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The Lipids of Marine Animals from Various Habitat Depths-IV. On the fatty acid composition of the neutral lipids in nine species of flatfishes

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Abstract

Nine species of flatfishes were examined for this study. The fatty acid composition of the neutral lipids in each flesh, viscera, liver, and gonad of the examined fishes was determined by gas-liquid chromatography. The results showed that the fatty acid composition in the liver of 'aburagarei', Japanese arrowtooth flounder, 'samegarei', roughscale sole, and 'akagarei', flathead sole, consisted markedly of large amounts of monoenoic acids, while relatively little of polyenoic acids. A similar tendency was recognized in the case of the flesh of 'aburagarei' and 'samegarei'. Besides, the ratio of monoenoic acid to polyenoic acid contents in the fatty acid composition of the liver of 'aburagarei', 'samegarei', 'akagarei', and 'ishigarei', stone flounder, gave the value of more than four. It seemed that this indicated a characteristic of the fatty acid composition of the neutral lipids in deep-sea fishes.

It has been well known that the characteristics or fatty acid composition of the fish lipids were considerably affected by compounded factors: their diet or maturity, environmental temperature, individuality of species, and what not[1].

All the while, some deeper pelagic fishes have been reported to have large amounts of wax esters, a fact which was characterized by a predominant of 18:1 acid[2–8]. We have observed the fatty acid composition of the neutral lipids, composed of abundant triglycerides, in deep-sea fishes to differ from those of fishes living at the near-surface in having greater relative amounts of monoenoic acids[9),10]. This phemonenon was obviously recognized in the fatty acid composition of the liver, suggesting that this indicated a characteristic of the fatty acid composition of deep-sea fishes. We have successively studied the fatty acid composition of the neutral lipids of the liver in six species of Gadiformes caught from various habitat depths[11]. From the results obtained, we have emphatically pointed out that the polyenoic acids decreased with increasing depth, while the monoenoic acids increased.

The present paper was undertaken to determine the extent of this difference, namely, the consistency with which it was demonstrated on the fatty acid composition of the netural lipids in some flatfishes from various habitat depths.

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The examined flatfishes, excepting 'aburagarei', were eatable fishes. However, there was relatively little information available concerning the fatty acid composition of their lipids.

Materials and Methods

Materials

The exmained samples comprised nine species of flatfishes, as given in Table 1. Catch localities and date, number of fishes, and mean body length and weight, of the same species are given in Table 2. 'aburagarei', 'samegarei' and 'akagarei' among those species were caught from more than 300-m depth, and the catching depths of the others were less than those of the former. The captured fishes were carried into our laboratory in a frozen state. Each species was examined irrespective of sex. The samples were divided into flesh, liver, and viscera, excepting the viscera including the liver in the case of 'hireguro', Japanese rex sole, and then each part was used for the extraction of lipids. When the species had a matured genital gland, the part was also used for this study.

Table 1. *The nine species of the examined flatfishes.*

Common name	Scientific name
'ABURAGAREI', Japanese arrowtooth flounder	*Atheresthes evermanni*
'SAMEGAREI', Roughscale sole	*Clidoderma asperrimum*
'AKAGAREI', Flathead sole	*Hippoglossoides dubius*
'ISHIGAREI', Stone flounder	*Kareius bicoloratus*
'MUSHIGAREI', Roundnose flounder	*Eopsetta grigorjewi*
'MAGAREI', Japanese dab	*Limanda herzensteini*
'BABAGAREI', Japanese dover sole	*Microstomus achne*
'MATSUKAWA', a kind of righteye flounder	*Verasper moseri*
'HIREGURO', Japanese rex sole	*Glyptocephalus stelleri*

Table 2. *The characteristics of the nine species of the examined flatfishes.*

Species	Catch		Fishes (sum)	Body length (mean) cm	Body weight (mean) gr
	Locality (offshore)	Date			
'ABURAGAREI'	Tokachi	Sept. '71	20(♂)	34.1	359.5
'SAMEGAREI'	Tokachi	Sept. '71	9(♂)	22.3	199.8
'AKAGAREI'	Ryotsu*	Mar. '72	12(♂)	24.9	133.9
'ISHIGAREI'	Setana	May '72	4(♂2, ♀2)	31.2	388.5
'MUSHIGAREI'	Setana	May '72	8(♀)	28.7	222.3
'MAGAREI'	Setana	May '72	10(♀)	30.3	394.0
'BABAGAREI'	Setana	May '72	8(♀)	32.1	398.1
'MATSUKAWA'	Setana	May '72	7(♂1, ♀6)	32.8	494.6
'HIREGURO'	Ryotsu*	Mar. '72	12(♂)	22.2	73.1

* Ryotsu: Niigata prefecture, others: Hokkaido.

