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The effect of different pesticides on the amphipod Gammarus roeseli Gervais

By

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ABSTRACT. The effects of different herbicides, pesticides and soil sterilizers on Gammarus roeseli have been investigated (groups of active ingredients: phenoxy acetic acid, carbamate, phosphoric acid-ester and aniline derivatives). During 168-hr exposure time the LC50 values decreased continually with temperature increasing from 5 to 20 °C. In the experiments carried out at 5, 10 and 15 °C, significant differences were found between the toxicity of pure 2,4-D and that of the Dikonirt preparation. According to the data obtained it is clear that there is no essential difference in the degree of tolerance of Gammarus specimens collected in various seasons of the year. Based on the Gammarus-tests, two of the 13 investigated inflows of Lake Balaton proved to be highly toxic for Gammarus roeseli.

Following the massive fish mortality in Lake Balaton during 1965, numerous data were collected evidencing the permanent pesticide pollution of the lake. Investigations carried out between 1965 and the 1970s (BARON et al. 1967, FELFÖLDY and TÓTH 1967, PONYI et al. 1968, PINKOLA and TÓTH 1971, PÁSZTOR et al. 1975, GÖNCZY et al. 1978) demonstrated the presence of DDT and its decomposed products, as well as γ-HCH, Aldrin, Dieldrin, chlorinated hydrocarbons in the aquatic animals. Since the 1970s derivatives of phenoxy-acetic acid and herbicides of triazin substance have also been found (CZEGLÉDI-JANKÓ et al. 1973, KÁROLY and FÜZESI 1977, PFEIFER et al. 1979).

During the years following the total ban of commercial production and use of chlorinated hydrocarbon-containing pesticides, they could still be detected in a significant amount in the water of Lake Balaton (PÁSZTOR et al. 1975, GÖNCZY et al. 1978). The main reason for this phenomenon is that the chlorinated hydrocarbons accumulated in plants and animals cannot precipitate because of the peculiar hydrographic characteristics of the lake (shallowness, wind effect, currents, etc). Comparing the series of data it has been established that the amount of residues of chlorinated hydrocarbons in predatory fishes has decreased. However, in alga-consuming ("filtering") silver carp (Hypophthalmichthys molitrix Val.) the residue content is still high (Table 1).

The amount of herbicides and pesticides used for the control of weeds in the drainage basin of the lake is continuously increasing. As an example, a set of data from gas-chromatographic investigations is shown (PFEIFER et al. 1979), proving the presence of a 2,4-D-containing herbicide (Dikonirt) in the lake and its tributaries since early spring till november (Table 3). This fact, among others, has stimulated us to study the effects of various pesticides on the biota of Lake Balaton. Due to their importance these researches have been financially supported by the Hungarian Academy of Sciences, Department of Natural Sciences II. (Biology), within the scope of a special programme. During the previous studies, the sensitivity of crustaceans (Eudiaptomus gracilis, Limnomysis benedeni, Dicerogammarus villosus and Gammarus roeseli) against pesticides was established and we concluded to that

Table 1. Level of pesticide residues in silver carp and pikeperch (mg/kg) at Keszthely Bay in June, 1973 (Pásztor et al., 1975)

Organ	Species	-HCH	Total DDT
muscle	silver carp	0.1360	0.506
	pikeperch	0.0133	0.1418
liver	silver carp	0.0357	0.1930
	pikeperch	0.0157	0.1418
brain	silver carp	0.0309	0.2002
	pikeperch	0.0078	0.1274

from these species, Gammarus roeseli seems to be a suitable object for further investigation. Its choice is justified by two reasons: 1) this animal is one of the most sensitive one to pesticides among the four species studied, 2) it can be collected in great amounts all year round from streams flowing into Lake Balaton.

The aim of our investigations was to elucidate the sensitivity of the above species to pesticides from many aspects.

MATERIAL AND METHODS

Eight different pesticides were used in this study (Table 2). Tests were performed at four temperatures (5, 10, 15 and 20 °C) in four replicas. The concentrations used were prepared from a standard solution diluted with filtered lake water. Toxicity of each concentration was checked on a group of ten animals. Following their collection the animals were kept at experimental temperatures for a week and then placed in beakers containing pesticide solution. Due to the predatory habit of the species each specimen was kept separately in 200 ml solution. The control group was kept in filtered lake water. If mortality exceeded 10% the experiment was not evaluated.

