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Changes in lipid accumulation of young red sea bream, *Pagrus major* released into the Inland Sea of Japan (Setonaikai)*

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Abstract: Physiological condition of young red sea bream, *Pagrus major*, released into the Inland Sea of Japan (Setonaikai) were monitored in terms of lipid stores comparing to the 0–age wild fish.

The wild fish accumulated lipids in muscle and intraperitoneal fat body during autumn, then exhausted the lipid reserves during wintering. In the released fish, however, there found two critical periods which were just after release and wintering within one year. The released fish lost lipid reserves soon by perturbation caused by environmental change, then recovered the lipid reserves during autumn to provide for the severe wintering. Therefore high ability of accumulating lipid may be advantageous to survive in the Setonaikai.

1. Introduction

Rearing technique for red sea bream is well established and mass production is being carried out by many organizations in Japan. In order to propagate fishery resources, more than 15,000,000 young red sea bream have be released into the coastal region every year. Nevertheless, while many factors would be responsible for the recovery (IMABAYASHI *et al.*, 1975, 1977; KISO, 1980; OMORI, 1980; MORI, 1980; MATSUMIYA and KISO, 1982), little work has been conducted on the recovery and assessment of fish released into the natural environment.

In this study, adaptation process of young red sea bream released into the natural environment were monitored in terms of biological and biochemical parameters.

2. Materials and Methods

Three groups of young fish (6–10cm in body length) which were produced under different conditions were released from several points of the center of Setonaikai, as shown in Fig. 1. These groups were discriminated by tagging or fin-clipping. The fish were caught by seine netting of a Fisherman's Association in the area shown in Fig. 1.

In Hiroshima Prefecture (Hiroshima Fish Farming Association and Fisherman's Association) the fish were produced by artificial feeding in floating net cages (Group O). The number of released fish was 1,168,000 in 1986 and 1,238,000 in 1987. In Momoshima Experimental Station of Japan Sea Farming Association (JASFA) fish larvae were semi-extensively reared in 9000 m^2 pond (2.5m in maximum depth) with natural organisms and supplemental feeding (Group M). The fish of Hakatajima Experimental Station of JASFA (Group H) were intensively produced, as the Group O. The released number of Group M and H was 50,000 each in both years.

Muscle, liver and intraperitoneal fat body (IPF) obtained from 2 to 10 fish were throughly mixed for proximate composition and lipid analyses. Crude protein was measured by Kjeldahl method. Lipid was extracted with methanol-chloroform. The lipid class composition was determined by an Iatroscan TH-10. For fatty acid analysis, lipid classes isolated by preparative TLC were converted into their fatty acid methyl esters by HCl-methanol. Similarity of fatty acid compositions was evaluated according to TAMURA and OSAWA (1969). In the case where two patterns are the same, pattern similarity value will be 1.

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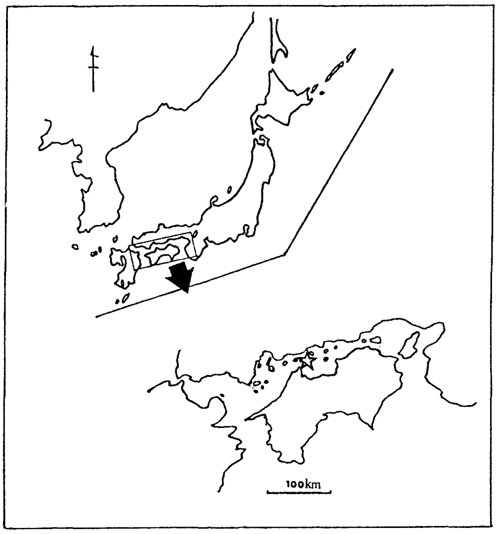

Fig. 1. Location of experimental field in red sea bream. Star is the figure indicates capture area. Fish were released into ca. 40 points within a radius of 50km from capture area.

3. Results

water temperature was maximum in August (26℃) and reached to minimum at March (11℃) in both years. According to observation of stomach content, 33-71% of individuals had the loaded stomach by some crustacean species. There was little or no difference in the major food composition between the released and wild fish, but the released fish seemed to ingest a little more quantity than wild fish. Body length of recovered fish ranged from 4.1 to 12.3 cm. In the Group M and H of 1986, body length decreased significantly within the first 30 days after release and increased thereafter. In winter time, growth was not found in the released groups, nor in the wild fish.

