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AN INVESTIGATION OF THE CONTENT OF THE CHLORINATED HYDROCARBON RESIDUES OF THE CRUSTACEAN PLANKTON IN THE BALATON

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Researches done in recent years have irrefutably demonstrated, especially with respect to the studies made on synthetic chemical substances deriving from agricultural areas and on the effects of DDT and its derivatives applied against mosquitoes, that the chlorinated hydrocarbons caused incalculable damages in the aquatic ecosystems (HUNT and BISHOFF 1960, KEIT et al. 1964, HICKEY and KEITH 1964, TARZWELL 1965, SEBESTYÉN 1967, etc.).

Investigations have currently come to the fore aiming at a better understanding of the accumulation of pesticides via the food chain. The indispensability of these studies were justified by the recognition that pesticide residues, of a relatively small concentration but arriving in the aquatic habitat, accumulate by way of the aquatic insect larvae and zooplankton organisms causing the death both of fish and fish-eating birds. The demonstration of the validity of accumulation through food chains was proved by the classic case of Clear Lake in California (HUNT and BISHOFF 1960). After treating the lake by 0.02 ppm DDT, the spray residue brought about, by concentrating through the plankton organisms (5 ppm) and fish (2 ppm) a high rate of death in the western grebe (1.600 ppm).

In the food chain, crustaceans, and especially those living in the plankton, play an important role by their very mass. Thus, the average yearly biomass of the zooplankton in the Balaton can be estimated to attain 1002 metric tons, of which the crustacean plankton constitutes 945 m. tons, hence about 94 per cent of the zooplankton (SEBESTYÉN 1958). With due regard to the fact that the yearly production of this group of organisms is about thirtyfold of the biomass (ENTZ 1954), the role and significance of the plankton crustaceans become increasingly conspicuous.

Parallel with the manufacture and application of the diverse pesticides, a number of research workers selected the notoriously sensitive *Daphnia*-species for establishing the rate of toxicity of these substances (e.g. ANDERSON 1945, 1960). In recent works, attempts have been made to use also other Crustacea genera for this purpose (SANDERS and COPE 1966, RUBER 1965, 1965a, KAMINSKI 1966, etc.). Beside these important tests field work involving crustaceans of the plankton is comparatively meagre, despite their known significance and importance (TARZWELL 1965, HICKEY and KEITH 1964).

In the course of our earlier investigations (BARON, CSONTI and PONYI 1967), we succeeded to show a significant amount of pesticide residues in the crustacean plankton of the Balaton. Since our data derive merely from some points of the lake and from the fall period, we deemed it necessary to extend our studies, as far as possible, to the entire open water body of the Balaton and the whole period of development of the crustacean plankton.

Material and methods

Samples were collected from transversal sections, at right angles to the longitudinal axis of the lake, namely 3 (M, K, G) from the SW, and 2 (A, E) from the NE sections of the Balaton (cf. SEBESTYÉN 1960, p. 118—119). Large-sized plankton-nets ($\varnothing = 0.22-0.27$ mm), towed by motorship, had been used. The collecting and analysis of the material was continuously made through 6 months, from May till October, 1967. On every occasion, about 500 g (wet weight) crustacean mass per section had been taken. The material was stored in refrigerators and worked up within a few days. The specific composition of the samples was also identified *(Table 1)*.

The identification of the spray residues was made by thin-layer chromatography (BARON et al. 1967). About 300—400 g of each sample were worked up, subsequent to having left them for one hour on filter paper in order to facilitate the evaporation of surplus water. The humidity content of the crustacean plankton analysed was 90.34 ± 0.74 per cent.

The specific composition and per cent distribution of the samples was established by recourse to the relative-quantitative method (SEBESTYÉN 1953).

Results and conclusions

Of the residue components studied, only the γ-HCH and DDT derivatives could be demonstrated *(Table 2)*.

Results show that the quantity of chlorinated hydrocarbons had variously evolved in space and time. In the sections, the value of the residues was the largest during the summer months (June, July, August). The summer maximum is also varying in the diverse sections *(Fig. 1)*. The highest values were found in the two sections of the NE basin and in section K of the SW part of the lake.

No connection between the distribution of the pesticide residues and the per cent composition of the plankton is apparent *(Table 1)*. The horizontal distribution of the content of spray residue in the crustacean plankton is therefore probably due to the fact that various amounts of pesticides became introduced to the diverse areas of the lake. The abrupt increase of DDT and its derivatives in the summer months may also be connected with campaigns attempting to destroy mosquitoes.

