ANNAL. BIOL. TIHANY | 27 | 3—7 | HUNGARIA 1960

SEASONAL CHANGES IN THE FAT CONTENTS OF THE CRUSTACEA PLANKTON IN LAKE BALATON

TIBOR FARKAS and SÁNDOR HERODEK

Received: 1st March, 1960

Organic matter produced by the phytoplankton is transmitted to fish in the most part by plankton crustaceans. This important roll of plankton crustaceans in the circulation of substances in natural waters obtained an early recognition and has been dealt with in numerous communications. Thus their nutrition and propagation conditions, connection with the phytoplankton, population dynamics, etc. are well-known in their main features. From the examinations carried out in Lake Balaton we also have a notion as to what amount of living substance plankton crustaceans represent and what seasonal changes this amount exhibits (SEBESTYÉN 1955). From the point of view of nutrients represented by the Crustacea plankton for fish it was considered necessary to determine the quantity of the most important types of compounds within this living matter (FARKAS 1958). Since the fat contents of the crustaceans proved to be rather high and as fats are compounds of a high energy-content, further on we made a detailed examination of fats.

As soon as in the first analyses it attracted attention that fat contents in samples collected at different times show a wide variation (FARKAS 1958). Serial examinations were made to find out the nature of these changes. As a results of these examinations a characteristic yearly cycle was obtained *(Fig 1)* according to which fat contents per dry-matter unit are higher in the winter and lower in the summer periods. This phenomenon was not known so far. Literary data report fat contents similar to that of the summer samples (GENG 1925; CLARKE—BISHOP 1948). What gives rise to the accumulation of fats is unknown. One may assume that the animal stores resources or reserves for the months to come when food will be scarce or that fat metabolism in winter time (cold water) is for some reason more favourable than that of carbohydrates. Of course, there may be many other explanations among which we can not make a choice at the present time.

In our previous publication (FARKAS—HERODEK 1959) we demonstrated that far reading changes take place even in the composition of fats in the course of the year. When temperature falls in autumn the amount of saturated fatty acids per total fat decreases and highly unsaturated acids with a long carbon chain are accumulating. This change can be easily interpreted by reasons that the melting point of fats thus declines and they do not chill out even in winter time.

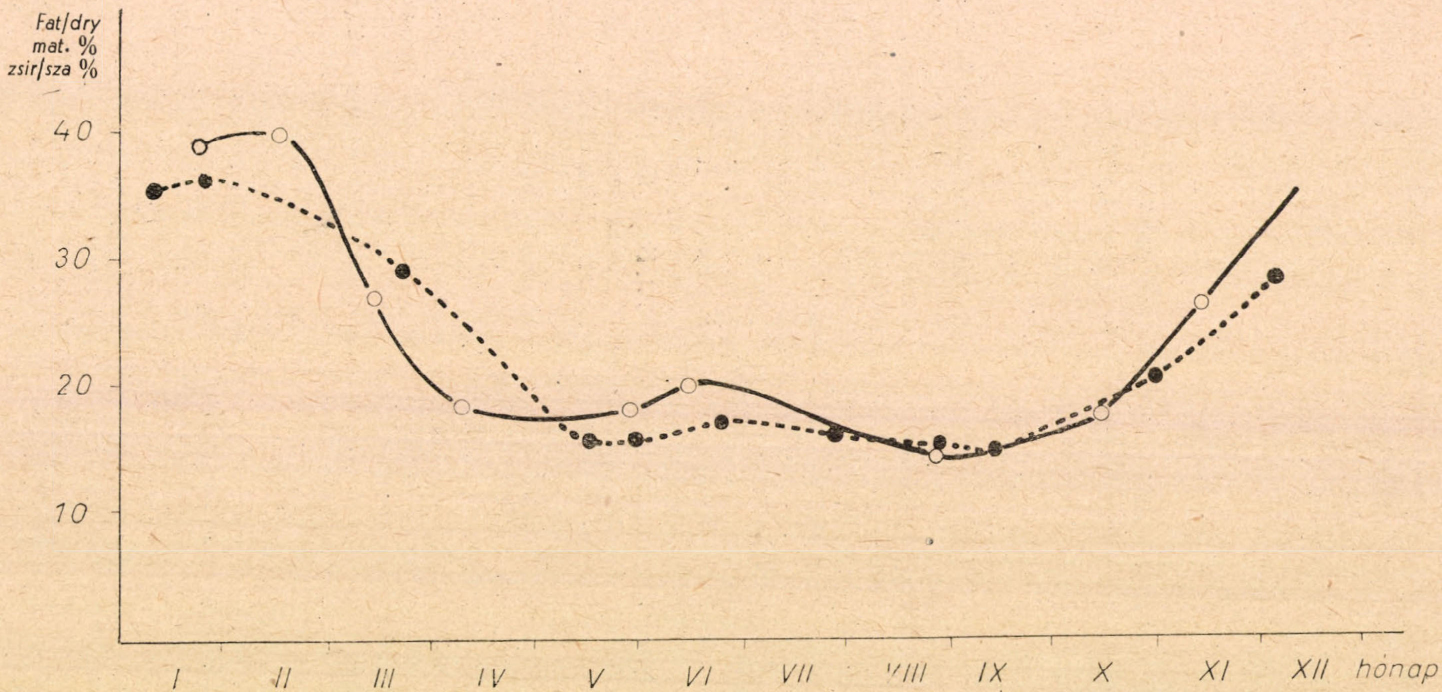

Fig. 1 The change of the fat contents per dry-matter in the Crustacea plankton in the course of the year

