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Effects of Dietary Lipid Levels on the Growth, Efficiency of Feed Utilizaion and Body Composition of Young Redlip Mullet*

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Feeding trials were conducted to investigate the effects of dietary lipid levels on the growth and efficiency of feed utilization for young redlip mullet *Liza haematocheila*. Experimental diets containing pollack liver oil (5-15%) as the lipid source, casein (48-28% in experiment I, 40% in experiment II) as the protein source, and dextrin and a-starch (35% in experiment I, 44-21.5% in experiment II) as the digestible carbohydrate source were fed to seven groups of experimental fish for eight weeks.

In experiment I, the fish fed on 13% lipid and 28% protein diet obtained almost the same growth and feed efficiency as the fish fed on 3% lipid and 48% protein diet. However, according to the increase in dietary lipid level, the lipid contents in dorsal muscle and liver and the liver glycogen content increased, and the protein content in dorsal muscle decreased conversely. Also the visceral ratio to body weight increased significantly with increasing dietary lipid level, therefore the deposition of lipid into fish viscera was indicated on higher lipid diets.

When the dietary protein level was constant (experiment II), the best growth and feed efficiency were obtained between 7 and 11% of the dietary lipid levels. On the other hand, better protein and lipid retentions in the body were noted on lower lipid (higher carbohydrate) diets. This indicates that carbohydrate exceeded lipid in the availability as an energy source for young redlip mullet, when the dietary protein level remained around 40%.

INTRODUCTION

In a previous study in which casein was used as the dietary protein source, the optimum protein levels (the optimum carbohydrate levels) for O-year and l-year redlip mullet *Liza haematocheila* were estimated to be 40-45% and 35% (35-29% and 41%), respectively (Yoshimatsu *et al.*, 1992). The results also indicated a possibility of high efficiency of utilizing dietary carbohydrate by redlip mullet. However, detailed knowledge about the nutritional requirements of mugilid fish including redlip mullet is still inadequate, especially for the dietary lipid in spite of its important role in fish feed (Watanabe, 1980). Generally, mullet has a high percentage of total lipid in its body, and can be classified as a 'fatty' fish (Iles and Wood, 1965; Perera and De Silva, 1978). Therefore, the utilization of dietary lipid in mugilid fish would be one of the important subjects that should be also clarified for the improvement of practical mullet feed

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Nutritional Requirements of Redlip Mullet- II.

production.

The objective of the present research was to determine the effects of dietary lipid levels on the fish growth performance, efficiency of feed utilization and body composition, and to estimate the optimum level of dietary lipid for young redlip mullet. Seven purified diets were prepared isocalorically for this purpose. The results of the feeding trials were judged by using various criteria: i.e., fish growth, feed efficiency, protein efficiency ratio, protein and lipid retentions in the body, chemical compositions of fish body and liver, the visceral ratio to body weight, hepatosomatic index, etc.

MATERIALS AND METHODS

Experimental fish and rearing condition

The fish used for the experiment were reared from eggs in the laboratory. When fish were six months old, they were transferred into 150 litter indoor rectangular aquaria with 30 individuals each (average body weight 6.91g) and fed the experimental diets. Each aquaria was aerated (400-600 ml/min) and supplied with a through-flow warmed sea water (2.0-2.5 l/min). The water temperature during the experimental period ranged from 21.0 to 23.7℃.

Table 1. Percent compositions of the experimental diets for young redlip mullet.

Ingredient	Diet No.						
	1	2	3	4	5	6	7
Casein*[1]	48	40	34	28	40	40	40
Dextrin	30	30	30	30	39	23.5	16.5
α-Starch	5	5	5	5	5	5	5
P. L. oil*[2]	5	9	12	15	5	12	15
Vitamins*[3]	3	3	3	3	3	3	3
Minerals*[4]	5	5	5	5	5	5	5
C. M. C.*[5]	2	2	2	2	2	2	2
α-Cellulose	2	6	9	12	1	9.5	13.5
DE(kcal/100g)*[6]	354.5	354.5	354.5	354.5	354.0	355.8	355.3
DE/P ratio*[7]	73.9	88.6	104.3	126.6	88.5	89.0	88.8
Natrient content in dry matter							
Crude protein	47.7	38.8	35.6	27.8	39.1	40.4	39.7
Crude lipid	2.9	6.8	10.0	12.9	3.2	10.5	14.3
Crude ash	3.9	3.1	3.0	2.6	2.9	3.2	3.2
Carbohydrate	39.8	41.0	39.4	40.0	49.2	31.8	24.9