The mode of body weight shown in Fig. 2 resembled that of the body length. Both wild fish and Group O gradually increased body weight till November, then slightly decreased. However, the Group M and H showed a little different mode during autumn. Condition factor showed a little variation during wintering.

IPF, a main energy reserve was fairly different among three released groups (Fig. 3). The Group H having high IPF ratio lost markedly IPF during the following days after release. IPF in wild fish and Group O increased at the end of autumn. During wintering, IPF was exhausted in all the groups, as well in wild fish.

Changes in proximate composition of muscle after release are shown in Table 1. Initial values of muscle crude protein and lipid ranged 19.4-21.6% and 1.0-1.6%, respectively. The Group H was higher in protein and lipid than Group M. The lipids were preferentially consumed after release and the protein was relatively constant till autumn. Although the wild fish retained higher lipid till the end of winter, the Group H exhausted almost of the lipid reserves (0.1%).

More than 90% of muscle lipid consisted of triglycerides (TG). The initial amount of TG in 100g of muscle was not different among the released group, as shown in

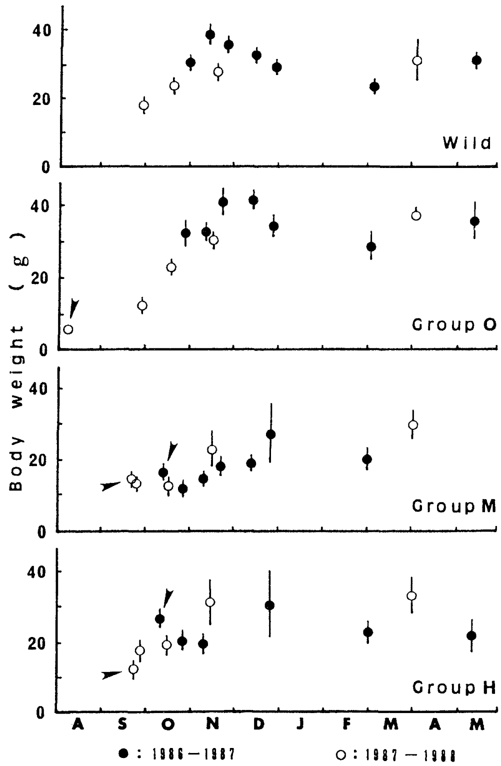

Fig. 2. Changes in body weight of wild and released red sea bream (mean & SE). Arrow indicate release time.

Fig. 4. TG were soon depleted within 50 days after release, then temporarily increased in autumn and decreased again in winter. While phospholipids (PL) were kept at constant level in muscle, slight decrease after exhaustion of TG was found during wintering.

The change of HSI after release was characteristic in each group. The values of Group O, M and wild fish ranged from 1.0 to 1.5. HSI of Group H (2.3 in 1986, 1.8 in 1987) decreased fairly just after release (1.6 and 1.2) and thereafter kept the value constant during wintering.

Main fatty acids of muscle TG are shown in Table 2. The wild fish was relatively low in $C_{18:2}$. While ther appeared some changes in the fish released in 1986, no remarkable variation was found in the fish in 1987 and wild fish. Accumulation of $C_{20:5}$ and selective mobilization of $C_{18:2}$ during wintering were found in the fish released in 1986. The changes in the fatty acid composition of the released groups were highly different among the groups and also between two years.

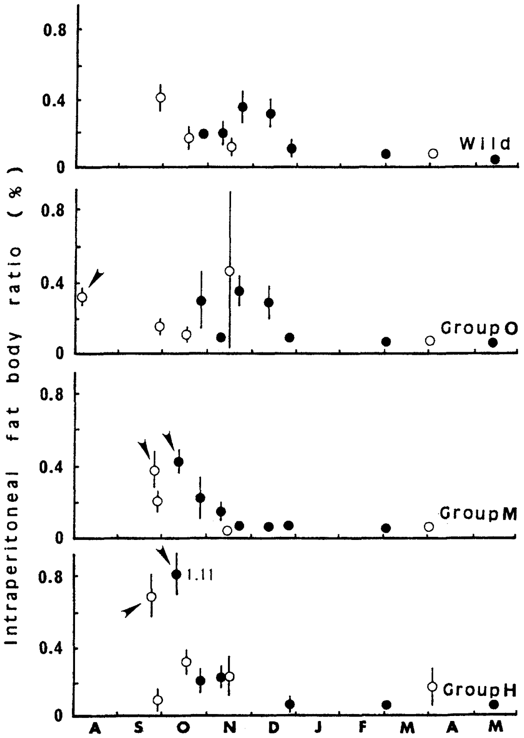

Fig. 3. Changes in intraperitoneal fat body (IPF) ratio of wild and released red sea bream (mean & SE).
IPF ratio = IPF / body weight × 100
Symbols refer to Fig. 2.

