Bulletin of the Japanese Society of Scientific Fisheries 51(9), 1487-1493 (1985)

Changes in Molecular Species of Fish Muscle Phosphatidylcholine of Chum Salmon during Migration*1,*2

Koretarō TAKAHASHI,*3 Makoto EGI,*4 and Kōichi ZAMA*3

(Accepted January 25, 1985)

Molecular species of muscle phosphatidylcholine (PC) of chum salmon of four different migratory stages were analyzed on HPLC.

By introducing principal component analysis (PCA) for the interpretation of the results, interesting movements were observed on the first and second, as well as the first and third principal component planes in accordance with the advance in migration. The plots of male and female moved almost together on these planes.

It was clearly seen that molecular species of (16:0)(22:6) drastically decreased when the upstream stage in spawning migration begins.

Chum salmon is a representative migratory fish that migrates from the sea to the river.

From the food chemical point of view, lipid content of muscle drastically decreases during spawning migration while that of water content increases.*5 This drastic change in proximate composition of muscle affects the quality of fish.

In this study, molecular species of muscle phosphatidylcholine (PC) of each migratory stage was investigated in order to know whether there is some change or not in muscle PC during migration.

Experimental

Total lipids were obtained in the same way as described in the previous paper[1] from the fish

Table 1. Chum salmon (*Oncorhynchus keta*) examined

Stage of migration and sex	Mean body length and weight Locality of catch	Date of catch
Feeding migration, Male	42.7 cm, 1367 g, 45°59′-49°29′N, 167°07′-175°30′E,	Aug. 1983
Feeding migration, Female	46.8 cm, 1593 g, 45°59′-49°29′N, 167°07-175°30′E,	Aug. 1983
Spawning migration, Male Sea run	63.0 cm, 3267 g, Yakumo-cho, Hokkaido, Japan	Oct. 1983
Spawning migration, Female Sea run	64.3 cm, 3573 g, Yakumo-cho, Hokkaido, Japan	Oct. 1983
Spawning migration, Male River	73.0 cm, 5000 g, Yakumo-cho, Hokkaido, Japan	Nov. 1983
Spawning migration, Female River	70.0 cm, 4740 g, Yakumo-cho, Hokkaido, Japan	Nov. 1983
Spent, Male	74.2 cm, 5140 g, Yakumo-cho, Hokkaido, Japan	Nov. 1983
Spent, Female	72.7 cm, 4273 g, Yakumo-cho, Hokkaido, Japan	Nov. 1983

*1 Molecular Species of Marine Animal Lipid—III.

*2 Presented at the Japanese Society of Scientific Fisheries Meeting, Sendai, October 1984.

*3 Laboratory of Food Chemistry I, Faculty of Fisheries, Hokkaido University, Hakodate, Hokkaido 041, Japan (高橋是太郎・座間宏一: 北海道大学水産学部).

*4 Present address: Kyowa Hakko Kogyo K.K., Tokyo 194, Japan (江木 衷: 協和発酵工業株式会社).

*5 M. HATANO: The Japanese Society of Scientific Fisheries Meeting, Sendai, October 1984.

Table 2. Lipid composition of chum salmon examined

Sample	Yield*1	Lipid							PC mg/100 g muscle
		Non-phospholipid*2				Phospholipid*2			
		TG	FFA	ST	NP others	PC	PS+PE	PL others	
Feeding migration, Male	10.4	92.1	0.4	0.7	0.2	2.3	3.6	0.7	230
Feeding migration, Female	12.4	94.1	trace	0.7	0.7	1.3	2.9	0.3	161
Spawning migration, Male (Sea)	1.1	40.7	0.8	4.7	1.1	19.3	29.8	3.6	212
Spawning migration, Female (Sea)	1.4	49.9	trace	2.6	0.3	17.3	26.7	3.2	242
Spawning migration, Male (River)	1.3	40.7	5.7	6.2	trace	12.7	32.9	1.8	165
Spawning migration, Female (River)	1.6	41.5	2.6	15.5	0.1	9.2	28.1	3.0	147
Spent, Male	1.1	32.7	22.5	4.3	5.2	12.2	11.2	11.9	132
Spent, Female	0.9	11.6	19.9	7.8	5.5	19.1	15.9	20.2	172

*1 g/100 g muscle. *2 g/100 g lipid.
TG, triglyceride; FFA, free fatty acid; ST, sterol; NP, non-phospholipid; PC, phosphatidylcholine; PS, phosphatidylserine; PE, phosphatidylethanolamine; PL, phospholipid.