*[1] Vitamin-free milk casein.
*[2] Pollack liver oil.
*[3] Halver's vitamin mixture (1957) + α-cullulose.
*[4] $NaH_2PO_4 \cdot 2H_2O$ 49.28, Fe-citrate 2.40, $AlCl_3 \cdot 6H_2O$ 0.015, $ZnSO_4 \cdot 7H_2O$ 0.291, $MnSO_4 \cdot 4\text{-}6H_2O$ 0.065, CuCl 0.009, KI 0.014, $CoCl_2 \cdot 6H_2O$ 0.086, α-cellulose 47.84g/ mixture 100g.
*[5] Carboxymethylcellulose.
*[6] Digestible energy of each component is estimated from the values for carp (Ogino et *al.,* 1976): 4 kcal/g protein, 8 kcal/g lipid and 3.5 kcal/g digestible carbohydrate.
*[7] Digestible energy to protein ratio, DE (kcal/kg)/protein (%).

Diets and feeding regime

Seven purified diets were formulated isocalorically (Table 1) using the values for common carp *Cyprinus carpio* (Ogino et *al.*, 1976). Vitamin-free milk casein was used as the dietary protein source, dextrin and a-starch (gelatinized starch) as the digestible carbohydrate source and pollack liver oil (P.L. oil) as the lipid source. In diets 1-4, 35% carbohydrate (the optimum level for O-year redlip mullet), 48-28% protein and 5-15% lipid were added to give various levels of protein and lipid in the diets. In diets 5-7, 40% protein (the optimum level for O-year redlip mullet), 44-21.5% carbohydrate and 5-15% lipid were added to give various levels of carbohydrate and lipid in the diets. The diets were processed into three different sizes of dry pellet and kept at -20°C. The experimental groups were categorized into two: experiment I (diets l-4) and experiment II (diets 2 and 5-7), and fed to satiation on the appropriate size of pellet three times a day for eight weeks.

Measurements and chemical analyses

All the experimental fish were weighed individually at biweekly intervals, after anesthetized with MS222 (100 ppm). At the end of the feeding trials hepatosomatic indices and the visceral ratios to body weight were calculated by using 25 individuals from each tank. Also proximate analyses for all diets, liver and dorsal muscle were carried out. The liver glycogen content from each dietary treatment fish and carbohydrate content of each diet were quantified by anthrone method (Carroll et *al.*, 1956) and phenollsulfuric acid method (Hodge and Hofreiter, 1962), respectively.

RESULTS

Rearing results in experiment I

The fish fed on diets l-4 showed almost the same growth and feed efficiency during the whole experimental period (Table 2, Fig. l),and there were no significant differences in their growth ($P>0.05$). Protein efficiency ratio and protein retention rate increased as the dietary lipid level was elevated (Fig. 2); this indicates that the greater body weight gain and the protein deposition into fish body per unit dietary protein were yielded on higher dietary lipid groups. Conversely, lipid retention in the body decreased with increasing dietary lipid level(Fig. 2), and on 3% lipid level the lipid retention rate was much greater than those obtained on higher lipid groups.

Rearing results in experiment II

When the dietary protein level was constant and kept at the optimum (40%), the fish growth was not affected significantly ($P> 0.05$) by the differences in dietary energy sources (Table 2, Fig. 1). Fish fed on diets 2 and 6 obtained the best weight gain and feed efficiency. The lowest weight gain and feed efficiency were observed on diet 7: the highest lipid and lowest carbohydrate diet, as shown in Fig. 2. Also the protein efficiency ratio on diet 7 was slightly lower than those of other dietary groups. Protein retention rate decreased gently and almost linerly with increasing lipid level between 3 and 11%, and declined at 14% lipid level. Lipid retention rate also decreased with increasing dietary lipid level, and the best value was noted on the fish fed on diet 5 containing the lowest lipid level. Namely, lower lipid and higher carbo-

Table 2. Effects of the dietary lipid levels on the growth and efficiency of feed utilization of young redlip mullet.