— — — —●— — — —●— — — — 1958

————○————○———— 1959

1. ábra : A crustacea-plankton szárazanyagra számított zsírtartalmának változása az év folyamán

— — — —●— — — —●— — — — 1958

————○————○———— 1959

Рис. 1: Изменение содержания жира Crustacea plankton в пересчете на сухое вещество в течение года

— — — —●— — — —●— — — — 1958 г.

————○————○———— 1959 г.

Naturally, the question arises whether the yearly cycle of fat contents and fatty acid composition could not be traced back to changes occurring in the composition of the Crustacea plankton as to species involved. Analysis of fatty acids and determinations of total fat contents were carried out in identical samples. Species occurring in the composition of the samples are shown in *Table 1.* These data fluctuating on a wide range can not be brought

Table 1 — 1. táblázat

Per cents of species included in the plankton samples examined
A vizsgált plankton-minták %-os faji összetétele

Data — Dátum	Cyclopida	Diaptomus gr.	Diaphanosoma	Daphnia
	%	%	%	%
1958. 16. V.	12,3	81,0	4,4	1,1
24. VI.	13,7	68,2	14,8	3,1
29. VII.	81,8	9,1	3,7	5,2
26. VIII.	35,7	19,3	29,0	15,2
15. IX.	35,0	39,3	19,0	6,0
4. XII.	19,0	70,2	0	10,8
1960. 23. I.	51,9	43,7	0	3,6
14. III.	77,7	22,3	0	0
11. IV.	50,0	48,6	0	1,3
11. VI.	8,1	16,6	32,9	42,1
14. VII.	30,4	34,6	30,5	5,6
24. VIII.	31,2	58,6	8,2	1,2

in connection with the very regular curve of fat contents and composition of fats showing one maximum in a year. It is more likely that temperature reaction is the same in the different members of the Crustacea plankton.

The second question that has to be dealt with is whether the change observed in the fatty acid composition of the Crustacea plankton is a consequence of processes taking place in the phytoplankton or not? Since it was not possible as yet to collect the amount of phytoplankton necessary for analyses no definite answer can be given to this question at the present time. To approach the problem winter and summer fatty acid composition of *Cladophora* collected from stones near the shore of the lake and its diatom cover (peryphyton) was determined with the aid of paper chromatography. The data shown in *Table 2* offer no explanation for the changes observed in the fat content and in the fatty acid composition of the crustaceans. As far as inferences can be drawn from measurements on the behaviour of the plankton algae, the increase of the fat contents and the accumulation of C_{20}—C_{22} fatty acids in the winter Crustacea plankton may be a result of the immediate influence of temperature on fat metabolism of the crustaceans. This would be in agrement with our hypothesis according to which the difference in the C_{20}—C_{22} fatty acid contents of marine and fresh water crustaceans is due to the difference in temperature. Lovern (1936) also found no such difference in the marine and fresh-water phytoplankton. This indicates that fats accumulated in the Crustacea plankton are not simply deposited algal fats. As a matter of fact we do not even know what part of the fats found in the plankton

Table 2 — 2. táblázat

Winter and summer fatty acid composition (wt.%) of the Cladophora and Diatomea cover
A Cladophora és kovamoszat-bevonat téli és nyári zsírsav-összetétele (súly%)

Name	Date	Water t °C	Fats dry matter %	Jodine Value *	Sat.			Unsat.				
					C_{14}	C_{16}	C_{18}	C_{14}^{**}	C_{16}^{**}	C_{18}^{**}	C_{20}^{**}	C_{22}^{**}
Cladophora I.	1959. VI. 15.	18	8,9	156,5	—	5,9	13,2	—	16,7	28,3	27,8	8,1
Cladophora II.	1960. I. 11.	0,5	10,6	155,7	3,8	9,9	—	1,0	26,2	41,5	12,9	4,0
Diatomea I.	1959. VI. 15.	18	8,9	193,5	—	9,9	4,2	—	10,9	37,7	2,0	35,1
Diatomea II.	1960. I. 11.	0,5	8,9	202,6	7,5	8,8	—	—	32,0	20,3	29,4	1,7

*According to Kaufmann
**As saturated acids

crustaceans originates in more or less assimilated algal fats and what part is synthetised by crustaceans. NAUMANN (1918) already pointed out that the latter may be rather considerable, since he has found Crustacea plankton of very high fat contents in an oligotrophic lake where the food of the Copepoda and the Cladocera mainly consisted of allochtonous detritus of carbohydrate contents. A more detailed chemical analysis of the phytoplankton in Lake Balaton might throw light on these conditions. From the above considerations it is clear anyway that even such energy supplying substances as depot fats are of a very specific character and strongly responsive to the changes of external factors.

