C. FAT METABOLISM IN FISHES.

VI. THE FATS OF SOME PLANKTON CRUSTACEA.

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IN previous papers [Lovern, 1932; 1934, 2] it has been shown that the fats from freshwater fish, taken as a whole, form a class distinct from those of marine species. It was suggested that differences of food might account for this, but at that time no data were available concerning the type of fat ingested in each case. The larger carnivorous fish (including all the marine species examined and all but one of those from fresh water) consume smaller creatures, mainly other fish in most cases, and here presumably the fat is of a type similar to that of the larger fish. The very small fish live largely on copepods and similar small crustacea, which are, indeed, the main link between vegetable and animal life in both salt and fresh water. The planktonic crustacea are almost exclusively vegetable feeders. It is of interest to know whether the same class distinction holds between freshwater and marine zooplankton as obtains for the fishes. If it does the idea of food differences being the cause of the observed distinctions in the case of the larger fish is considerably strengthened. This theory will receive further support if the composition of the zooplankton fats is closely similar to that of the fish fats, suggesting that ingested fat is largely deposited unchanged.

Very little is known regarding the composition of these crustacean fats. Collin *et al.* [1934] examined the fat from *Calanus finmarchicus* and also mixed copepod fat. Their results, whilst not giving details of composition, indicated a resemblance of type between the fatty acids of these fats and those of fish fats. They further found appreciable quantities of wax alcohols present. No freshwater crustacea seem to have been examined.

In this paper the results obtained with the fats from one marine species and three freshwater species are given.

EXPERIMENTAL.

The fats were obtained by desiccating with anhydrous sodium sulphate and extracting with ether. The marine species used was *Calanus finmarchicus*. This is a relatively large organism and easily obtained pure by the use of tow nets of a suitable mesh. It was collected in large quantities in Loch Sunart, Argyllshire, during May 1933, and sufficient fat was available for a full-scale quantitative analysis (200 g.).

As for freshwater organisms, it is often the case that a particular pond or lake is dominated by one organism, and by the use of a suitable net fairly pure samples may be collected. From a small sheet of water near Aberdeen, a considerable quantity of *Cyclops strenuus* was obtained almost pure, the contaminants being mainly other species of *Cyclops*. From Loch Lochy, Inverness-shire, a pure sample of *Daphnia galeata* was obtained and from Loch Ness a somewhat mixed sample, almost all of the genus *Diaptomus* with *D. gracilis*

greatly predominating. There will be no serious error in considering this as all *D. gracilis*. From these freshwater organisms only sufficient fat was available in each case for analysis by semi-micro-methods [Lovern, 1934, 1]. All the fats were deep red in colour and all contained a considerable quantity of acid pigment matter. The characteristics of the fats are given in Table I, and the compositions of the mixed fatty acids in Table II, as weight and molar percentages.

Table I. *Characteristics of fats.*

Species	Saponification equivalent	Iodine value	% saponifiable
<i>Calanus finmarchicus</i>	457.5	177.6	32.0
<i>Cyclops strenuus</i>	341.7	236.2	20.0
<i>Daphnia galeata</i>	410.7	142.9	22.3
<i>Diaptomus gracilis</i>	367.6	153.8	17.5

Table II. *Compositions of mixed fatty acids.*

Species	Saturated acids				Unsaturated acids				
	C ₁₂	C ₁₄	C ₁₆	C ₁₈	C ₁₄	C ₁₆	C ₁₈	C ₂₀	C ₂₂
					Weights %				
<i>C. finmarchicus</i>	—	8.3	10.6	1.3	1.6 (-2.0 H)	11.8 (-2.4 H)	16.8 (-5.1 H)	24.5 (-7.8 H)	25.1 (-8.1 H)
<i>C. strenuus</i>	—	5.9	15.6	1.0	2.9 (-2.7 H)	30.3 (-3.0 H)	25.2 (-5.2 H)	15.6 (-8.6 H)	3.5 (- ? H)
<i>D. galeata</i>	0.9	3.5	13.0	1.7	2.8 (-2.0 H)	21.1 (-2.0 H)	44.9 (-5.0 H)	12.1 (-8.0 H)	Nil
<i>D. gracilis</i>	—	2.6	20.0	1.6	Nil	15.7 (-2.0 H)	34.6 (-4.5 H)	25.5 (-7.1 H)	Nil
					Mols. %				
<i>C. finmarchicus</i>	—	10.3	11.7	1.3	2.0	13.2	17.1	22.9	21.5
<i>C. strenuus</i>	—	6.9	16.3	0.9	3.4	32.0	24.1	13.7	2.7
<i>D. galeata</i>	1.2	4.1	13.6	1.6	3.3	22.3	43.2	10.7	Nil
<i>D. gracilis</i>	—	3.1	21.4	1.6	Nil	16.9	34.0	23.0	Nil

DISCUSSION.

It will be observed that all the fats contain large amounts of unsaponifiable matter. Whilst this was not examined in detail, its appearance strongly suggested the presence of wax alcohols, in agreement with the finding of Collin *et al.* [1934].

It will be seen from Table II that all the fats contain the typical "fish oil" fatty acids (palmitoleic, C₂₀ acids *etc.*). Moreover, the class distinction between fats of marine and freshwater origin is markedly in evidence. This difference has been previously defined [Lovern, 1932] as increased proportions of C₁₆ and C₁₈ unsaturated acids and decreased C₂₀ and especially C₂₂ acids in the freshwater fats, as contrasted with those from marine sources. *D. gracilis* fat is the least typically freshwater fat, but even here the entire lack of C₂₂ acids and the high content of C₁₈ unsaturated acids would put this fat into the freshwater class.

A point of interest is the extremely high average unsaturation of the C₁₈ and C₂₀ unsaturated acids, as well as the presence of polyethylenic C₁₆ acids in all cases.

It would seem that the fats of the vegetable-feeding zooplankton, from both salt and fresh water, correspond so closely to those of the marine and freshwater fish respectively that a simple deposition of ingested fat, largely unchanged in

composition, would account for the observed characteristics of marine and freshwater fish fats. It may well be that the whole character of fish fats is due to the type of fat occurring in their essential food supply—the plankton crustacea.

It would be of interest to know whether the compositions of the crustacean fats are in turn largely decided by the type of fat in the food; whether, in fact, as suggested previously [Lovern, 1932], it is really the plant life of the medium which is affected by the presence or absence of salt. Experiments in progress point to this being the case and suggest that even in the crustacea the ingested vegetable fat is mainly deposited unchanged.

SUMMARY.

The fats from three freshwater and one marine species of plankton crustacea have been examined. The mixed fatty acids of the freshwater species show the same class distinction when contrasted with the acids of the marine species as is observed with the fatty acids of fish from the respective habitats.

The close correspondence in type of the fats from crustacea and fish suggest that fat ingested by the fish is largely deposited unchanged, and that the class differences observed between the fats from freshwater and marine fish as a whole have a dietary origin.

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