Diet No.	1	2	3	4	5	6	7
Experimental group	I	I II	I	I	II	II	II
Average initial weight (g)	6.82±0.58	6.90±0.59	6.78±0.60	6.80±0.60	7.01 ±0.59	7.05±0.52	7.02±0.55
Average final weight (g)	23.5±3.4	23.3i3.7	23.2±5.4	23.Ozt4.7	22.1t3.2	23.9±3.7	21.7±4.6
"t" test	NS*1	— NS	NS	NS	NS	NS	—
Average weight gain (%)	244.9	233.8	236.5	237.9	215.2	239.3	203.2
Hepatosomatic index**	1.57±0.28	1.62f0.29	1.68±0.38	1.69±0.28	1.54f0.22	1.46±0.34	1.29±0.23
"t" test	—	NS S*3	NS	NS	S	S	—
WV/BW (%)*4	8.98±0.75	9.63±1.53	11.6k1.15	10.8±1.87	8.77±1.50	10.1±0.96	10.1±1.57
"t" test	NS	S	S	S	S		NS
Final survival rate (%)	100	98.3	93.3	96.7	93.3	100	86.7
Daily feed intake (%)	4.01	4.04	4.15	4.11	4.12	4.08	4.41
Daily growth rate (%)	1.97	1.94	1.96	1.94	1.85	1.94	1.82
Feed efficiency (%)	49.0	47.7	46.7	47.2	44.9	47.7	40.8
Protein efficiency ratio*5	1.03	1.24	1.31	1.70	1.15	1.18	1.03
Protein retention rate (%)*6	21.5	24.7	25.9	32.2	25.6	23.0	19.8
Lipid retention rate (%)*7	70.1	37.7	32.8	27.2	42.5	24.1	21.3

*1 Not significantly different ($P > 0.05$).
*2 Liver weight (g) x 100 / body weight (g), n=25.
*3 Significantly different ($P < 0.05$).
*4 Whole viscera (g) x 100 / body weight (g), n=25.
*5 Body wet weight gain (g)/ protein fed (g).
*6 Muscle protein gain (g) × 100 / protein fed (g).
*7 Muscle lipid gain (g) × 100 / lipid fed (g).

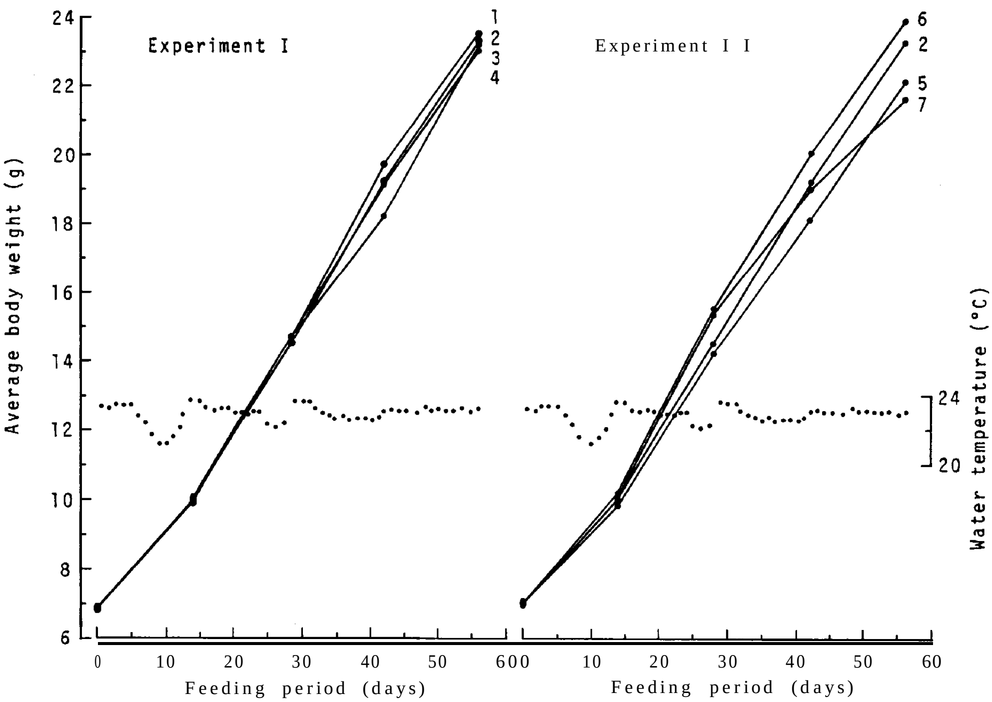

Fig. 1. Growth curves of young redlip mullet fed on diets containing various levels of lipid.

Table 3. Effects of the dietary lipid levels on the body and liver compositions (%).