Table 3. *Total lipid contents and properties of the neutral lipids in each part from nine species of flatfishes.*

Species	Part	Total lipid %*	Neutral lipid		
			%**	I.V. (Wijs method)	Unsap. matter %
'ABURAGAREI' *A. evermanni*	Flesh	4.1	88.5	141.1	2.7
	Viscera	2.6 } 5.7	82.5	163.1	12.1
	Liver	12.6 }	93.8	98.6	5.5
'SAMEGAREI' *C. asperrimum*	Flesh	5.6	95.6	174.6	2.4
	Viscera	1.9 } 4.5	89.0	194.5	17.6
	Liver	12.5 }	93.1	112.1	7.1
'AKAGAREI' *H. dubius*	Flesh	1.9	92.6	182.1	5.6
	Viscera	1.5 } 3.8	87.9	154.7	12.8
	Liver	21.5 }	93.7	127.6	5.8
'ISHIGAREI' *K. bicoloratus*	Flesh	3.0	97.0	174.5	3.1
	Viscera	1.1 } 4.3	39.1	171.2	26.4
	Liver	12.9 }	95.5	124.1	7.5
'MUSHIGAREI' *E. grigorjewi*	Flesh	2.9	90.2	183.6	3.8
	Viscera	1.6 }	64.1	167.8	16.1
	Liver	10.9 } 3.1	89.3	144.2	7.1
	Ovary	1.9 }	72.5	—	17.1
'MAGAREI' *L. herzensteini*	Flesh	1.0	76.4	185.0	6.3
	Viscera	1.3 }	74.9	202.9	18.1
	Liver	14.3 } 2.0	93.4	141.6	7.6
	Ovary	1.2 }	38.9	—	31.5
'BABAGAREI' *M. achne*	Flesh	2.3	85.0	174.4	4.1
	Viscera	1.5 }	70.6	208.5	13.7
	Liver	5.4 } 2.5	80.0	145.4	7.9
	Ovary	2.7 }	72.8	—	7.6
'MATSUKAWA' *V. moseri*	Flesh	1.0	84.8	185.1	5.9
	Viscera	1.2 }	42.1	179.2	25.1
	Liver	9.3 } 1.7	80.5	138.9	7.3
	Ovary	0.8 }	34.3	—	28.3
'HIREGURO' *G. stelleri*	Flesh	1.2	82.2	172.8	10.1
	Viscera*	3.5	87.7	151.9	16.7

* % to wet weight. ** % to total lipid. * This part included liver.

Experimental methods

Experimental methods, *i.e.*, lipids extraction, fractionation of the neutral lipids using a solvent acetone, preparation of fatty acids and unsaponifiable matters, determination of fatty acids by gas-liquid chromatography (GLC), thin-layer chromatography (TLC), all were done after the same methods or conditions described previously[11]. The iodine value and unsaponifiable matter content of the neutral lipids were determined[12].

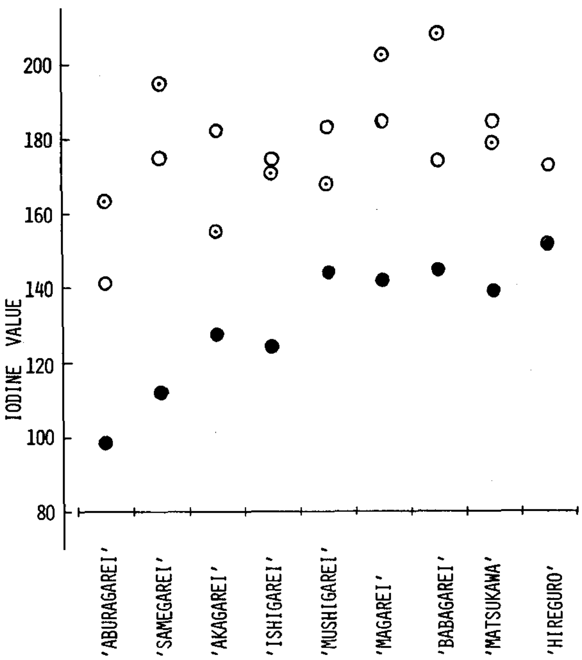

Fig. 1. Iodine value of the neutral lipids in each part of the examined flatfishes. Flesh (○), Viscera (⊙), Liver (●), Viscera including liver (◉).

