An Orientational Survey on the Side-effects and Environmental Distribution of Insecticides Used in Tsetse-Control in Africa

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The environmental implications which may result from the use of chlorinated hydrocarbon insecticides have aroused far more concern in Europe and the United States than in many tropical regions of the world, although large amounts of these pesticides are used throughout the tropical belt.

This study deals with the environmental distribution and side-effects of dieldrin and DDT used in tsetse-control in Kenya and Nigeria. General levels of contamination have been measured in Lake Victoria and Lake Chad and some of its tributaries. Additional information concerning this study will be published separately (1,2,3).

Methods

Observations were made in 1968 in sprayed areas at different intervals after treatment. Birds were collected with mist nets (15 x 3 m), a shotgun (bore 12) and a rifle (0.22). Fish was bought from the local fishermen.

For chemical analysis whole fish, lateral muscles of fish and livers and brains of birds were homogenized in a meat grinder or in a mortar and the homogenate dried with anhydrous sodium sulfate (4). The dried tissue homogenates were stored in alumina containers with screw caps (Krieg and Zivy, Paris), which were sealed with plastic tape. The containers were forwarded to the laboratory in Utrecht and stored at -15°C after arrival.

The chemical analysis proceeds as follows. Samples are extracted with petroleum ether. After careful evaporation of the extract the residue is dissolved in hexane and submitted to liquid liquid partition with dimethylformamide (5) and column chromatography over activated Florisil. Column chromatography is performed in two steps: First the apolar compounds are eluted with hexane; and then dieldrin and endrin are eluted with 10% diethylether in hexane. Final detection is carried out by gas liquid chromatography with electron capture detection (A-610-C and 204-B-1 instruments of Varian Aerograph). The pyrex columns were packed with (a) intimately mixed equal portions of previously coated 80/100 mesh Gas Chrom Q; one portion with 15% QF-1 and the other with 10% DC 200; and (b) 10% DC 200 on Gas Chrom Q 80/100 mesh (6).

Observations in direct relation to spraying

Observations during and immediately after dieldrin spraying

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TABLE 1

Residues of dieldrin in the livers and brains of birds which were found dead or dying in the Wandere Valley

Species[a]	Sex	Date	Residue in ppm	
			liver	brain
Camaroptera brevicaudata	♀	8/2[b]	34	8.0
Camaroptera brevicaudata	♂	9/2	29	17
Camaroptera brevicaudata	♀	12/2	25	20
Melocichla mentalis	♂	8/2	23	-[c]
Melocichla mentalis	♀	10/2	18	15
Melocichla mentalis	♂	12/2	25	-[c]
Laniarius aethiopicus	♂	9/2	21	6
Cossypha heuglini	♂	10/2	27	7
Cisticola spec.	♀	12/2	27	20
Turdoides jardinei	♀	12/2	32	22
Tchitria viridis	♂	13/2	20	15
Centropus superciliosus	♀	13/2	57	13

a/ Bird names are in accordance with Mackworth Praed and Grant (10).

b/ The area was sprayed on 6/2/1968 at 5%.

c/ Head eaten by predator.

TABLE 2

Residues of dieldrin and DDE in the tissue of birds caught at Sikri

Species	n	Days after treatment	Tissue	Residue in ppm[a]	
				dieldrin	DDE
Camaroptera brevicaudata	5	66-70	liver	2.3 (1.0 - 3.0)	0.30 (0.10-0.42)
			brain	0.45 (0.10 - 0.68)	0.16 (0.10-0.26)
Turdoides melanops	3	70	liver	5.6 (5.0 - 6.0)	0.027 (0.024-0.032)
Icteropsis pelzelni	3	70	liver	1.4 (0.92 - 1.7)	0.12 (0.072-0.15)
Sylvietta whytii	2	68	liver	0.17 (0.17 - 0.18)	0.44 (0.21-0.68)
			brain	0.11 (0.10 - 0.12)	0.35 (0.22-0.49)
Cisticola spec.	2	61	liver	0.087 and 0.25	< 0.07
Pycnonotus xanthopygos	6	61-68	liver	0.48 (0.16 - 1.9)	< 0.10
			brain (4)	0.068 (0.057 - 0.086)	< 0.011

a/ The mean and range are given.

were carried out in a riverine forest bordering the Wandere Valley, a small streambed along the eastern slopes of the Ruri Hills in South Nyanza, Kenya. Dieldrin was sprayed selectively using knapsack spraying equipment (2.5% and 5.0% watery emulsions formulated from Dieldrex 20%).

Table 1 lists the residues of dieldrin in the livers and brains of the birds which were found dead or dying within 10 days after spraying. The finding of fresh specimens already eaten partly by predators indicated that the carcass disappearance rate was high. The levels found approximate the concentrations found in experimentally poisoned birds (7,8). Hence with respect to the lethal action of the pesticide, the insectivorous birds in this tropical habitat are very probably of similar susceptibility.

Graham (9) has listed species of birds found dead within 10 days after spraying against tsetse flies in Botswana. Spraying was not carried out with knapsack spraying equipment, but with a more powerful instrument (type not specified). Birds listed include some of the species found dead or dying in our study area, but also species which were observed alive or which contained relative low residues (1) in our study area.

Species found dead by Graham and alive or carrying low residues in our study are: Halcyon leucocephala, Phoeniculus purpureus, Streptopelia capicola, Turtur chalcospilos, Dicrurus adsimilis, and Hirundo spec. This supports the assumption made by Graham that the damage to wildlife in the operation he studied was probably greater than if knapsack sprayers would have been used. By using the latter the insecticide can be sprayed selectively to the parts of the trees where the flies find their resting sites.

