs, was slaughtered and various tissues were analyzed for possible PCB residues.

Methods

Sample extraction and gas chromatographic analysis were performed according to the method for chlorinated insecticides published by Saschenbrecker and Ecobichon (15). The final volume of 10 ml of a solution in heptane, obtained through this method, was divided into two equal aliquots. A portion of the first aliquot was injected directly into the gas chromatograph. The second aliquot was used to distinguish between PCB and chlorinated insecticides. This second aliquot was refluxed for 12 minutes with 5 ml of 2 per cent ethanolic KOH to dehydrochlorinate possible residual DDT and metabolites. The reaction mixture was salted out with approximately 5 ml of saturated NaCl and the supernatant phase was adjusted to the original 5 ml volume with heptane (14). This procedure permits the conversion of DDT and its analogs to the next lower chlorinated compound through the hydrolysis of alkyl chlorine and is quantitative, while aryl chlorine (as in PCB) remains inert to this type of treatment. As a result of this treatment, a change in the retention time in the DDT group pesticides takes place, whereas no changes are observed with PCB. An additional identification of PCB was performed by selective nitration, at 0 and 100° C, on a parallel sample according to the method of Risebrough *et al* (13).

Results

Analyses of samples from the dead steer revealed the presence of PCB at the following levels:

Muscle	1.370 ppm
Perimuscular fat	4.956 ppm
Urine	0.131 ppm

The milking cow, involved in the incident, did not exhibit any signs of illness, but samples of milk from this animal, taken one day, two weeks and one month after the incident, contained 0.331, 0.226 and 0.113 ppm of PCB, respectively.

The steer which also exhibited no signs of illness and which was slaughtered three months after the incident, showed the presence of PCB in tissues at the following levels:

Muscle	0.132 ppm
Perimuscular fat	1.384 ppm
Liver	1.223 ppm
Kidney	0.534 ppm

The chemical analyses failed to reveal the presence of chlorinated pesticides or organophosphorus compounds on any of the above samples.

The PCB showed 13 distinct peaks on the chromatograms. The peaks of each individual sample were numbered according to the code of Reynolds (11) and expressed as a percentage of the total. These percentages are given in Table I.

TABLE I

Individual Chromatogram Peaks of PCB, Expressed as a Percentage of the Total

Peak No	*Aroclor 1254 Std	Dead Steer			Milking Cow			Slaughtered Steer			
		Muscle	Fat	Urine	Milk 1 day	Milk 2 wk	Milk 1 mo	Muscle	Fat	Liver	Kidney
1	9.7	9.5	5.6	8.2	7.5	9.8	11.0	8.0	5.3	8.4	
2	5.7	5.2	3.2	5.7	4.4	4.2	3.9	5.0	3.0	5.0	3.9
2a	2.6	4.3	2.9	4.6	3.4	3.3	3.0	2.0	2.1	2.2	2.3
3	11.4	12.5	14.2	18.6	12.3	20.0	20.4	12.8	9.3	16.0	13.2
4	11.2	12.1	9.7	11.9	10.2	7.9	6.1	11.4	8.4	11.2	12.7
5	9.1	12.1	23.1	9.3	23.2	16.8	17.4	10.0	30.2	12.9	12.1
6	9.8	10.3	12.7	12.4	13.0	6.0	4.6	8.4	14.0	6.4	8.6
6a	4.8	3.5	3.2	3.1	2.7	2.8	2.8	4.0	3.2	3.1	3.0
7	8.1	8.1	6.2	7.2	5.5	5.7	5.5	9.3	6.0	8.4	9.3
8	7.2	5.7	5.0	5.2	4.8	4.6	4.6	7.4	5.5	6.4	7.4
9	4.8	4.8	4.1	5.2	4.1	4.2	3.7	4.9	3.5	3.9	5.4
10	8.4	7.7	6.2	7.2	5.8	5.6	4.6	6.4	6.0	8.7	8.6
11	3.1	1.8	1.5	0.6	1.4	1.4	1.4	2.5	1.4	1.7	1.6
12	2.3	1.3	1.2	0.5	1.0	1.0	1.0	1.7	1.1	1.5	1.2
13	1.8	1.1	1.2	0.3	0.7	0.7	0.7	2.4	1.2	2.2	1.2

*Commercial preparation of PCB supplied by Monsanto Canada Ltd., Toronto, Ontario.