According to the effects of pesticides their toxicity may be acute or chronic. For the estimation of acute toxicity usually a short exposure time (24, 48, 96 hrs) is applied, while

Table 2. Grouping of tested pesticides and chemical composition of their active ingredients

Groups	Trade name	Chemical composition of active ingredients
Herbicides	Dikonirt	2,4-dichlorophenoxy acetic acid
	Eridocane 6E	S-ethyl-dipropylthiocarbamate
	Satecid 65 WP	N-isopropyl-2-chlor-acetanilide
Pesticides	Dimecron 50	0,0-Dimethyl-0-1-methyl-2 carbo-diethyl-amido-2-chloro-vinil-phosphate
	Ditrifon 5	0,0-Dimethvl-1-hydroxi-2,2,2-trichloro-ethyl-phosphate
	Fekama AT 25	0,0-Dimethyl-(2,2,2-tricholo-1n-butyril-oxyethyl)-phosphate
Soil sterilizers	Dyfonate 10 G	0-ethyl-S-phenyl-ethyl-dithio-phosphate
	Ipam	N-methyl-ammonium-dithiocarbamate

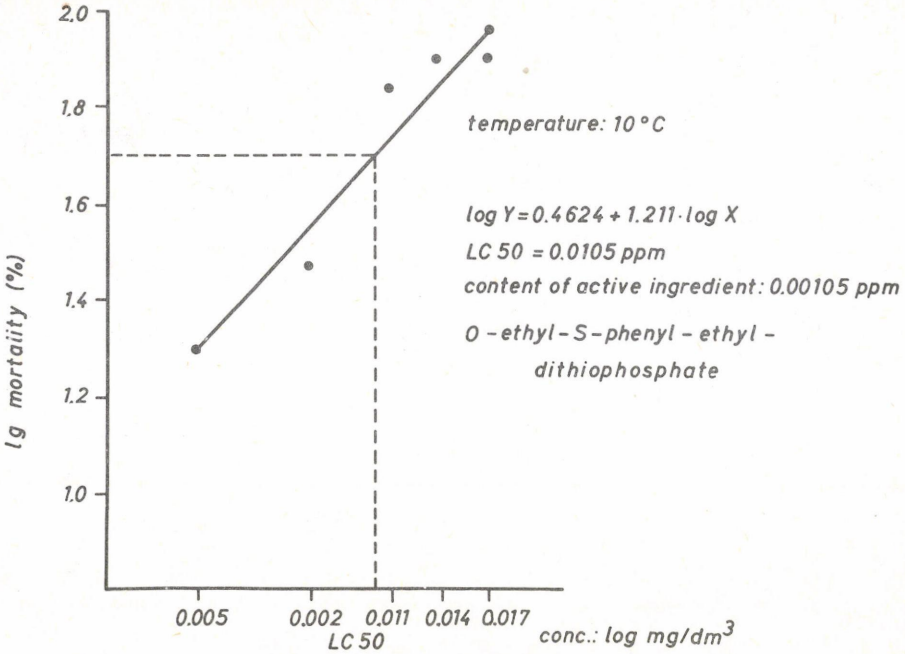

Fig. 1. Results of Gammarus roeseli test exposed to soil sterilized Dyfonate 10-G for 7 days (log-log transformation)

