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SHORT COMMUNICATIONS

DIELDRIN RESIDUES IN ANIMAL TISSUE FROM NORTHERN BOTSWANA

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ABSTRACT. Levels of chlorinated pesticides have been determined for samples of animal tissue from the Savuti channel in northern Botswana. Extraction was performed using a hexane/dimethylformamide partition method. Detection and quantification were carried out using gas chromatography with an electron-capture detector. Negligible amounts of lindane and DDT were present but dieldrin was found in concentrations in the range 6 to 400 ppb.

INTRODUCTION

Dieldrin is one of the group of chlorinated hydrocarbon pesticides which was first used widely in the world because of its cheapness and efficacy. However, following growing fears over its toxicity (1), its possible mammalian carcinogenicity (2), and its persistence in the environment, its use has been increasingly restricted, so that it is now classified as a 'Group I' pesticide, with very few permitted applications (3,4).

In Botswana, use of dieldrin was introduced in the 1960's (5) as part of the campaign to control the Tsetse fly (*Glossina morsitans*) which is the vector for the various *Trypanosoma spp* that cause sleeping sickness. The fly is found only in the Okavango Delta in the north west of the Country, and its presence has in many ways preserved this unique ecosystem from mankind's harmful effects. However the range of the fly has been steadily growing since the late nineteenth century, so imperilling people and their livestock living on the periphery of the Delta. Early control efforts begun in 1943 were costly, environmentally questionable, and largely ineffective, so use of chemical pesticides appeared very attractive. Comparative studies showed that dieldrin was more effective than DDT in control of the fly, hence its use was introduced in 1967, and regular applications were made until 1984, when it was replaced by the pyrethroid deltamethrin (7). Rather than blanket spraying the whole Delta, which would have been difficult given the terrain, ground spraying using 3% dieldrin was done in selected areas, these being chosen with a view to maximum effectiveness in controlling spread of the fly (5). Over this period, most areas received several treatments, but these were rarely in successive years, the one exception being the Savuti Channel, which forms a possible "bridge" for the fly to spread eastwards. It thus seemed to us probable that samples from this area would indicate the impact of the pesticide on the environment, the extent of bio-accumulation, and whether fears raised in the popular press were justified.

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MATERIALS AND EXPERIMENTAL METHODS

Materials. Animal tissue samples were collected from the Savuti Channel (1978), and flown in ice to Gaborone where they were stored at -20°C in the Chemistry Department until analysis.

All chemicals used were analytical grade, and solvents were distilled before use.

Samples were analysed on a Perkin-Elmer F33 Gas Chromatograph fitted with an electron-capture detector, and using a glass column (2 m x 3 mm) packed with 2½% OV-17 on Chromosorb-G (AW-DCMS) with (white spot) nitrogen as carrier gas. The oven temperature was maintained at 170°C, and the injection port at 250°C.

Preparation of samples. Extraction was performed using the method of de Faubert Maunder et. al. (8). Samples (10 g) were ground up (blender) with three to four times their weight of anhydrous sodium sulphate. The finely ground mixture was exhaustively extracted (Soxhlet) with hexane for up to 16 hrs. The extract was concentrated to 50.00 ml. A 25.00 ml portion of this was washed with dimethylformamide (DMF) saturated with hexane (3 x 10 ml), and the combined extracts then washed with hexane saturated with DMF (10 ml). After the layers had separated, the hexane layer was removed and washed with a further portion of DMF (10 ml), then all the DMF extracts (~40 ml) were added to 2% aqueous sodium sulphate (200 ml). The mixture was shaken vigorously for 2 minutes, and allowed to settle for 10 minutes. The upper layer was separated and the aqueous layer and glassware washed with an additional small volume of hexane. The hexane extracts were combined and the volume adjusted to 10.00 ml.

This solution could be further purified by passing through a short column of Florisil (30 g), eluting with 50% hexane/dichloromethane (300 ml), evaporation, and then dissolving the residue in hexane, again to a total volume of 10.00 ml.