Fractionation of sterin esters and triglycerides in the neutral lipids

The neutral lipids in each liver of 'aburagarei' and 'magarei', Japanese dab, were applied to a column packed with silicic acid (100 mesh, Kanto chemical Co.,), activated for 5 hrs at 100°C. Each column was developed one after another with various solvent such as 1%, 2%, 4%, 10%, 50% ether in hexane, and ether. Fractions of 20 ml each were collected throughout the chromatographic runs. Each eluant of 2% and 10% ether in hexane contained sterin esters and triglycerides, respectively. The fatty acid composition of these two components were also determined by GLC.

Results

Lipid contents and characteristics of the neutral lipids

The contents of the total lipids and of the neutral lipids in the total lipids, and the characteristics of the neutral lipids of each part in the examined flatfishes, are given in Table 3. The total lipid contents of the liver were larger than those of the other parts, as a rule. The contents of the flesh in 'samegarei' and 'aburagarei' were remarkably high in comparison with those of the other species. Besides, comparing the contents of the flesh and the all joined parts,

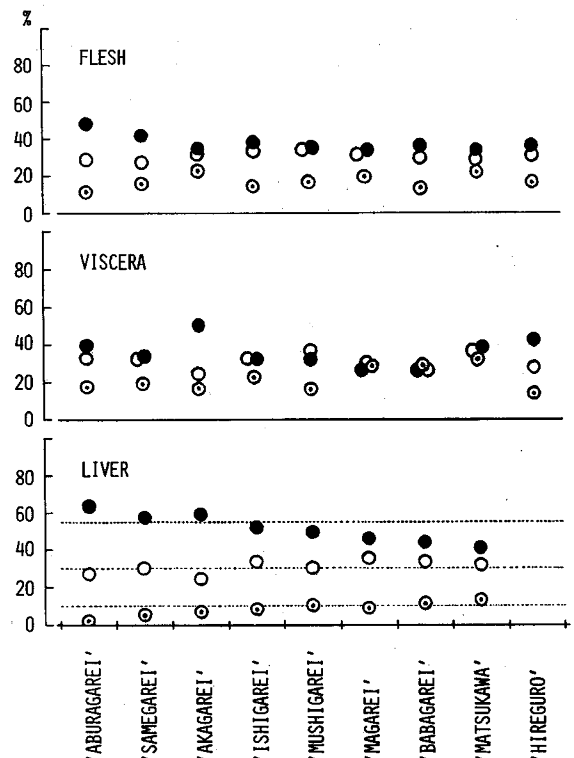

Fig. 2. The contents of the major saturated, monoenoic and polyenoic acids in the fatty acid composition of the neutral lipids of each part of the examined flatfishes.
Saturated acids (14:0+16:0+18:0) (○)
Monoenoic acids (16:1+18:1+20:1) (●)
Polyenoic acids (20:4+20:5+22:6) (⊙)
'HIREGURO': Viscera including liver.

excluding the flesh among the examined samples, both made no great difference.

The neutral lipid contents in the total lipids of the viscera in 'ishigarei' and 'mushigarei', roundnose flounder, and the ovary in 'magarei' and 'matsukawa', a kind of righteye flounder, were smaller than 34.3–64.1% in comparison with the range of 70.6–95.6% in the others.

The TLC analyses of the neutral lipids revealed that triglycerides were the predominant components in all the parts of the examined samples, while wax esters were exceedingly small.

As shown in Fig. 1, the iodine values of the liver had significantly a tendency to low values comparing with those of the flesh and viscera in all species. Besides, the values of the liver in 'aburagarei' and 'samegarei' were the lowest among the others, and those of 'akagarei' and 'ishigarei' continuing on the former. This tendency recognized in the liver, however, was not remarkably in those of the