Table 3. Fatty acid composition of diglyceride acetate derived from lecithin of chum salmon muscle

Fatty acid	Sample							
	Feeding migration		Spawning migration				Spent	
	Male	Female	Male*1	Female*1	Male*2	Female*2	Male	Female
12:0	0.09			0.03			trace	0.06
14:0	4.58	3.10	1.98	2.78	3.34	3.74	3.49	3.53
15:0	0.82	0.68	0.37	0.42	0.42	0.44	0.37	0.32
16:0	29.02	32.26	30.02	26.84	23.95	28.61	29.51	26.15
16:1	1.79	1.38	1.66	2.19	2.60	2.56	2.41	1.83
17:0	1.14	0.92	0.43	0.38	0.61	0.50	0.35	0.48
17:1	0.44	0.37	0.25	0.16	0.36	0.25	0.42	0.27
18:0	1.03	1.11	0.72	0.59	1.23	0.52	1.45	0.83
18:1	8.43	8.27	6.40	4.68	5.04	7.25	9.65	6.64
18:2	0.51	0.52	0.37	0.51	0.94	0.64	0.60	0.46
19:1 or 18:4			0.46	0.63	0.97	0.97	0.34	0.39
19:2	0.69	0.56			1.36	1.19	0.33	0.49
20:0	1.01	0.77	0.67	0.79	3.27	trace	trace	0.79
20:1	0.10	0.10	0.39	0.29	2.29	0.52	1.11	0.05
20:2	0.11	0.09	0.06	0.04			0.33	0.14
20:3	0.65	0.58	0.13	0.13	0.06		0.93	0.88
20:4	0.79	0.67	1.54	1.83	3.00	1.80	0.41	0.51
20:5	11.49	10.18	15.00	16.22	19.00	23.66	15.87	16.96
22:3	0.07							
22:4	0.42	0.34	0.18	0.19				0.12
22:5	1.05	0.98	1.16	1.87	2.48	1.93	1.75	2.37
22:6	35.00	36.40	38.20	39.30	28.77	25.43	30.67	36.70
others	0.77	0.73	0.01	0.13	0.31		0.01	0.03

* % in muscle lecithin.
*1 Sea run. *2 River.