Analysis of extracts. Aliquots (5 µl) of standards of DDT, dieldrin, and lindane of known concentration were injected to establish detector response and retention times, and to give the relationship of peak area to amount applied. All solvents after purification were checked for absence of peaks, and blank determinations were performed following the extraction procedure above but omitting the animal tissues. The recovery level was determined by adding 10 µg of dieldrin to an extracted sample, and repeating the full extraction process. Determinations on each sample were done in duplicate. Extractions were repeated with samples "spiked" with dieldrin to demonstrate peak coincidence.

RESULTS AND DISCUSSION

None of the samples analysed showed any trace of lindane, which was hardly surprising given that there is no record of the pesticide having been used at all in the area. Nor were there significant amounts of DDT, but all showed the presence of dieldrin, consistent with the repeated applications of the latter in the Savuti area, and restricted use of DDT. Table 1 gives quantities of dieldrin found in the samples analysed. Recovery levels were about 88%, but this factor has not been included in the calculation, so actual burdens of pesticide must be considered as a little higher than shown.

The species investigated were chosen because it was felt that they would be those most likely to accumulate the pesticides from their position in the food chain, and so indicate the environmental stress actually occurring. Thus dieldrin leaching into the waters of the Savuti channel would be accummulated by

Table 1. Amounts of dieldrin found.

Animal		Sample	Amount of dieldrin ppm (mg/kg)
Crocodile A	- muscle + adipose	1	0.070 (± 0.002)
Crocodile B	- liver	2	0.035 (± 0.002)
Crocodile C	- tail muscle	4A	negligible
	fat	4B	0.130 (± 0.002)
Crocodile D	- muscle	7	0.012 (± 0.002)
Fish eagle	- brain	3	0.100 (±0.004)
King fisher III	- brain	6A	0.006 (± 0.001)
	liver	6B	0.630 (± 0.012)
King fisher V	- brain	5A	0.012 (±0.003)
	liver	5B	0.390 (± 0.008)

fish, which could in turn be consumed by predators such as crocodiles (*Crocodilus niloticus*), fish-eagles (*Haliaetus vocifer*), and pied kingfishers (*Ceryle rudis*).

The seven animals analysed all showed modest amounts of dieldrin present, with the insecticide occurring as expected mostly in the liver and fatty tissue. The levels found are comparable to or less than those noted elsewhere in the world where dieldrin has been used (Table 2), and indeed rarely exceed the values permitted in meat sold for human consumption (4).

Table 2. Comparative values for dieldrin in birds.

Country	Species	tissue	Mean values mg/kg (with max)	Ref.
Canada	California Gull (*Larus californicus*)	brain	0.04	9
		liver	0.07	
		abd. fat	1.0 (1.9)	
Norway	Starling (*Sturnus vulgaris*)	breast muscle	0.37	10
South Africa	Reed Cormorant (*Microcarbo africana*)	brain	0.35	4
		fat	0.71 (1.04)	
		liver	0.083 (0.17)	
	Darter (*Anhinga rufa*)	brain	0.43	
	White-breasted Cormorant (*Phalacrocorax lucidus*	brain	3.4	
		fat	1.14 (1.85)	
	Egyptian Goose (*Alopochen aegypticus*)	liver	1.46 (2.70)	
	Guinea fowl (*Guttera lividicollis*)	fat	3.15 (29.32)	
		liver	0.063	
United kingdom	Heron (*Ardea cinerea*)		3.30	3
	"Freshwater birds"		5.50	

Although no information is available on toxic doses or LD_{50}'s for the species analysed from Botswana, if one assumes they are similar to those listed in Table 2, then it is probably safe to say that the levels found are tolerable, and are not likely to cause environmental harm. It is also known that levels are subject to equilibrium processes, such that a steady state is reached, so it is not impossible that with the repeated sprayings in Savuti prior to 1979 these values reflect equilibrium levels in those species, and that with the cessation of dieldrin spraying in 1984, levels will drop (11, 12). Future work would examine this, and also determine residues for other areas in the Okavango systems, where spraying has been less or non-existent.

CONCLUSIONS

Although dieldrin residues have been found in predator species in an area when extensive dieldrin spraying has been carried out, the levels are all less than 1 ppm, and can probably be considered as acceptable, especially since spraying has ceased.

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