Table 4. *Fatty acid composition of the neutral lipids*

Species	'ABURAGAREI' *A. evermanni*			'SAMEGAREI' *C. asperrimum*			'AKAGAREI' *H. dubius*			'ISHIGAREI' *K. bicoloratus*		
Parts	Flesh	Viscera	Liver	Flesh	Viscera	Liver	Flesh	Viscera	Liver	Flesh	Viscera	Liver
Fatty acid												
14:0	5.5	5.4	3.7	7.1	5.0	5.5	6.6	4.8	5.2	8.0	5.5	7.0
15:0	0.3	0.5	0.2	0.7	0.8	0.3	0.7	0.3	0.4	1.0	0.5	0.5
16:0	20.2	22.5	19.3	15.9	20.2	20.4	21.8	16.1	17.6	22.5	23.2	24.5
17:0	1.4	1.8	1.8	2.0	2.3	2.1	0.6	0.9	1.3	1.7	1.6	1.6
18:0	3.6	5.2	4.2	3.9	7.2	4.2	3.2	3.2	1.7	2.4	4.5	1.5
19:0	1.0	1.2	0.6	2.4	2.0	0.8	0.3	0.9	1.3	1.7	1.0	0.9
20:0	0.2	tr*	tr	0.2	0.3	0.1	tr	0.1	0.1	0.2	0.2	0.2
total	32.2	36.6	29.8	32.2	37.8	33.4	33.2	26.3	27.6	37.5	36.5	36.2
14:1	0.3	0.4	0.2	0.8	0.7	0.4	0.5	0.6	1.0	0.9	0.4	0.7
15:1	0.2	0.2	0.1	0.4	0.5	0.2	0.2	0.2	0.2	0.3	0.2	0.2
16:1	9.8	10.5	10.6	16.6	10.2	10.3	11.7	16.8	19.6	15.9	11.4	22.8
17:1	1.0	1.2	0.6	1.8	1.2	0.5	1.4	1.3	1.5	1.6	1.1	1.2
18:1	31.6	24.9	48.0	22.6	21.1	44.4	21.3	30.7	37.6	19.0	18.2	27.6
19:1	0.6	0.8	0.3	0.6	0.7	0.3	0.7	0.4	0.4	0.7	0.5	0.5
20:1	6.3	4.2	4.5	3.0	2.0	2.6	2.4	2.6	1.6	2.8	2.1	1.4
22:1	1.6	0.6	0.4	0.3	0.2	0.4	0.9	0.9	0.5	0.6	0.5	0.2
24:1	—	—	—	—	—	—	—	—	—	—	—	—
total	51.4	42.8	64.7	46.1	36.6	59.1	39.1	53.5	62.4	41.8	34.4	54.6
16:2	—	—	0.7	—	0.9	0.3	—	—	—	—	—	—
18:2	0.7	0.8	0.3	0.9	0.8	0.3	1.8	0.9	1.2	1.0	0.8	0.8
18:3	0.2	tr	tr	0.2	0.4	0.1	tr	tr	0.1	0.6	0.5	0.2
18:4	2.7	1.7	1.4	2.9	1.8	1.1	1.0	1.1	0.9	2.7	1.8	1.3
20:2	0.8	tr	0.4	0.2	0.8	0.3	0.2	0.4	0.8	0.7	0.6	0.3
20:4	1.8	1.3	tr	1.0	2.6	0.4	3.5	4.6	1.6	1.7	3.7	0.6
20:5	5.8	10.1	2.6	13.2	12.9	4.5	10.5	7.6	3.2	8.1	10.7	4.3
21:5	tr	tr	—	0.9	0.6	—	0.7	0.6	tr	0.4	0.6	tr
22:2	tr	tr	tr	0.3	tr	0.4	0.2	0.2	0.1	tr	0.7	tr
22:5	0.6	0.9	—	0.9	0.8	—	1.1	0.4	0.3	0.6	1.8	tr
22:6	3.6	5.3	tr	1.3	3.7	tr	8.5	4.4	1.8	4.7	8.0	1.8
total	16.0	20.1	5.4	21.8	25.3	7.4	27.5	20.0	10.0	20.5	29.2	9.3
?	0.3	0.4	—	—	0.4	—	0.2	0.1	—	0.1	—	—
M/P**	3.2	2.1	12.0	2.1	1.4	8.0	1.4	2.7	6.2	2.0	1.2	5.9

* Trace. ** Ratio of monoenoic acids to polyenoic acids.

flesh and viscera. It was suggestive that the fatty acid composition in the liver of 'aburagarei' and 'samegarei', or of 'akagarei' and 'ishigarei', were somewhat different from those of the other species.

The contents of unsaponifiable matters were larger in the viscera comparing with the flesh and liver, as a rule, and those of the ovary in 'magarei' and 'matsukawa' were also a predominance. The results of TLC analyses showed that sterins were larger components of the unsaponifiable matters, while hydrocarbons, fatty alcohols or glyceryl ethers smaller in all parts of the examined samples.