Diet No.	Moisture	Crude protein	Crude lipid	Crude ash	Glycogen
			Dorsal muscle		
Initial	79.3	18.6	1.2	1.7	
1	75.9	20.3	3.3	1.3	
2	75.6	19.6	4.1	1.4	
3	74.7	19.4	5.3	1.2	
4	74.6	18.9	5.6	1.3	
5	75.9	21.1	2.5	1.5	
6	75.4	19.2	4.1	1.3	
7	73.9	19.1	5.4	1.2	
			Liver		
1	66.4	15.7	17.4	1.8	0.03
2	63.2	15.8	21.4	2.5	0.20
3	62.9	14.9	21.2	1.8	0.38
4	62.4	14.6	22.1	2.1	0.53
5	64.6	15.3	17.9	2.8	0.33
6	61.3	15.7	22.3	2.0	0.00
7	62.2	14.9	22.5	1.9	0.00

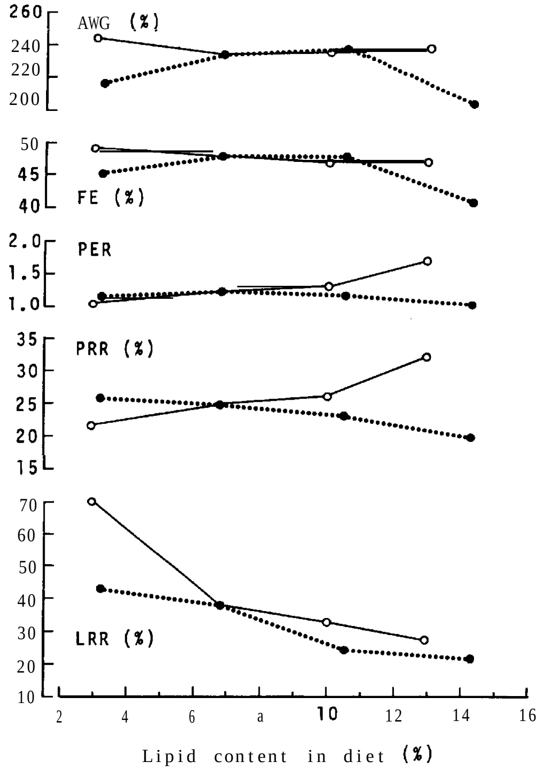

Fig. 2. Effects of dietary lipid levels on the average weight gain (AWG), feed efficiency (FE), protein efficiency ratio (PER), protein and lipid retentions in the body (PRR and LRR). ○—○, experiment I; ●---●, experiment II.

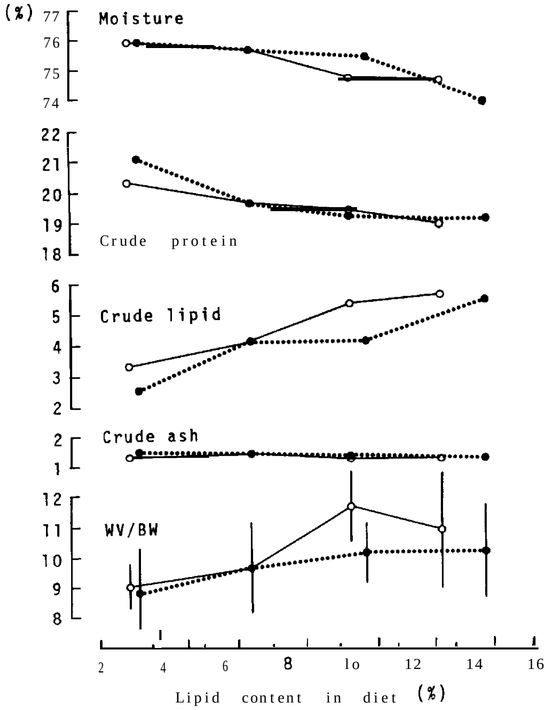

Fig. 3. Relation between the dietary lipid level and the chemical composition in fish body and the visceral ratio to body weight (WV/SW). Vertical lines indicate the range of SD (n=25), ○—○, experiment I; ●---●, experiment II.

hydrate diets yielded the better utilization in both dietary protein and lipid.