Methods

Determination of total fat contents were carried out with the SOXHLET method, based on the weight decrease of 100 to 200 mg samples weighed in. Perparation of fatty acids for paper chromatography and paperchromatographing itself were executed according to our previous publication (FARKAS—HERODEK 1959). Part of the samples had been hydrogenated before the development of the spots in the presence of a Pd catalizator.

Determination of the composition of samples as to species was carried out with the aid of relative quantitative computations on the basis of the number of individuals.

Summary

Fat contents of the Crustacea plankton per dry-matter in Lake Balaton shows a regular yearly cycle with a winter maximum. Neither this cycle nor the seasonal change in fatty acid composition shown earlier can be traced back to changes found in the composition of samples according to species.

Though plankton algae were not examined it has been stated for *Cladophora* and for its diatom cover (periphyton) that contrary to what was observed in crustaceans the amount of C_{20}—C_{22} fatty acids is lower in winter time (cold water). It may be assumed that temperature has an immediate effect upon the metabolism of fats in crustaceans.

REFERENCES

CLARKE, G. L., BISHOP, D. W. (1948): The nutritional value of marine zooplankton with a consideration of tissue as an emergency food. — *Ecology* **29**, 54—71.

FARKAS, T. (1958): Összehasonlító vizsgálatok alacsonyabb- és magasabbrendű rákok kémiai összetételén (Comparative studies on the chemical composition of lower and higher crustaceans). — *Annal. Biol. Tihany* **25**, 179—186.

FARKAS, T., HERODEK, S. (1959): Paper chromatographic studies on the fatty acid composition of some fresh-water crustaceans. — *Acta Biol. Acad. Sci. Hungaricae* **10**, 85—90.

FARKAS T., HERODEK S. (1959): Bonyolult zsírsavkeverékek papírkromatográfiája (Paper chromatography of complex fatty acid mixtures). — *Annal. Biol. Tihany* **26**, 203—209.

GENG, H. (1925): Der Futterwert der natürlichen Fischnahrung. — *Z. für Fischerei* **23**, 137—165.

LOVERN, J. A. (1936): Fat metabolism in fishes. IX. The fats of some aquatic plants. — *Biochem. J.* **30**, 387—390.

NAUMANN, E. (1918): Einige Gesichtspunkte betreffs der Fettproduction des Süsswasser-Zooplanktons. — *Arch. für Hydrobiol.* **13**, 307—312.

SEBESTYÉN, O. (1955): Mennyiségi planktontanulmányok a Balatonon. V. Biomasszaszámítások nyíltvízi crustaceákon (Quantitative plankton studies on Lake Balaton. V. Biomass computations on free water crustaceans). — *Annal. Biol. Tihany* **23**, 75—94.

A BALATONI CRUSTACEA-PLANKTON ZSÍRTARTALMÁNAK ÉVSZAKOS VÁLTOZÁSA

Farkas Tibor és *Herodek Sándor*

Összefoglalás

A balatoni crustacea-plankton szárazanyagra vonatkoztatott zsírtartalma téli maximummal szabályos évi ciklust mutat. Sem ez a ciklus, sem a zsírsav összetételében korábban kimutatott évszakos változás nem vezethető vissza a minták faji összetételében talált változásokra.

Planktonalgákat nem tudtunk vizsgálni, de a *Cladophora* és a rajta élő diatomák esetében a rákokkal éppen ellentétben, télen alacsonyabb a C_{20}—C_{22}-es zsírsavak mennyisége. Feltételezzük, hogy a hőmérséklet közvetlenül gyakorol hatást a rákok zsíranyagcseréjére.

ИЗМЕНЕНИЕ СОДЕРЖАНИЯ ЖИРА В CRUSTACEA-PLANKTON ОЗЕРА БАЛАТОНА В ТЕЧЕНИЕ ГОДА

Фаркаш Тибор — Херодек Шандор

Выводы

Содержание жира в Crustacea-plankton в пересчете на сухое вещество в озере Балатон, достигая максимума в зимнее время, показывает правильный круглогодичный цикл. Ни этот цикл, ни сезонное изменение, показанное ранее в составе жирной кислоты, нельзя объяснить изменениями в видовом составе образцев.

Исследование планктоновых водорослей не было возможно, но в случае Cladophora и живущих на нее диатомовых водорослей, в противоположность ракообразным, количество жирных кислот C_{20}—C_{22} в зимнее время является более низким. Предполагается, что температура оказывает непосредственное влияние на обмен жировых веществ раков.