Fatty acid composition

The fatty acid composition of the neutral lipids of each part of all nine species of flatfishes are given in Table 4. In the composition the saturated acids 16:0, 14:0 and 18:0, the monoenoic acids 18:1, 16:1 and 20:1, including 22:1 of the liver in 'matsukawa', and the polyenoic acids 20:5, 22:6 and 20:4, were relatively high contents as a rule. The sum contents of the major fatty acids in each part, namely, those of saturated acids 14:0, 16:0 and 18:0, of the monoenoic *of each part from nine species of flatfishes. (% wt)*

'MUSHIGAREI' *E. grigorjewi*				'MAGAREI' *L. herzensteini*				'BABAGAREI' *M. achne*				'MATSUKAWA' *V. moseri*				'HIREGURO' *G. stelleri*	
Flesh	Viscera	Liver	Ovary	Flesh	Viscera	Liver	Ovary	Flesh	Viscera	Liver	Ovary	Flesh	Viscera	Liver	Ovary	Flesh	Viscera*
8.3	5.6	5.6	5.2	6.1	4.0	5.3	3.7	6.4	3.3	5.9	6.5	5.2	4.6	10.6	13.2	4.7	5.5
0.6	0.9	0.5	0.6	0.6	0.8	0.3	0.8	0.7	1.2	0.8	1.1	0.5	1.2	0.6	2.4	1.7	1.2
22.4	25.3	21.9	32.3	23.1	19.2	27.2	23.8	19.8	17.6	24.6	17.6	20.5	24.3	17.0	16.7	23.1	18.7
1.7	2.6	2.6	2.0	1.0	1.9	1.8	1.8	2.8	2.1	1.3	2.5	0.7	2.2	1.0	0.8	3.6	2.8
3.1	5.7	2.3	3.6	3.3	6.8	2.6	4.1	3.3	4.7	2.7	2.9	2.7	7.4	3.2	1.7	3.2	2.8
1.8	1.8	0.7	0.8	0.8	1.3	1.0	1.2	3.6	0.9	0.9	1.8	1.7	1.0	0.4	2.2	1.6	1.2
0.2	0.3	0.2	0.1	0.2	0.2	0.1	0.2	0.3	0.3	0.2	0.2	0.1	0.3	0.2	0.4	0.2	0.3
38.1	42.2	33.8	44.6	35.1	34.2	38.3	35.6	36.9	30.1	36.4	32.6	31.4	41.0	33.0	37.4	38.1	32.5
0.6	0.7	0.7	0.5	0.3	0.4	0.3	0.3	0.7	0.7	0.8	1.1	0.3	0.7	0.5	2.6	1.9	1.3
0.3	0.4	0.1	0.5	0.5	0.4	0.2	0.2	0.4	0.6	0.5	0.5	0.4	0.5	0.2	1.3	0.8	0.7
14.0	11.5	18.0	11.2	13.9	8.1	15.4	10.3	14.6	7.5	11.1	13.3	14.3	11.1	5.6	20.8	15.7	16.5
1.9	1.5	1.1	1.3	1.1	1.4	1.2	1.2	1.6	1.3	0.9	1.9	1.6	2.1	0.7	2.2	1.6	2.1
18.4	17.7	29.1	15.1	16.2	15.4	28.9	17.0	18.8	17.4	30.0	16.4	17.9	14.5	27.8	7.5	17.5	22.8
0.6	1.0	0.6	0.5	0.5	0.7	0.5	0.5	0.8	0.8	0.4	0.7	0.6	0.8	0.5	0.7	0.6	1.5
2.5	1.7	2.0	1.0	4.2	2.5	1.8	1.6	2.5	1.6	3.1	2.6	2.1	1.1	7.3	0.4	2.8	3.1
0.7	0.6	0.5	0.4	1.4	0.2	0.3	0.5	0.2	0.7	0.2	0.4	0.4	0.1	6.2	0.2	0.7	0.8
—	—	—	—	—	tr	tr	tr	—	—	—	—	—	—	—	—	—	—
39.0	35.1	52.1	30.5	38.1	29.1	48.6	31.6	39.6	30.6	47.0	36.9	3[illegible].6	30.9	48.8	35.7	41.6	48.8
—	—	—	0.4	0.3	—	—	—	—	—	—	—	0.2	0.4	—	0.8	—	—
1.0	1.1	0.9	0.8	0.7	0.9	0.9	0.8	1.2	0.9	0.6	0.8	0.7	1.0	1.2	1.6	1.2	1.7
0.5	0.7	0.2	0.3	0.2	0.6	0.1	0.8	0.4	0.5	0.2	0.8	0.2	0.6	0.8	1.4	0.2	0.3
2.4	2.0	1.0	0.9	2.3	2.8	1.6	1.8	4.4	1.6	1.3	4.1	1.9	1.1	2.6	1.6	1.8	1.1
0.6	0.6	0.4	0.3	0.4	0.9	0.5	0.7	0.4	0.8	0.3	0.4	0.3	0.4	0.6	1.0	0.6	0.8
2.0	2.3	1.5	2.9	3.4	5.3	1.2	7.0	2.6	5.5	2.2	1.5	2.3	3.6	2.0	3.4	2.2	3.7
10.4	8.5	4.7	8.5	11.0	15.7	5.5	12.5	8.0	15.7	6.6	12.2	13.6	11.2	5.7	10.4	8.1	6.6
0.6	0.7	0.5	0.8	0.8	1.1	tr	0.7	0.6	1.8	1.0	0.8	1.1	0.7	tr	0.5	0.3	0.3
tr	0.3	0.3	0.3	0.2	0.2	0.3	0.5	0.6	0.5	0.7	0.2	0.4	tr	tr	0.4	0.4	0.2
1.3	0.9	0.9	2.3	2.2	2.5	1.0	2.8	2.4	4.5	1.7	3.7	2.8	1.9	tr	0.7	0.4	0.6
4.0	5.5	3.7	7.5	4.4	6.7	1.9	5.0	2.7	7.0	2.0	4.1	5.8	7.2	5.4	1.8	4.3	3.3
22.8	22.6	14.1	25.0	25.9	36.7	13.0	32.6	23.3	38.8	16.6	30.1	29.3	28.0	18.3	23.6	19.5	18.6
—	—	—	—	0.8	—	—	0.2	0.2	0.4	—	0.3	1.7	—	—	3.2	0.8	0.2
1.7	1.6	3.7	1.2	1.5	0.8	3.7	1.0	1.7	0.8	2.8	1.2	1.3	1.1	2.7	1.5	2.1	2.6