Body composition

In experiment I, while crude lipid contents in dorsal muscle and liver increased, moisture and crude protein contents decreased with increasing dietary lipid level (Table 3, Figs. 3 and 4). Glycogen content in the liver increased with increasing lipid level (Fig. 4), however, there appeared no significant differences ($P>0.05$) in the hepatosomatic indices among all the dietary groups (Table 2). The visceral ratio to body weight increased significantly ($P < 0.05$) with increasing dietary lipid level (Fig. 3). This indicates that when higher lipid diets were fed, the dietary lipid could be deposited not only into dorsal muscle but also into visceral cavity. Therefore, even the high growth performance obtained on diet 4 (13% lipid) would be due to the increase of lipid content in the body.

Experiment II exhibited almost the same trend in relation to the body composition and the dietary lipid level as those obtained in experiment I. While crude lipid contents in the dorsal muscle and liver were positively correlated with lipid levels, the crude protein and moisture contents in the dorsal muscle showed negative correlation (Table 3, Figs. 3 and 4). As a result of two experiments, the body composition was

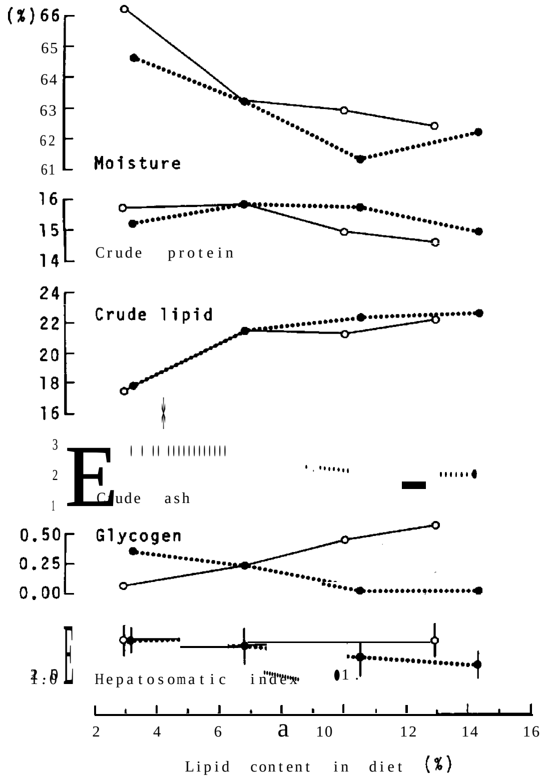

Fig. 4. Relation between the dietary lipid level and the chemical composition in fish liver and the hepatosomatic index. Vertical lines indicate the range of SD (n=25), ○—○, experiment I; ●---●, experiment II.

mainly affected by the change in dietary lipid level alone, except that of the liver glycogen content which showed positive correlation with dietary carbohydrate levels. Though each diet contained 21.5-44% of digestible carbohydrate, the liver glycogen content was extremely low as shown in Table 3, especially when the fish were fed on low carbohydrate diets, as compared with the values obtained in fishes (e.g. red sea bream *Pagrus major)* reported by Furuichi (1983). This suggests the possibility of redlip mullet utilizing dietary carbohydrate effectively as an energy source without retaining it as liver glycogen, in agreement with the suggestion for young grey mullet *Mugil cephalus* by Perera and De Silva (1978). Visceral ratio to body weight increased significantly ($P<0.05$) with increasing dietary lipid level (Fig. 3); this indicates the deposition of lipid into fish viscera on higher dietary lipid groups, as well as the result obtained in experiment I.

DISCUSSION

There were no significant differences in the fish growth, and a slight decrease in their feed efficiencies were observed when the dietary protein level was lowered from 48 to 28% by raising its lipid level from 3 to 13% (raising digestible energy to protein ratio from 73.9 to 126.6). Thus, under isocalorical conditions, the 20% of dietary protein could be replaced successfully by the supplement of additional 10% of lipid with almost no loss in feed utilization for young redlip mullet. Takeda et *al.* *(1975)* and Takeuchi *et al.* (1978) reported that some amount of dietary protein was able to be spared by the supplement of dietary lipid under isocaloric dietary conditions for rainbow trout *Oncorhynchus mykiss* and yellowtail *Seriola quinqueradiata*, respectively. Because of the differences in their feed compositions, energy content in each diet, fish sizes used for the experiments and the criteria for judging the protein sparing effect, it might be difficult to compare and determine each effect strictly. Nevertheless, the result obtained in experiment I showed the possibility of high protein sparing effect by lipid for redlip mullet. However, it would be necessary to investigate in detail about the effect, under conditions with various levels of digestible energy and so on.