Residue levels in birds caught two months after spraying.

Birds were caught on the peninsula Sikri which protrudes into Lake Victoria near the Ruri Hills referred to above.

The area was sprayed for the first time between 23 September and 3rd October 1967 and for the second time between 13th November and 24th November 1967 (at 5.0% both times).

The residues of dieldrin and DDE in the tissues of the resident bird species are given in table 2.

Concentrations of dieldrin are highest in Turdoides melanops. This species lives near the water and was caught close to the fringe of papyrus beds bordering part of the peninsula. Obviously these birds got their residues from the dieldrin sprayed in lake-shore operations against Glossina fuscipes. The same applies for Icteropsis pelzelni living in the same habitat. Residue levels are intermediate in Camaroptera brevicaudata, a species which was severely affected in the Wandere Valley operations. The results show that about two months after treatment residues are markedly lower relative to the levels observed in birds dying shortly after spraying.

Residues of DDE are low. Relative high levels of DDE were detected in the livers of three specimens of Milvus migrans shot at Sikri (table 3). All three specimen of Milvus migrans contained the remnants of small rodents in their stomachs.

TABLE 3

RESIDUES IN MILVUS MIGRANS

Reg.no.	Sex	Tissue	Residue in ppm dieldrin	DDE
1	♀	liver	1.4	10.3
		brain	0.83	4.8
2	♂	liver	0.98	10.3
		brain	0.49	3.3
3	♂	liver	1.4	3.8
		brain	0.94	1.4

DDE residues in the tissues of these kites are much higher than those in the other species. It is probable that the birds acquired these residues by feeding on contaminated food elsewhere in Africa.

General contamination of the aquatic environment

For measuring the general contamination levels of Lake Victoria and the Chad basin a number of indicator organisms have been selected.

Among the birds Ceryle rudis, the pied kingfisher and Phalocrocorax africanus, the african cormorant are suitable indicator-organisms for the aquatic habitat. They occur everywhere in Africa south of the Sahara and the range of the pied kingfisher goes as far as Turkey and Israel. Both species seem to be residents through their range (11,12).

Likewise fish species were collected. Species of the genera Tilapia, Alestes, Clarias and Hydrocynus were selected for this purpose.

It was intended in this study to include a mollusc species in the sampling program and it was decided beforehand that the lamellibranch Etheria elliptica should be a suitable indicator-organism for the African continent. However in most places visited no specimens could be found.

The results of the residue analyses are given in table 4.

The residue levels in Ceryle rudis are three to four times as high as those in Phalocrocorax africanus. The kingfishers fish almost exclusively close to the shore and are liable to be the first fish-eating species to be exposed to the dieldrin used in lake shore spraying operations. After one year the residues in this species have dropped markedly which indicates that run-off in the wet season did not result in an increase of the local contamination level.

Residue levels in lake Chad and some of its tributaries are low in spite of the abundant use of chlorinated hydrocarbon insecticides in the countries which surround the lake (vector control, cotton culture). The riverine forests bordering the Yobé river system have been sprayed with tons of DDT between

TABLE 4

Residues of insecticides in aquatic indicator organisms from Lake Victoria and the Chad Basin

Sampling place	Date	Spec.	n	Tissue[a]	Residue in ppm	
					dieldrin	DDE
Lake Victoria						
Sikri shore	26/1/1968	Cer. rudis	5	L	1.3 (0.91-1.8)	0.32 (0.18-0.44)
id.	id.	Phal.afr.	5	L	0.30 (0.04-0.40)	0.10 (0.06-0.14)
id.	10/2/1969	Cer.rudis	5	L	0.24 (0.15-0.30)	0.19 (0.078-0.31)
Homa Bay	31/1/1968	Til.esculenta	5	TB	0.049 (0.014-0.086)	<0.010
id.	id.	Al.jacksoni	5	TB	0.045 (0.023-0.071)	<0.013-0.025
Mirunda Bay	7/2/1968	Clar.mozambicus	4	LM	0.010 (0.009-0.012)	<0.010
Chad Basin[b]						
Zigage flood plain (NC)	9/3/1968	Cer.rudis	5	L	<0.006-0.025	0.010-0.097
Logone at Pouss (NC)	11/3/1968	id.	4	L	<0.010	0.16 (0.09-0.26)
Lake at Mallamfatori (N)	18/3/1968	id.	4	L	<0.010	0.12 (0.06-0.17)
Yobé at Abadan (N)	20/3/1968	id.			<0.010	0.096 (0.04-0.15)
id.	id.	Phal.afr.	7	L	<0.004-0.17	0.026 (0.012-0.040)
Chari at Ft.Lamy (Ch)	23/3/1968	Hydrocynus forskali	4	TB	<0.006	0.009 (0.008-0.011)

a/ L=liver, TB = totalbody, LM = lateral muscle

b/ Name of country betw. parentheses NC = North Cameroon, N = Nigeria, Ch = Chad

1952 and 1966 (13). Endrin, which is used in the cotton growing areas was not detected in this study (detectability limit <0.008 ppm). The residues observed in the Chad basin are low compared to the residues found in wildlife specimens from the Atlantic and Pacific (14,15). The results are not contradictory to the hypothesis that in these arid countries a large proportion of the insecticides are lost into the atmosphere by evaporation and co-distillation. If this is true the arid parts of the globe can be supposed to be an important source for the relative high concentrations found in regions of the Atlantic and Pacific, transport by air and precipitation by rain being the main mechanisms of transport. The study is continuing. It is also considered that in some of the river systems concerned only a fraction of the catchment water reaches the lake (3).

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