* This part included liver.

acids 16:1, 18:1 and 20:1, and of the polyenoic acids 20:4, 20:5 and 22:6 are shown in Fig. 2. In the liver, the correlation that the contents were plotted in the order of the monoenoic, saturated, and polyenoic acids was obviously indicative. Especially the monenoic acid contents in 'aburagarei', 'samegarei' and 'akagarei' were particularly in a relatively high level, correspondingly a low level for the polyenoic acids, in comparison with the other species. Besides, as shown in Fig. 3, 18:1 acid contents of the liver in 'aburagarei' and 'samegarei' indicated the correlation of the much more abundant, correspondingly a little for the sum content of 20:5 and 22:6 acids, being dissimilar to those of the other species.

Previously, we suggested that the total monoenoic acids to the polyenoic acids ratio in the fatty acid composition of the neutral lipids of deep-sea fishes, notably in the liver, had a value of more than four, differently those of the near-surface fishes had one less than four[10,11]. The tendency was particularly shown in a relatively high level of the ratio in the liver of 'aburagarei', 'samegarei', 'akagarei' and 'ishigarei', while those of the other species were reduced to low level. It was suggestive that the fatty acid composition of the liver in deep-sea fishes was

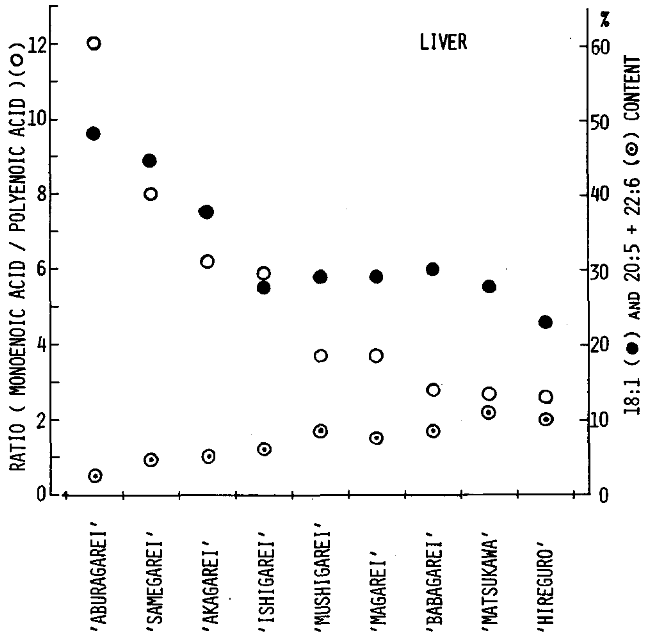

Fig. 3. Ratio of the monoenoic acids to the polyenoic acids, and the content of 18:1 acid and (20:5+22:6) acids.
'HIREGURO': Viscera including liver.

remarkably different from that in the near-surface fishes.