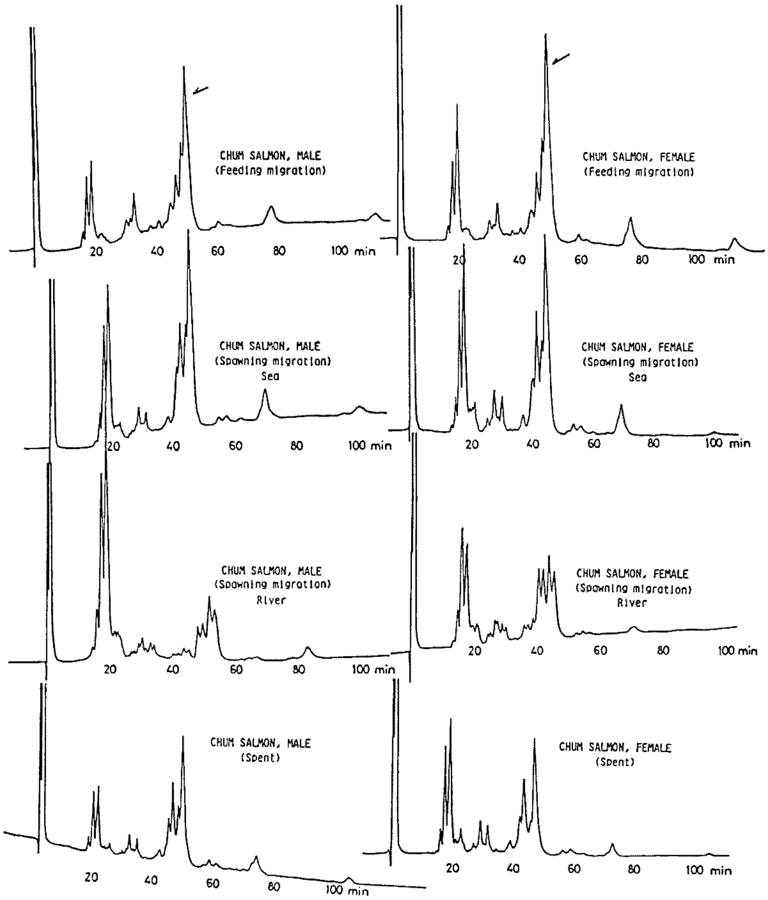

Fig. 1. HPLC chromatograms of chum salmon muscle PC on each stage of migration.

muscle of chum salmon shown in Table 1. Lipid composition analysis as well as molecular species analysis and principal component analysis (PCA) were also done in the same manner as described in the previous paper.[1)]

Results and Discussion

Table 2 shows the yield of total lipid and the percentage of each lipid class against total lipid. And on the right end of this table, the PC mg/100 g muscle are shown. There is a drastic drop in the amount of total lipid and triglycerides between the stage of feeding migration and spawning migration and the amount of PC ranges between 161–230 mg/100 g muscle.

In Table 3, changes in fatty acid composition of diglyceride acetates (this represents the fatty acid composition of PC) during migration are shown. At the level of this analysis, not any significant differences are observed among the four stages.

HPLC chromatograms of each stage of migration are shown in Fig. 1 and the appreciable amount molecular species of PC in the order of elution on HPLC are shown in Figs. 2–5. As it is obviously seen in these figures, chum salmon at the stage of feeding migration has (16:0)(22:6) as the most outstandingly predominant peak (shown by arrows in Fig. 1) compared with other three stages. At the stage of spawning migration, this peak *i.e.* (16:0)(22:6) becomes relatively smaller. Up to these two stages, the chromatographic patterns are analogous between male and female. When the fish starts ascending the river, drastic decrease in the amount of (16:0)(22:6) and (16:0)(20:5) are observed. Unlike the chromatographic patterns at the stage of sea, outstanding differences are observed between male and female. The content of (22:6)(22:6)

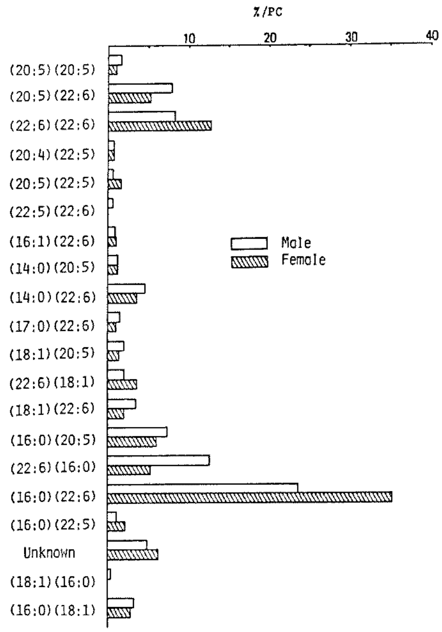

Fig. 2. Molecular species of chum salmon muscle PC at the stage of feeding migration.

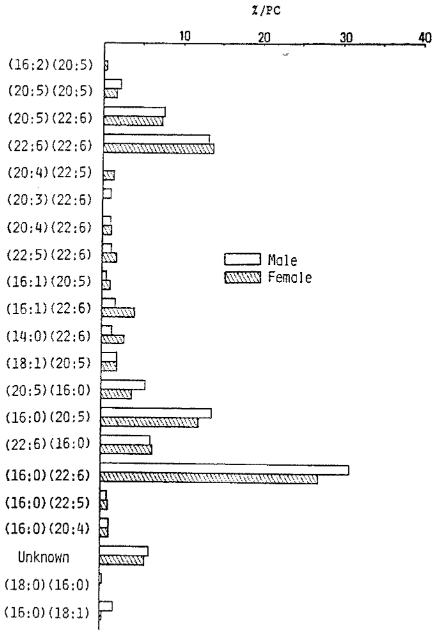

Fig. 3. Molecular species of chum salmon muscle PC at the stage of spawning migration (sea).