JONES and MOYLE's data (1963) demonstrate that the treatment of lakes by DDT is detrimental to the crustacean population. The effects appear in the periodic decrease of quantity subsequent to the treatment. The first application of DDT on the shores of the Balaton, for experimental purposes, was made in 1950—51 (MIHÁLYI and SOÓS 1952), and it is also regularly continued since

Table 1
Per cent composition of the crustacean plankton investigated for the demonstration of chlorinated hydrocarbons

Date of collection Species	M	K	G	A	E
16—18 May					
Diaphanosoma brachyurum	—	2.22	1.91	1.82	0.82
Daphnia cucullata	5.46	11.85	17.20	7.88	14.75
D. hyalina	20.00	31.84	10.19	12.73	12.29
Eudiaptomus gracilis	20.00	29.63	54.13	51.51	47.54
Cyclops vicinus	24.25	8.89	12.74	19.39	11.47
Mesocyclops leuckarti	29.10	8.14	3.18	4.24	9.02
Others	1.21	7.41	0.64	1.82	4.10
20 June					
Diaphanosoma brachyurum	22.05	18.49	17.68	Pesticides were not analysed	
Dauphia cucullata	23.57	30.39	17.68		
D. hyalina	12.86	14.53	10.20		
Eudiaptomus gracilis	12.13	4.40	5.44		
Mesocyclops leuckarti	24.99	30.39	46.25		
Others	4.41	1.76	2.72		
18—20 July					
Diaphanosoma brachyurum	37.88	37.16	47.24	9.67	38.73
Daphnia cucullata	17.42	7.78	6.75	12.10	2.81
D. hyalina	3.02	2.02	1.23	3.23	1.81
Eudiaptomus gracilis	9.09	15.54	30.67	59.68	30.28
Mesocyclops leuckarti	30.30	30.40	13.50	15.32	26.76
Others	2.27	6.08	0.61	—	—
15—16 August					
Diaphanosoma brachyurum	4.07	35.66	18.18	17.18	31.72
Daphnia cucullata	23.57	25.17	2.48	4.69	2.07
D. hyalina	0.81	—	—	—	—
Eudiaptomus gracilis	21.14	28.67	52.06	52.34	50.34
Mesocyclops leuckarti	45.53	9.08	27.27	23.44	14.48
Others	4.88	1.40	—	2.34	1.38
19—20 September					
Diaphanosoma brachyurum	20.42	22.79	11.11	11.71	34.13
Daphnia cucullata	7.72	8.83	11.10	11.18	22.22
D. hyalina	0.70	0.73	—	—	0.79
Eudiaptomus gracilis	57.74	44.85	68,88	65.79	34.91
Cyclops vicinus	6.33	6.62	4.44	4.61	1.58
Others	1.47	1.47	0.74	—	3.97

1957—58. If the average summer amount of open water crustacean plankton of 1955 and 1958 is compared (as calculated from SEBESTYÉN's data 1960), it will be found that whereas the average value was 28.40 ± 4.57 individuals/liter in 1955, it decreased to 15.60 ± 2.34 ind/l. in 1958. The two values differ significantly ($0.05 > P > 0.02$).

By comparing the pesticide content of the animal groups analysed during 1966—1967 *(Table 3)*, it appears that the highest means derive from the crustacean plankton originating from the middle of summer. Since the objects studied do not derive from identical dates, the comparison of the values should be considered for general information only.

Comparing various summer samples of some lakes, KEITH et al. (1964) found, among others, that the highest amount was demonstrable from the suspended material (plankton!) (6.0—9.3 ppm), followed by that of fish

Table 2

The content of chlorinated hydrocarbons of samples of crustacean plankton in various areas of the Balaton

Date of collection	Section studied	Chlorinated hydrocarbon residues in ppm					
		HCH			DDT		
		γ	DDD	DDT	?	DDE	Total
V. 17.	A	ny	0.01	0.02	0.03	0.14	0.20
V. 18.	E	0.06	0.02	0.02	0.02	ny	0.12
V. 16.	G	0.06	0.06	0.06	0.06	ny	0.24
V. 16.	K	0.03	0.08	0.06	0.03	ny	0.20
V. 16.	M	0.07	0.07	0.07	0.07	ny	0.28
VI. 20.	G	0.10	0.02	0.10	ny	ny	0.22
VI. 20.	K	0.20	0.50	0.60	0.20	0.80	2.30
VI. 20.	M	0.10	0.10	0.10	0.10	0.10	0.50
VII. 20.	A	2.00	2.30	2.00	ny	3.00	9.30
VII. 19.	E	1.00	0.20	0.80	ny	0.80	2.80
VII. 19.	G	0.20	0.30	ny	ny	ny	0.50
VII. 18.	K	0.30	0.30	1.20	ny	0.20	2.00
VII. 18.	M	0.10	0.10	0.30	ny	0.10	0.60
VIII. 16.	A	0.15	0.20	0.25	ny	0.06	0.66
VIII. 16.	E	0.08	0.08	0.40	0.16	0.13	0.85
VIII. 15.	G	0.04	0.10	0.50	0.20	0.20	1.04
VIII. 15.	K	0.05	0.10	0.30	0.10	0.30	1.30
VIII. 15.	M	0.06	0.02	0.05	0.02	0.03	0.18
IX. 20.	A	0.01	0.01	0.02	0.02	0.04	0.10
IX. 20.	E	0.01	0.02	0.01	0.01	0.01	0.06
IX. 19.	G	0.01	0.02	0.01	0.02	0.02	0.10
IX. 19.	K	0.01	0.01	0.02	0.02	0.03	0.09
IX. 19.	M	0.02	0.02	0.02	0.02	0.03	0.11
X. 23.	A	ny	ny	ny	o	ny	ny
X. 23.	E	0.01	0.01	0.01	o	0.01	0.04
X. 17.	G	0.01	ny	0.01	ny	0.01	0.03
X. 17.	K	ny	ny	0.01	o	0.01	0.02
X. 17.	M	0.01	ny	0.01	o	ny	0.02