From the comparative study, the fatty acid composition of sterin esters and triglycerides of the neutral lipids in 'aburagarei' and 'magarei', of different habitat depths, were determined to clear the differences between the two. The chromatograms of the fractionation by a column of the neutral lipids of the liver in those two species are shown in Fig. 4. Sterin ester and triglyceride contents in both neutral lipids were respectively 3.7% and 76.8% in the former, and 9.2% and 79.2% in the latter. Triglycerides present in the netural lipids were the relatively larger amounts in both species. Besides, the sterin ester contents were different from these two species. The fatty acid composition of sterin esters and triglycerides in both two species are given in Table 5. It showed that 16:0 and 18:1 acid contents in triglycerides were larger than those of sterin esters, while 16:1 acid contents in sterin esters were larger than those of triglycerides. The 20:5 acid contents in sterin esters were relatively larger than those in triglycerides in 'aburagarei', while those in 'magarei' were different from the results of the former. The total monoenoic acid contents of triglycerides in 'aburagarei' were the much more abundant in comparison with those in 'magarei'. The monoenoic acids to the polyenoic acids ratio showed a considerably high value of 28.8 in triglycerides of 'aburagarei', while a low value was found in sterin esters. The ratio in sterin esters of 'magarei' had a relatively high value compa-

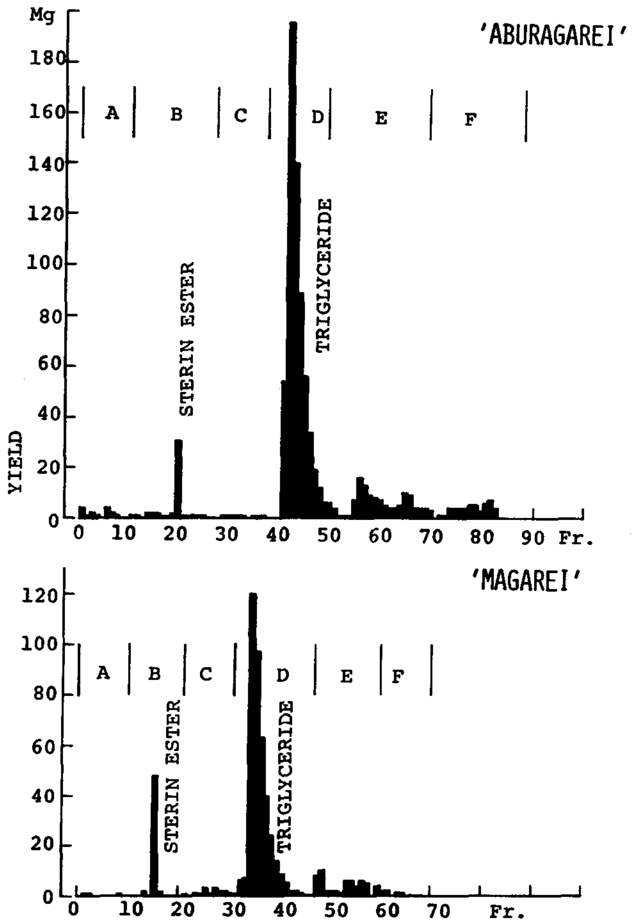

Fig. 4. Chromatography of the neutral lipids in the liver of 'ABURAGAREI' and 'MAGAREI'.
column: 35 g ('ABURAGAREI') and 26 g ('MAGAREI') column of silicic acid.
eluent: A, B, C, D, and E agreed to 1%, 2%, 4%, 10% and 50% ether in hexane, F, ether.
sample: 803 mg ('ABURAGAREI') and 480 mg ('MAGAREI').

ring with that in triglycerides.