(14:0)(20:5), (17:0)(22:6) and (22:6)(18:1) are trace.

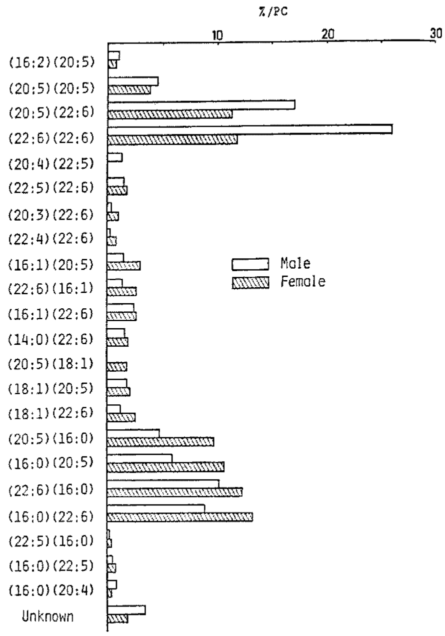

Fig. 4. Molecular species of chum salmon muscle PC at the stage of spawning migration (river).

(14:0)(20:5), (17:0)(22:6) and (22:6)(18:1) are trace.

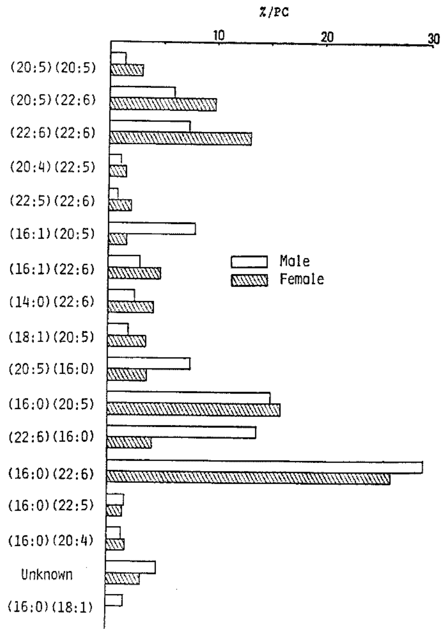

Fig. 5. Molecular species of chum salmon muscle PC at the stage of spent.

(14:0)(20:5), (17:0)(22:6) and (22:6)(18:1) are trace.

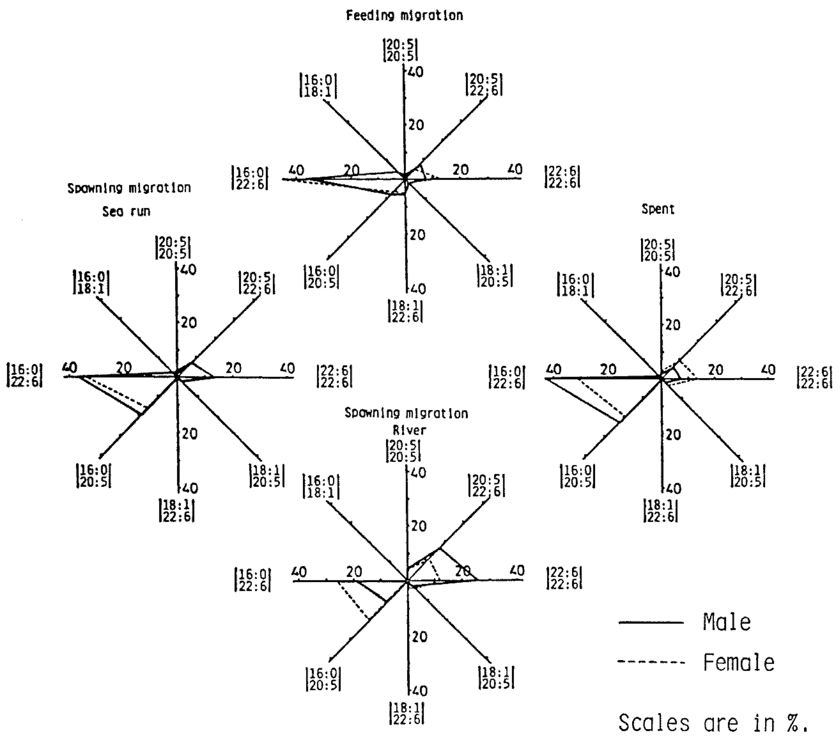

Fig. 6. Radar charts of main molecular species of chum salmon muscle PC on each stage of migration.