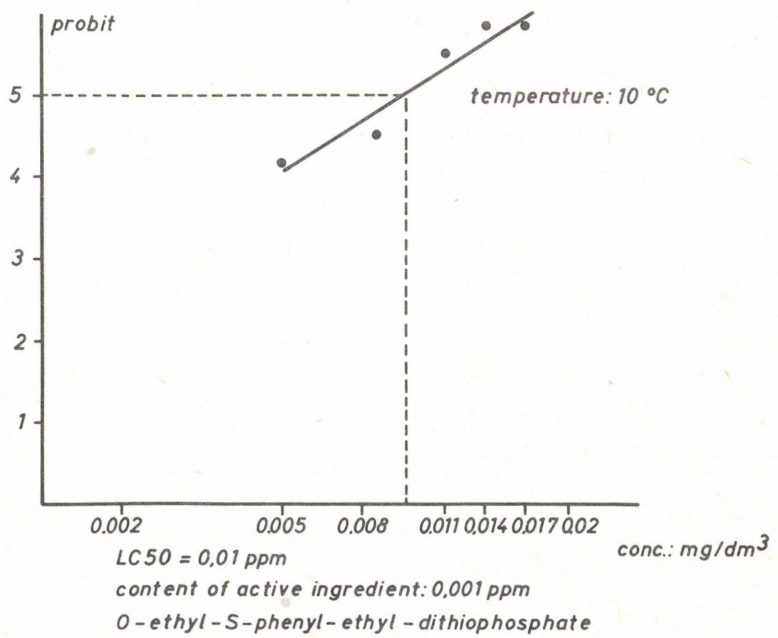

Fig. 2. Results of Gammarus roeseli test exposed to soil sterilized Dyfonate 10-G for 7 days (probit transformation)

Table 3. Occurrence of 2,4-D in the water of Lake Balaton and its tributaries ($\mu g/dm^3$) in 1977 (Pfeifer et al., 1979) (compare Fig. 5)

		22 March	12 April	6 May	1 June	1 July	9 August	20 September	14 October	13 November
Western zone canal (abbr. C. Nyugati)	a	-	2	1	-	-	-	-	-	-
	b	-	-	-	1	2	-	-	-	-
	c	-	4	-	-	4	1	-	-	-
Canal Keleti-bozót (abbr. C. Keleti)	a	-	2	-	3	5	-	2	-	-
	b	-	2	2	4	1	-	1	1	-
	c	-	1	-	-	1	-	2	-	-
Water gang Ordacsehi (abbr. W.g. Ordacsehi)	a	-	-	2	-	2	-	-	-	-
	b	-	-	-	2	1	1	-	-	-
	c	-	-	-	-	1	1	-	-	-
Stream Egerviz	a	-	-	4	4	5	-	1	-	-
	b	-	-	2	4	1	2	1	-	-
	c	-	-	4	6	1	ø	1	-	-
Stream Aszófő	a	-	-	2	5	-	1	1	1	-
	b	-	-	2	ø	10	2	1	-	-
	c	-	-	4	ø	2	3	2	-	-

ø= no sample; - = 2,4-D 1 $\mu g/dm^3$; a = sample from inflow; b= sample from 100 m off the estuary; c= sample from 500 m off the estuary

Table 4. Results of Gammarus roeseli test with 7 days exposure in 1976-77 (Roman numbers indicate the months of collection of animals)

Name of preparation	LC50 (mg/dm^3)				LC50 active ingredient (mg/dm^3)				pH of solution
	5°C	10°C	15°C	20°C	5°C	10°C	15°C	20°C	
2,4-D					97	78	64.6	33.6	7.2
Dikonirt	87.1_{III}	82.3_{I}	79.5_{XII}	55.3_{XII}	63	59.5	57.5	40	8.45
Eradicane 6E	21_{IV}	17_{XII}	11.8_{X}	9.6_{IX}	1.26	1.02	0.708	0.576	8.2
Satecid 65 WP	5.1_{III}	3.9_{XI}	2.6_{XII}	1.5_{XII}	3.315	2.536	1.69	0.65	8.45
Dimecron 50	0.46_{I}	0.33_{VII}	0.23_{I}	0.18_{VII}	0.23	0.165	0.115	0.09	8.45
Ditrifon 5	1.2_{I}	1.0_{XII}	0.6_{XI}	0.42_{XI}	0.06	0.05	0.03	0.021	8.45
Fekama AT 25	5.3_{XII}	4.0_{XI}	3.5_{IX}	2.2_{XI}	1.325	1.00	0.875	0.55	8.3
Dyfonate 10 G	0.0127_{III}	0.009_{IX}	0.008_{IX}	0.0076_{X}	0.00127	0.0009	0.0008	0.00076	8.3
Ipam	2.7_{III}	2.4_{XI}	2.3_{XII}	2.3_{XII}	0.54	0.48	0.46	0.46	8.35