Variation of fatty acid composition of IPF was not as high as that of muscle TG. As seen in muscle TG, IPF of wild fish was relatively low in $C_{18:2}$. Muscle PL were characterized by high proportion of highly unsaturated fatty acids, and did not change the proportion.

The similarity of fatty acid compositions between wild and released groups was high in the values before release (>0.87), and decreased with the passage in the natural environment in the 1986-released class(<0.49). However, the fish released in 1987 showed high similarity with the wild fish (>0.88). The similarity in fatty acid composition of IPF was high and always over 0.80, regardless of the released year.

4. Discussion

Wild red sea bream is generally lower in lipid reserves than cultured fish. The lipid amount of surviving coho salmon released into a stream closely approximated that of wild fish (WOOD *et al.*, 1960). The high divergency of initial lipid level would be highly dependent on rearing condition. While high lipid reserves are not essential for cultured fish, the energy accumulation in released fish might play an important role in the natural environment.

When young red sea bream are released into the natural environment, they spend at least 7 to 10 days without feeding (KOSHIISHI and YASUNAGA, 1980; MATSUMIYA and KISO, 1982). Thereafter feeding could be commenced, but not sufficient to provide for required energy or to grow (NAKAGAWA *et al.*, 1991). The environmental change would cause serious perturbation which might draw hormonal imbalance and elevation of glyconeogenesis. Depression of HSI which is a good indicator in assessing environmental impact (HEIDINGER and GRAWFORD, 1977; BARNES et al., 1984) implied purturvation by environmental change.

The fish grew until the beginning of winter, probably due to active feeding. However, temporal

Table 1. Changes in muscle protein (P) and lipid (L) of red sea bream after release (%)

Capture	Wild		Group O		Group M		Group H	
			Released group					
	P	L	P	L	P	L	P	L
Oct. 9, 1986					20.2	1.1 (0)	21.6	1.3 (0)
Oct. 25,	21.1	0.8	21.7	0.9 (82)	21.4	0.9 (14)	19.6	0.9 (14)
Nov. 8,	20.8	1.0	20.6	0.9 (96)	20.4	0.7 (28)	20.0	0.7 (28)
Nov. 20,	21.4	0.9	21.6	1.0 (108)	20.1	0.7 (40)		
Dec. 11,	21.8	1.1	22.1	0.9 (129)	19.9	0.8 (61)		
Dec. 24,	20.1	1.0	20.1	0.8 (142)	19.7	0.8 (74)	18.7	0.8 (74)
Feb. 28, 1987	20.5	0.8	19.8	0.7 (208)	18.1	0.7 (140)	19.5	0.6 (140)
May. 10,	18.8	0.6	18.3	0.5 (279)			17.0	0.1 (211)
Aug. 5, 1987			19.4	1.6 (0)				
Sep. 25,					19.7	1.1 (0)	21.3	1.4 (0)
Sep. 26,	20.3	1.0	18.0	0.8 (50)	19.7	0.9 (1)	19.8	1.1 (1)
Oct. 15,	20.7	1.0	18.3	0.5 (70)	19.6	0.9 (20)	19.2	1.1 (20)
Nov. 13,	20.4	1.0	20.7	0.9 (99)	18.9	0.9 (49)	19.6	1.0 (49)
Mar. 3, 1988	20.8	1.0	20.4	0.7 (237)	19.9	0.8 (189)	20.4	0.8 (189)

Parentheses mean days after release.

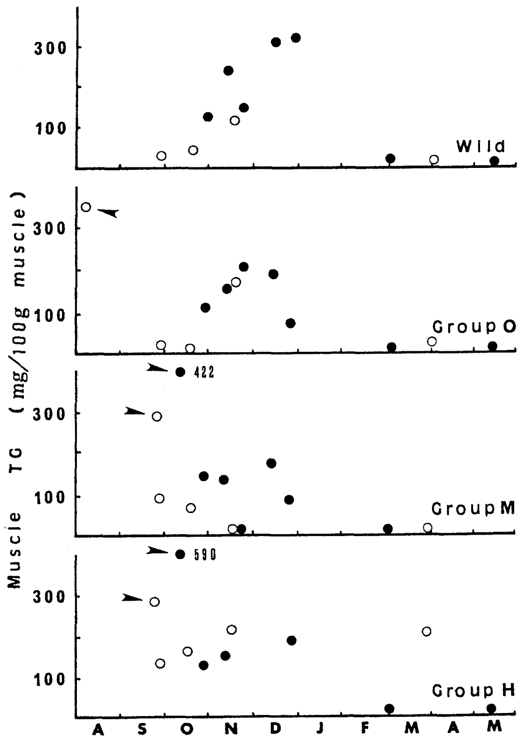

Fig. 4. Changes in muscle triglycerides (TG) of wild and released red sea bream (mean & SE). Symbols refer to Fig. 2.