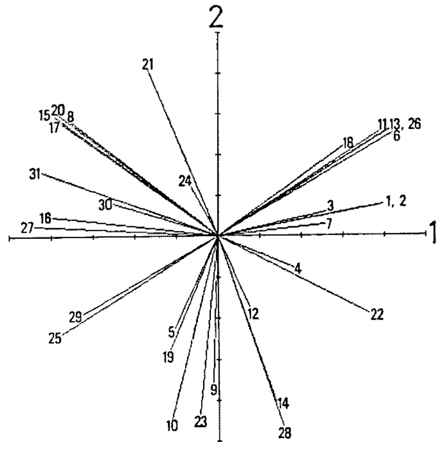

Fig. 7. Eigenvectors of appreciable amount PC molecular species on the first and second principal component plane on PCA.

1. (16: 2)(20: 5)	2. (20: 5)(20: 5)	3. (20: 5)(22: 6)	4. (22: 6)(22: 6)
5. (20: 4)(22: 5)	6. (22: 5)(22: 6)	7. (20: 3)(22: 6)	8. (20: 5)(22: 5)
9. (20: 4)(22: 6)	10. (22: 6)(22: 4)	11. (22: 4)(22: 6)	12. (16: 1)(20: 5)
13. (22: 6)(16: 1)	14. (16: 1)(22: 6)	15. (14: 0)(20: 5)	16. (14: 0)(22: 6)
17. (17: 0)(22: 6)	18. (20: 5)(18: 1)	19. (18: 1)(20: 5)	20. (22: 6)(18: 1)
21. (18: 1)(22: 6)	22. (20: 5)(16: 0)	23. (16: 0)(20: 5)	24. (22: 6)(16: 0)
25. (16: 0)(22: 6)	26. (22: 5)(16: 0)	27. (16: 0)(22: 5)	28. (16: 0)(20: 4)
29. Unknown	30. (18: 1)(16: 0)	31. (16: 0)(18: 1)	

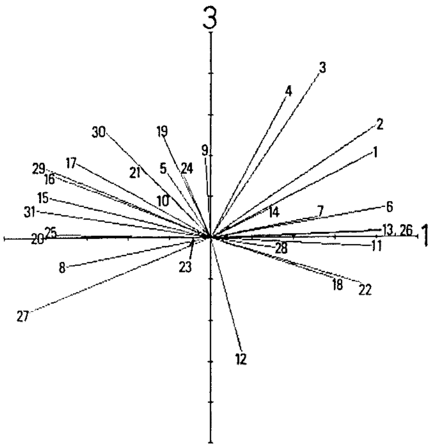

Fig. 8. Eigenvectors of appreciable amount PC molecular species on the first and third principal component plane on PCA. Numbers are the same as in Fig. 7.

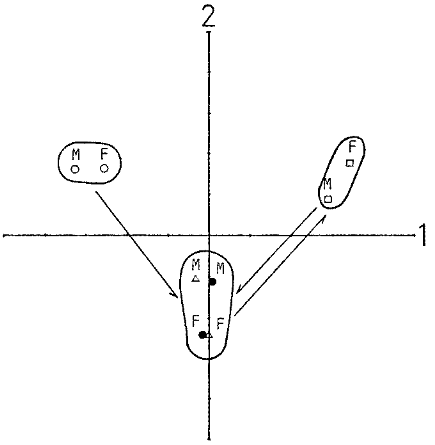

Fig. 9. Plots of principal loading on the first and second principal component plane on PCA.

Refer to the eigenvectors in Fig. 7 as background of this plane.