water of Lake Balaton	8.4
water of stream Aszófő	8.15

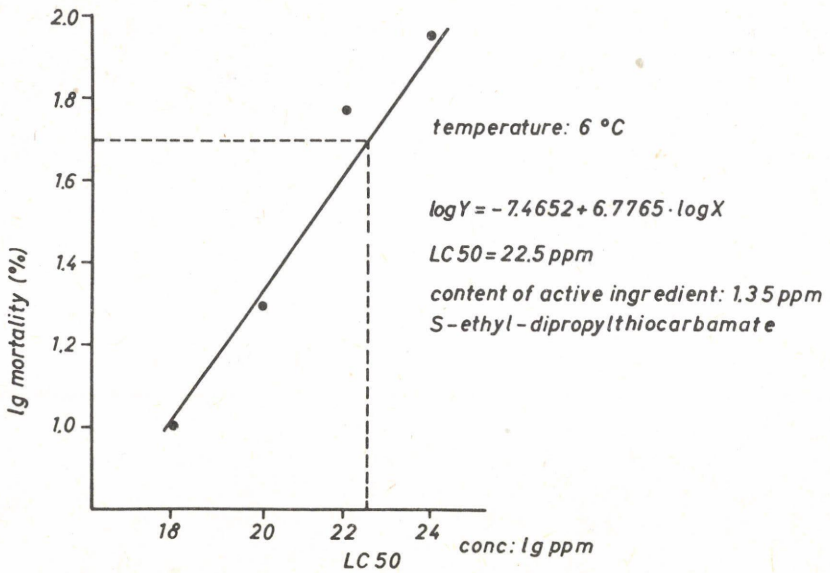

Fig. 3. Results of Gammarus roeseli test exposed to herbicide Eradicane 6 E for 7 days (log-log transformation)

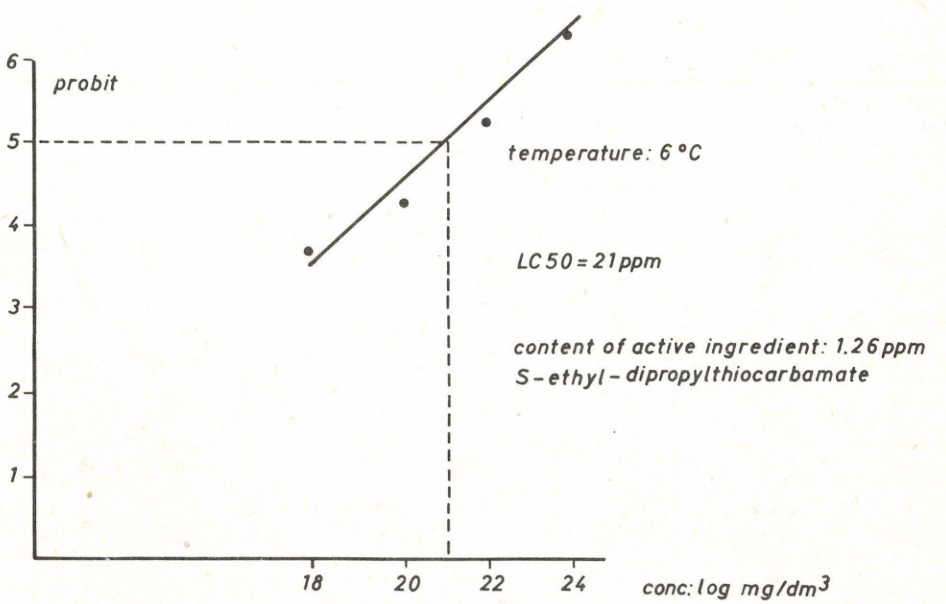

Fig. 4. Results of Gammarus roeseli test exposed to herbicide Eradicane 6 E for 7 days (probit transformation)

for that of the chronic one some weeks or a longer period is needed. In our investigations the short exposure time of the so-called express methods was unacceptable and one week (168 hrs), a period longer than that of the standard tests, was used. In the toxicological studies the standardized methods of the Comecom countries were also taken into consideration (COMECON, 1976).

The results were statistically analyzed both by probit and log-log transformations. These were necessary in order to eliminate the effects of incidental factors and to evaluate the data objectively. From the comparison of Figs 1-4 it is evident that the calculated values according to log-log and probit transformations were nearly identical:

Dyfonate		Eradicane	
log-log	0.0105 mg/dm^3	log-log	22.5 mg/dm^3
probit	0.01 mg/dm^3	probit	21 mg/dm^3

While the values were nearly equal, we continued with the calculations using probit values.