decrease in fish size seen in both Group M and H released in 1986 at the end of autumn may be partly explained by the temporal shortage of available food organisms.

Marked body weight loss during wintering would be resulted from exhaustion of body constituents due to decline of feeding activity and of available feed organisms. The red sea bream is a non-migratory, but low availability of food and low water temperature induce the dispersion from nursery grounds to depth. Therefore migration of larger fish from the field could partly account for the marked decrease in body weight just after release. It could be said that sufficient lipid reserves supported by active feeding during autumn would be essential to pass throughout the winter under poor energy intake.

Although all the fatty acids were equally mobilized in the wild fish, specific fatty acids were selectively consumed by the survivors after release. The mode of fatty acid selectivity might be derived from the dietary history which affected TG structure and lipid mobilization. However, the survivors were thought to adapt well themselves in the natural environment. Therefore the fatty acid utilization of survivors released in 1986 might indicate

Table 2. Changes in fatty acid composition (%) of muscle triglycerides of red sea bream after release in 1986

Group/Capture	Fatty acids						
	16:0	18:0	16:1	18:1	18:2	20:5	22:6
Wild							
Oct. 25, 1986	21.6	9.0	7.6	19.7	1.6	12.5	10.2
Nov. 20	20.6	11.2	7.3	27.3	1.6	7.2	6.2
Dec. 24	20.4	7.9	8.8	25.6	1.8	11.5	8.5
Feb. 28, 1987	22.2	9.1	8.0	20.3	2.4	11.5	14.5
May 10	17.6	9.2	7.5	22.4	1.6	14.5	7.3
Group O							
Oct. 25, 1986	21.5	9.6	6.4	32.2	7.9	3.5	6.7
Nov. 20	23.6	9.9	7.4	23.8	1.5	8.4	9.2
Dec. 24	15.6	6.0	6.4	16.9	2.3	30.4	7.5
Feb. 28, 1987	3.2	1.2	1.0	2.3	tr.	88.5	1.1
May 10	10.7	4.6	4.3	10.3	1.8	46.5	7.7
Group M							
Oct. 9, 1986	20.6	6.8	6.3	21.0	3.7	9.1	15.7
Nov. 8	18.8	7.3	6.0	20.8	4.4	9.3	13.2
Dec. 24	17.2	6.9	7.6	20.2	3.4	15.4	11.4
Feb. 28, 1987	9.7	4.0	3.5	13.3	2.2	50.1	5.0
Group H							
Oct. 9, 1986	23.0	7.8	5.4	24.5	6.8	5.8	11.1
Nov. 8	22.2	8.6	5.0	26.5	5.9	2.6	9.3
Dec. 24	19.7	8.0	6.3	22.7	7.0	6.5	9.2
Feb. 28, 1987	15.3	5.9	5.8	18.8	1.9	31.6	7.3
May 18	4.4	1.3	1.9	5.8	1.4	76.0	2.6

insufficient adaptation in feeding habit in the environment.

Retardation of release time would result in defficient lipid stores for wintering on account of insufficient period for recovering lipid reserves. Accordingly, the ability to elevate lipid reserves would be essential for survive in the natural environment.

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瀬戸内海に放流したマダイ体成分の変化

Javier VILLA-NAVARRO・中川平介・高場　稔

要旨：異なった飼育方法で生産した３群のマダイを瀬戸内海に放流した後、採捕してマダイの体成分、主として蓄積脂質を測定し、天然環境における生理状態を、同時に採捕された天然マダイと比較した。放流後の環境の変化により筋肉、腹腔内脂肪組織の脂質が減少したが、秋に活発な摂餌により脂質量に回復傾向がみられた。しかし、水温が低下する冬季は絶食状態にあり蓄積脂質の枯渇がみられた。この現象は天然マダイにおいても観察された。これらの現象から脂質の蓄積能の高いことが冬季の水温の低い瀬戸内海で生残するための重要な条件の１つと推定される。