Discussion

In the fatty acid composition, the contents of 18:1 acid, or the ratio of the total monoenoic acid to the total polyenoic acid contents in the liver of 'aburagarei', 'samegarei' and 'akagarei', which are charcteristic of deep-sea flatfishes, differed from those of the other species. This phenomenon was un-

Table 5. *Fatty acid composition of triglycerides and sterin esters in liver from 'ABURAGAREI' and 'MAGAREI'.*

	'ABURAGAREI'		'MAGAREI'	
	Triglyceride	Sterin ester	Triglyceride	Sterin ester
Fatty acid		% wt		
14:0	3.3	6.1	4.2	8.5
15:0	0.2	1.8	0.4	2.2
16:0	19.3	14.6	24.5	16.7
17:0	0.8	2.8	1.3	2.9
18:0	3.7	4.0	2.5	2.3
19:0	0.9	1.1	1.1	1.2
20:0	tr*	0.4	0.1	0.1
total	28.2	30.8	34.1	33.9
14:1	0.2	1.9	0.4	2.8
15:1	0.1	1.0	0.2	1.2
16:1	10.8	27.4	16.7	35.6
17:1	0.3	2.5	0.9	2.6
18:1	53.0	16.8	34.6	15.1
19:1	0.2	0.4	0.2	0.6
20:1	4.3	1.1	2.0	0.4
22:1	0.3	0.4	0.3	tr
24:1	—	—	—	—
total	69.2	51.5	55.3	58.3
16:2	tr	—	—	—
18:2	0.2	1.0	0.5	1.7
18:3	tr	0.5	0.1	0.2
18:4	1.0	2.0	0.8	0.3
20:2	0.3	1.0	0.4	0.4
20:4	0.4	3.2	tr	2.7
20:5	0.5	7.3	4.2	1.7
21:5	tr	1.0	0.3	tr
22:2	—	0.6	0.3	0.3
22:5	tr	—	1.5	—
22:6	—	tr	1.9	tr
total	2.4	16.6	10.5	7.8
?	0.1	1.2	—	—
M/P**	28.8	3.1	5.3	7.5

* Trace.
** Ratio of monoenoic acids to polyenoic acids.

doubtedly noticeable in the fatty acid composition of triglycerides in 'aburagarei'. These characteristics were slightly indicative in the case of the flesh of 'aburagarei' and 'samegarei'. The liver fatty acids of 'aburagarei' and 'samegarei' had essentially the same tendency as the much more abundant monoenoic acids and the less polyenoic acids previously described[9),10),11)].

It was reported that the lipids of some deep-sea fishes had the predominant of wax esters, were characterized in having large amounts of 18:1 acid[2-8]. We have pointed out that the fatty acid composition of the neutral lipids, primarily consisting of triglycerides, in the liver of deep-sea fishes were different from those of the near-surface fishes. The ratio of the monoenoic acid to the polyenoic acid contents took a value of more than four in the deep-sea fishes, whereas a value of less than four in the near-surface fishes. We appointed this ratio as one characteristic of the deep-sea fish lipids. The reason of this phenomenon appearing in deep-sea fishes was discussed somewhat[11]. Namely, it seemed that the influences of the phytoplanktons were slightly affected to the deep-sea animals into the food chain, simultaneously with a decreasing of the contents of 20:5 and 22:6 acids corresponding with 18:3 acid family originated from phytoplanktons throughout the food chain. The presumable indication is discussed as follows. The organisms at the near-surface on the continental shelf contain larger quantities with variousness, however, those in the deep-sea are decreasing in species and quantities, therefore, the fishes in the deep-sea live under the severe state of food habitats. It has been suggested that the deep-sea fishes should be equipped so as to eat any food item that they should chance to meet in their relatively impoverished environment. Inferring from those, namely, it seemed that deep-sea fishes exist on inveterate starvation. Considering these facts, it was inferred that the fatty acid metabolism in the deep-sea fishes was affected with starvation, differencing from the near-surface fishes. Recently, we investigated the changes of the component fatty acids of 'mafugu', a puffer fish, *Fugu vermicular porphyreum*, keeping alive in starving conditions (unpublished data). We observed interstingly that at an early stage the polyenoic acids such as 20:5 and 22:6 acids were maintained or proportionally increased, while these acids decreased at a prolonged starvation.

On the other hand, light, temperature, pressure, nutrient salt or dissolved oxygen in the deep-sea are different from those of the near-surface, and it was thought that these environmental conditions should be affected to the fatty acid metabolism, not a little. We explained a little of the characteristics in the fatty acid composition of the deep-sea fishes, henceforth, express studies on the fatty acid metabolism in the deep-sea fishes to prove the reason of the phenomenon described above were required.

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