○M: Feeding migration, Male.
○F: Feeding migration, Female.
●M: Spawning migration, Male (Sea).
●F: Spawning migration, Female (Sea).
□M: Spawning migration, Male (River).
□F: Spawning migration, Female (River).
△M: Spent, Male.
△F: Spent, Female.

is extremely high followed by (20: 5) (22: 6) in male. Finally at the stage of spent salmon, (16: 0) (22: 6) as well as (16: 0) (20: 5) relatively increase compared with the former stage in the river. These are more concretely seen in radar charts of

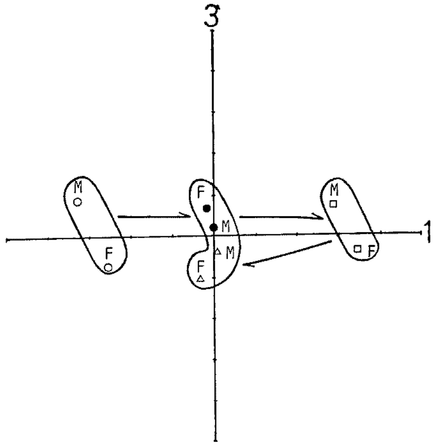

Fig. 10. Plots of principal loading on the first and third principal component plane on PCA.

Refer to the eigenvectors in Fig. 8 as background of this plane.

○M: Feeding migration, Male.
○F: Feeding migration, Female.
●M: Spawning migration, Male (Sea).
●F: Spawning migration, Female (Sea).
□M: Spawning migration, Male (River).
□F: Spawning migration, Female (River).
△M: Spent, Male.
△F: Spent, Female.

the main molecular species as illustrated in Fig. 6. The axes of these charts are arranged in sequence of elution (clockwise) and the original data have been employed from the area of each peak in Fig. 1 (See Figs. 2–5). These charts are arranged in sequence of migration movement (anticlockwise). It is clearly seen from this figure that at the stage of sea run, slight differences in patterns of radar charts can be observed between male and female while that of river, outstanding differences are observed especially at the spawning stage. It is obviously seen from this Fig. 6 that the amount of (16: 0) (20: 5) is relatively very small in feeding migration stage compared with those of other three stages. The amount of (20: 5) (22: 6) and (22: 6) (22: 6) is surprisingly high at the river spawning stage.

The author has employed PCA again as discussed in the previous paper.[1]

In Fig. 7, eigenvectors of appreciable amount molecular species are shown as small numbers on the first and second principal component plane. And in Fig. 8, eigenvectors of the same molecular species are generated on the first and third principal component plane.

Principal loading was plotted on the first and second principal component plane as shown in Fig. 9 and on the first and third principal component plane as shown in Fig. 10. The movement according to the stage of migrations are shown by arrows. Very interesting movements are observed in these figures. By refering the eigenvectors in Fig. 7 at the same time, it can be observed that the movement direction from feeding migration stage to spawning migration stage (sea) is nearly parallel to the eigenvectors numbered 8, 15, 17, and 20 while it makes a right angle against eigenvectors 25 and 29. This shows that although the amounts of number 8 ((20: 5) (22: 5)), number 15 ((14: 0) (20: 5)), number 17 ((17: 0) (22: 6)) and number 20 ((22: 6) (18: 1)) are small as have been seen in Fig. 2 and Fig. 3, drastic decrease of these molecular species occurs between these two stages, making good contrasts to number 25 ((16: 0) (22: 6)) and 29 (unknown) which keep the constant amount. On the other hand, when the migratory stage proceeds to the spawning stage in the river, the movement of the arrow in this figure becomes almost parallel to the eigenvectors of number 25, 29 and also 6, 11, 13, 18 and 26. Number 25 is (16: 0) (22: 6), and the rest 6, 11, 13, 18 and 26 are small peaks. So it might be possible to conclude that (16: 0) (22: 6) is almost constant at the sea stage and becomes changeable at the stage of river.

Spent salmon showed an analogous position with that of spawning migration stage in the sea in PCA planes as it is shown in Figs. 9 and 10. And from these two figures, it is clearly seen that the differences between male and female are considerably small compared with the differences among the migratory stages.

Acknowledgements

M. Hatano, K. Takama, and T. Hirano provided considerable advices.

Reference

1) K. Takahashi, H. Ebina, M. Egi, K. Matsumoto, and K. Zama: *Bull. Japan. Soc. Sci. Fish.*, **51**, 1475~1486 (1985).