Table 5. Results of Gammarus test, exposed to various dilutions of water from the two most toxic inflows (mortality in %)

Time of collection	Ordacsehi water gang					Csókakői stream				
	0%	25%	50%	75%	90%	0%	25%	50%	75%	90%
21.1.1976	60									
29.1.1976	80									
4.2.1976	50									
12.2.1976	100									
24.2.1976	70					0				
2.3.1976	60					30				
9.3.1976	90					100				
16.3.1976	80					100				
24.3.1976	100	60	40	0	0	100	100	60	40	0
7.4.1976	100	50	10	0	0	70	10	0	0	0
7.4.1976	100	100	100	74	74	100	100	74	54	30
14.4.1976	40	20	20	0	0	100	40	20	20	0
21.4.1976	20	0	0	0	0	100	60	20	0	0
28.4.1976	0					100	30	10	0	0

Note: 0%, 25%, 50%, 75%, 90% = dilution of water in %

RESULTS

The results obtained are summarized in Table 4. From the data it is evident that the LC50 values gradually decrease with increasing temperature. The toxicity of pure 2,4-D (94%) is somewhat less than that of the Dikonirt preparation at temperatures ranging from 5 to 15°C. The pesticides and soil sterilizers are especially toxic to Gammarus roeseli. Of the chemicals tested, Dyfonate and Ditrifon proved to be the most toxic. During the investigations the herbicides practically did not alter the pH of the solutions, with the exception of

2,4-D. The pH of the lake water and that of the Aszófő stream was nearly equal. The test animals were collected in different months, but their sensitivity did not show any significant changes.

Adaptability of the "Gammarus-test" for characterization of the "toxicity" of inflowing waters

Following the local fishkill in 1975, complex investigations were carried out in 13 inflows of Lake Balaton with the aim of predicting any massive fish mortality. These studies were initiated by István LÁNG, Deputy Secretary General of the Hungarian Academy of Sciences, and organized by VITUKI (Research Centre for Water Resources, Budapest). The participating institutions determined different water quality indicating components. We were responsible for the so-called "Gammarus-tests".

Our investigations proved two inflows to be highly toxic out of the 13 checked (Fig. 5), while in the others about 20-40% mortality was observed. Water samples from the two most toxic inflows were diluted to different concentrations and even at 50% dilution complete mortality (100%) occurred (Table 5). The toxicity of the waters has not been determined, because no additional data were placed at our disposal (i.e. results of gas-chromatographic analyses). We have to point out that Gammarus roeseli inhabits or inhabited those inflowing waters and lake water of Lake Balaton which do not or did not contain any polluting agents (PONYI 1956, 1957).