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Discussion

The DDT pesticide group and PCB have certain similar physical and chemical properties. Since the DDT group possesses lipophilic properties, it was to be anticipated that PCB would share this affinity for fatty tissue as well. It is evident from the above data that the PCB compounds have this definite predilection for adipose tissues, since their concentration in fat was three times that in the muscle of the dead steer and ten times that in the muscle of the slaughtered steer.

It is interesting to note that in milk, peaks Nos. 1 and 3 increased substantially in the first month whereas peaks Nos. 4, 5 and 6 decreased during the same period. On the other hand, apart from peak No. 1, contrary effects were observed in fat samples obtained from the steer that died during the incident and the steer which was slaughtered three months later. The cause of these variations cannot be ascertained at the present time.

The decrease in the concentration of PCB in the milk was slow, pointing to possible danger from the exposure to dairy cattle to these products. At the same time it is interesting to note that there was a tenfold difference in the PCB in the muscle of the two steers analyzed three months apart but only a fourfold difference in the fat. This points again to a strong lipophilic property of PCB and to their persistence in fat. It is difficult to draw any conclusions from the above findings, since very little information is available about the effects of PCB on food-producing animals and, consequently, on man.

At the present time, we are unaware of any information on the use of PCB in pesticide formulations in Canada. However, they were probably used for that purpose in the U.S.A. since, in April 1970, the manufacturers of PCB in that country requested the Department of Agriculture to prohibit their use in insecticide formulations.

Since PCB are available in Canada also, we wonder what their uses are in this country and how they contaminate the environment. On numerous occasions we have detected the presence of PCB in gulls from southern Ontario but were unable to locate the source.

Summary

A milking cow and two steers were exposed to PCB, probably as a result of drinking water from a contaminated stream. One of the steers died from unknown causes immediately after exposure. Analyses indicated that PCB were still present in the milk of the cow one month after exposure and in the tissues of both steers, one of which was slaughtered three months after the incident.

Résumé

Une vache laitière et deux bouvillons furent exposés à des biphényles polychlorés, probablement en buvant de l'eau provenant d'un ruisseau contaminé. Un des bouvillons mourut de causes inconnues aussitôt après avoir été exposé à ces composés. Les analyses ont démontré que la présence des biphényles polychlorés dans le lait a persisté pendant au moins un mois après l'ingestion de ces substances par la vache. On a également décelé la présence de ces mêmes composés dans les tissus des deux bouvillons, l'un mort sur la champs, l'autre tué trois mois après l'incident.

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BOOK REVIEW

Health and Disease in Farm Animals. First Edition. W. H. Parker. Published by Pergamon Press, Oxford, England and Toronto. 1970. 301 pages. Price $6.25.

This book is an attempt to bridge the gap between the veterinarian and those concerned with animal husbandry, i.e. agriculture students, 4-H er's and the better-than-average farmer.

The contents of this book are divided into two main sections – (1) the structure and function of the animal body, and (2) health and disease. The first section is subdivided into body systems with each body system being discussed in easily readable non-medical language. The second section is divided into the general principles of diseases, government policies on disease control (U.K.), the relationship of environment to health and disease and special medicine.

The main domestic animals discussed in this book are cattle, sheep and swine, generally in that order, however, specific species disease problems are also adequately discussed where applicable as well as the species differences of the same disease. The geographical examples apply mainly to the British Isles. Regardless, the principles of health promotion and prevention of disease are factual, as well as being easily readable, and applicable world wide.

This book is to be recommended to supplement course content or lecture material of a veterinarian involved in teaching agricultural students, or lecturing to 4-H er's or better-than-average farmers. There are a few spelling mistakes present within the text which detract slightly from an otherwise excellent little book for those concerned with animal husbandry of cattle, sheep and swine. *J. A. Mills.*

Diseases of Poultry. Second Edition. P. Seneviratna. Published by The Macmillan Company of Canada, Toronto. 1969. 229 pages. Price $7.40.

An author attempting to cover the entire field of poultry diseases in 229 pages is hampered by a decision as to whether he wishes his text to be a comprehensive reference for specialists in avian diseases, or merely a handbook for others who are occasionally confronted with domestic bird disease problems. Unfortunately, the author of this particular text has performed neither of these functions.

The dissertations on most of the important diseases are too short and not inclusive enough to be of any significant value to the pathologist who is attempting to make a precise differential diagnosis, and yet the very brief descriptions of some of the diseases and parasites would prove to be only confusing to someone not experienced in the field.

The illustrations do not add to the text, due to the lack of contrast in reproduction. *H.C.C.*

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