Remark: α-, β-, δ-HCH; aldrin, dieldrin were not demonstrable by the method applied
? = unknown component

Table 3

The chlorinated hydrocarbon content of some groups of organisms of the Balaton, as found by investigations in 1966—67
(mean values in ppm)

	Crustacea[2]	Fish[1]	Bivalves[1]
γ-HCH	0.72	0.19	0.23
DDT (total)	2.32	1.04	0.90

[1] = Based on the data of Baron et al. 1967; the column of fish represent the means of 4 common species.
[2] = Mean values from July.

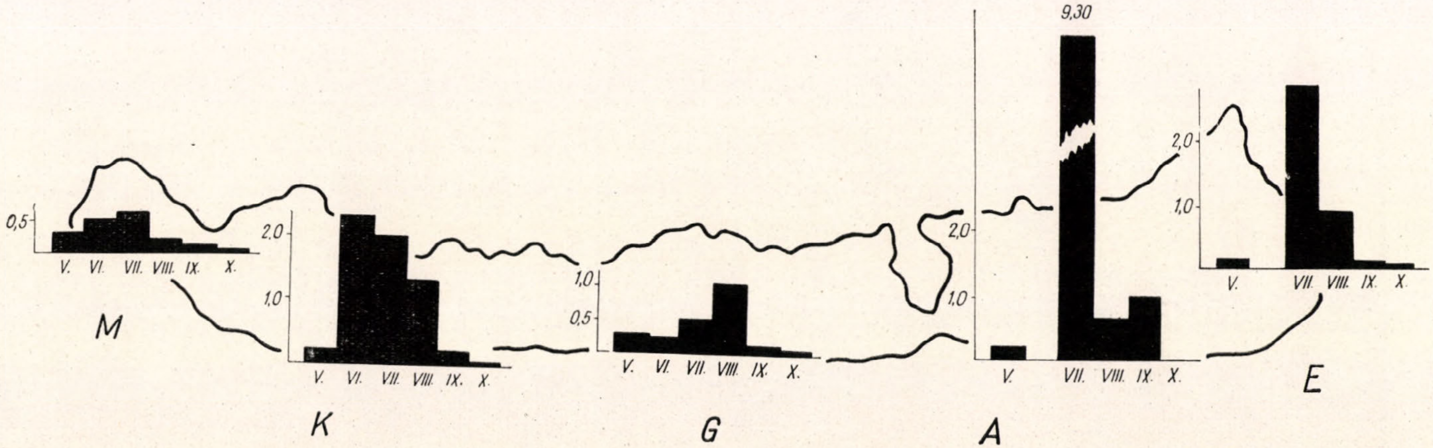

Fig. 1. The spatial and temporal fluctuation of the contents of chlorinated hydrocarbon residues in the crustacean plankton in the open water of the Balaton

1. ábra. A Crustacea-plankton klórozott szénhidrogén-maradék tartalmának tér- és időbeli változása a Balaton nyíltvízében

(1.5—3.3) and sedimented organic detritus (0.4—1.5). On the basis of the distribution of pesticides deriving from the animal groups shown in *Table 3*, we contend that the conditions in the Balaton are of the same nature, since the bivalves feed also on the fine sedimentary detritus of the bottom, and it is thus that the order of sequence

Crustacea > fish > bivalve

can be explained.

Summary

The authors investigated the amount of spray residue in the crustacean plankton in 5 transversal sections of the Balaton, during 6 months in 1967. It was established that significant quantities of residues in the various sections of the lake can be found during the summer months. The amount of pesticides accumulated in the crustaceans in various sections of the Balaton is of diverse rates.

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A CRUSTACEA-PLANKTON KLÓROZOTT SZÉNHIDROGÉN-MARADÉK TARTALMÁNAK VIZSGÁLATA A BALATONON

Összefoglalás

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Szerzők 1967-ben 6 hónapon keresztül a Balaton 5 keresztszelvényében vizsgálták a Crustacea-plankton permetmaradék mennyiségét. Megállapították, hogy a tó különböző szelvényeiben jelentős mennyiségű maradékok a nyári hónapokban találhatók. A Balaton különböző részeiben a rákokban felhalmozódott pesticidek mennyisége különböző mértékű.

АНАЛИЗ НАКОПЛЕНИЯ ПЕСТИЦИДОВ В ПЛАНКТОННЫХ РАКООБРАЗНЫХ ОЗЕРА БАЛАТОН

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Содержание пестицидов в планктонных рачках исследовали в течение 6 месяцев на пяти поперечных разрезах озера Балатон. Существенное содержание пестицидов обнаруживается в разных точках озера только в течение летних месяцев. В количественном отношении наблюдается различие между разными участками озера по содержанию пестицидов в планктонных ракообразных.