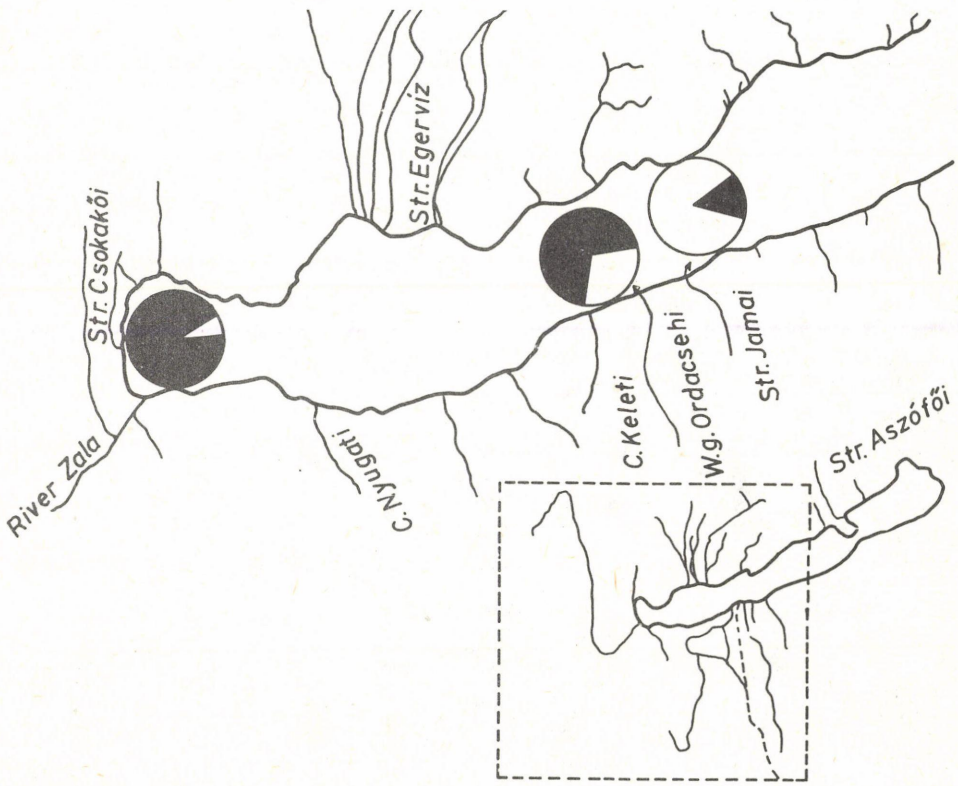

Figure 5. Map of 13 investigated inflows of Lake Balaton with indication of the three most polluted streams according to the Gammarus roeseli tests (the areas of black circular segments are proportional to the mortality of the test animals)

REFERENCES

BARON, F., PONYI, J.E. & CSONTI, F. (1967): Investigation of pesticide residues in fish and other aquatic organisms of Lake Balaton and some other aquatic habitats. - Annls. Biol. Tihany, 34: 117-128.

COMECON (1976): Egységes vízvizsgálati módszerek III. Biológiai módszerek [Uniform water-examination methods III. Biological methods]. (in Hungarian). Második kiadás. - VITUKI, Budapest, pp. 250.

CZEGLÉDI-JANKÓ, G., PONYI, J.E. & CSONTI, F. (1973): A Balaton peszticid szennyezettségi dinamikájának néhány kérdése [Problems of the dynamics of the pesticide pollution of the Lake Balaton]. (in Hungarian) - Halászat, 19 (66): 74-75.

FELFÖLDY, L. & TÓTH, L. (1967): A mezőgazdasági kemizálásnak hatása a vízgazdálkodásra I. Peszticidek [Effect of agricultural chemical processing on the management of watersupplies I. Pesticides]. (in Hungarian). - Vízügyi szakmai világbeszámolók, 18, VITUKI, Vízügyi Müszaki Tájékoztató Iroda, Budapest, pp. 184.

GÖNCZY, Cs., HOLLÓ, A., PÁSZTOR, Zs. & PONYI, J.E. (1978): Chlorinated hydrocarbon pollution in Lake Balaton and the Hármas Körös River, in the water and the biotope, in 1975 and in spring 1977 (in Hungarian with English and Russian summary). - Hidrológiai Közlöny, 11: 519-523.

KÁROLY, G. & FÜZESI, I. (1977): A Balaton és befolyó vizeinek vizsgálata peszticidmaradványokra 1976 tavaszán [Study of water samples of the Lake Balaton and tributaries for pesticide residues in spring 1976]. (in Hungarian). - Növényvédelem, 13 (6): 257-260.

PÁSZTOR, Zs., PONYI, J.E., GÖNCZY, L. & HOLLÓ, A. (1975): Investigations by gas chromatograph on the chlorinated hydrocarbon pollution in two areas of Lake Balaton. - Annls. Biol. Tihany, 42: 191-202.

PINKOLA, L. & TÓTH, L. (1971): A Balaton peszticid-viszonyainak feltárása [Survey of the pesticide conditions of Lake Balaton. Report on the work of VITUKI in 1968]. (in Hungarian). - Beszámoló a VITUKI1968. évi munkájáról, Budapest, p. 227-244.

PFEIFER, Gy., PONYI, J.E. & NAGY, Z. (1979): Pesticide residues in Lake Balaton. - Symp. Biol. Hung., 19: 21-26.

PONYI, J.E. (1956): Ökologische, ernährungsbiologische und systematische Untersuchungen an verschiedenen Gammarus-Arten. - Arch. Hydrobiol., 52 (3): 367-387.

PONYI, J.E. (1957): Untersuchungen über die Crustaceen der Wasserpflanzenbestände im Plattensee. - Arch. Hydrobiol., 53 (4): 537-551.

PONYI, J.E., CSONTI, F. & BARON, F. (1968): An investigation of the content of the chlorinated hydrocarbon residues of the crustacean plankton in the Lake Balaton. - Annls. Biol. Tihany, 35: 183-189.

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