When dietary protein level was constant (experiment II), the best growth and feed efficiency were observed between the lipid levels of 7–11%. The protein efficiency ratios in each lipid level were almost at the same, but the protein and lipid retentions in the body were negatively correlated with its dietary lipid level. This result indicates both dietary protein and lipid were utilized more effectively for the fish growth in higher carbohydrate diets. Therefore carbohydrate can be more available as an energy source than lipid for young redlip mullet, between 3–14% lipid levels. Takeuchi *et al.* (1979) investigated the availability of carbohydrate (5–50% dietary levels) and lipid (5 and 15% dietary levels) for common carp using diets whose protein level was constant at the optimum (32%). Their results showed that there was no difference affecting growth between them as energy sources. Though both mullet and carp are categorized into the same omnivorous fish (Matsubara *et al.*, 1979), the result of the present research disagreed with that of common carp; probably because of subtle differences in feeding habits and nutritional requirements between these two species. The body composition was affected by changing dietary lipid levels, and higher lipid diets produced higher lipid contents in their body and viscera. These data suggest that the excess amount of dietary lipid over 11% level might reduce both fish meat quality and the efficiency of dietary protein utilization.

Judging from the results of the two feeding trials and analytical data, the optimum level of dietary lipid for young redlip mullet would be estimated to be around 7–11%, when the dietary protein (casein) level is 40%. Expensive dietary protein should be utilized most effectively in the practical feed production. According to the results of the present research, carbohydrate was more available for the dietary energy source in the case of young redlip mullet. So in order to spare dietary protein, the increase in amount of carbohydrate should be applied rather than the supplement of dietary lipid, when reasonable amount of quality lipid is in the diets. This may be more beneficial for both reasons of economy and the convenience in handling fish feed.

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REFERENCES

Carroll, N. V., R. W. Longley and J. H. Roe 1956 The determination of glycogen in liver and muscle by use of anthrone reagent. *J. Biol. Chem., 220: 583-593*

Furuichi, M. 1983 Studies on the utilization of carbohydrate by fishes. *Rep. Fish. Res. Lab. Kyushu Univ.,* No.6: l-59

Halver, J. E. 1957 Nutrition of salmonoid fishes-III. Waterrsoluble vitamin requirements of chinook salmon. *J. Nutr., 62: 225-243*

Hodge, J. E. and B. T. Hofreiter 1962 Determination of reducing sugars and carbohydrates. *In* " Methods in Carbohydrate Chemistry", Vol. 1, ed. by R. L. Whistler and M. L. Wolfrom, Academic Press, New York, pp. 388-389

Iles, T. D. and R. J. Wood 1965 The fat/water relationship of North Sea herring, *Clupea harengus* and its possible significance. *J. mar. biol. Ass. U. K.., 45: 353-366*

Matsubara, K., A. Ochiai and T. Iwai 1979 Feeding habit. *In* "Ichithyology", Vol. 1, Koseisha-Koseikaku, Tokyo, pp. 159-168 (in Japanese)

Ogino, C., J. Y. Chiou and T. Takeuchi 1976 Protein nutrition in fish-VI. Effect of dietary energy sources on the utilization of protein by rainbow trout and carp. *Bull. Japan. Soc. Sci. Fish., 42:* 213-218

Perera, P. A. B. and S. S. De Silva 1978 Studies on the chemical biology of young grey mullet, *Mugil cephalus* L., *J. Fish Biol., 13: 297-304*

Takeda, M., S. Shimeno, H. Hosokawa, H. Kajiyama and T. Kaisyo 1975 The Effect of dietary calorie-to-protein ratio on the growth, feed conversion and body composition of young yellowtail. *Bull. Japan. Soc. Sci. Fish., 41: 443-447*

Takeuchi, T., T. Watanabe and C. Ogino 1978 Optimum ratio of protein to lipid in diets of rainbow trout. *Bull. Japan. Soc. Sci. Fish., 44: 683-688*

Takeuchi, T., T. Watanabe and C. Ogino 1979 Availability of carbohydrate and lipid as dietary energy sources for carp. *Bull. Japan. Soc. Sci. Fish., 45: 977-982*

Watanabe, T. 1980 Lipid. *In* "Nutrition and Feeding in Fish", ed. by C. Ogino, Koseisha-Koseikaku, Tokyo, pp. 149-186 (in Japanese)

Yoshimatsu, T., M. Furuichi and C. Kitajima 1992 Optimum levels of protein in purified experimental diets for redlip mullet. *Bull. Japan. Soc. Sci. Fish., 58: 2111-2117*