GROWTH AND FOOD CONSUMPTION IN PLAICE Part II KAREIUS BICOLORATUS (BASILEWSKY)

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By

Masayoshi HATANAKA, Masaya KOSAKA and Yûji SATÔ

Department of Fisheries, Faculty of Agriculture,
Tohoku University, Sendai, Japan

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The biology of a species of plaice, *Kareius bicoloratus* (BASILEWSKY), collected in the Bay of Sendai has already been published, one in 1952 (3) concerning the growth and spawning, and another in 1954 (4) on feeding habits. Recently, a feeding experimemt was undertaken at "Matsushima Aquarium" to determine the relation between growth and food consumption in this plaice. With available data, the amount of foods necessary for the yearly growth of the individual plaice was studied and some informations were added concerning the quantitative analysis of plaice productions in the Bay of Sendai.

The feeding experiments were performed three times, each under different temperature conditions, during the period from the winter of 1955 to the summer of 1956. Specimens used were caught by a pound trap, "Sudate", set in the Bay of Matsushima. They ranged between 1 and 2 years in age and between 86 g and 302 g in weight. About 10 individuals, each tagged with a vinyl ribbon to distinguish one another, were reared for a time in a concrete aquarium, which measured 1.7 m long and 1.7 m wide with 45 cm depth, and provided with running water. Prior to the start of each experiment, the fish were kept for two or three weeks to become adapted to the feeding in the aquarium.

For food the shucked clam, *Venerupis japonica*, weighing 0.7 to 3.8 g each, were mainly used, and the annelid, *Tylorrynchus heterochaetus*, or flesh of the mackerel, *Pneumatophorus japonicus*, were also used to find the different efficiencies of food conversion. The plaice were fed sufficiently once a day, and the daily ration of individual fish were recorded. Fish were weighed and measured once per ten days. Temperature and salinity of sea water were recorded daily.

Before proceeding further we wish to express our hearty thanks to Mr. Y. Takahashi, the director of Matsushima Aquarium, and to the staff there for their kind co-operation during the experiments.

Stomach Contents

As previously reported (4), the food items of this plaice in the Bay of Sendai are quite variable, including annelid worms, various molluscs, small and large crustaceans and fish. As the fish grow larger they prefer foods of the items and in the order just mentioned. The percentage weight of stomach contents to the body weight was calculated for each fish from the data obtained in 1952 and the means are given in Table 1 separately for the ages and the dates of collections.

Table 1. Percentage weight of stomach contents to the body weight in *Kareius bicoloratus* in the Bay of Sendai in 1952.

Date	1 year in age			2 years in age			3 years in age		
	Numb.	Ave. weight (g)	Feeding rate (%)	Numb.	Ave. weight (g)	Feeding rate (%)	Numb.	Ave. weight (g)	Feeding rate (%)
June 10, '52	2	119.0	0.84	6	111.7	0.36			
July 1, "	6	77.0	1.03	5	162.2	2.20	1	460	0.37
" 25, "	2	78.5	1.34	4	112.5	1.47	1	287	0.24
Aug. 14, "	5	93.2	0.09	7	139.3	0.14			
Dec. 6, "	2	139.0	0.50	6	378.5	0.05			
Dec. 25, "	10	177.8	0.00	4	277.3	0.00			

The maximum rate of feeding in Table 1 was 2.20 per cent among the two-year-old fish collected on July 1. An individual, weighing 247 g, among this collection, showed 8.2 g (or 3.3 per cent) in weight of the stomach contents, which consisted of the sand launce, *Ammodytes personatus* (2). The standing amount of feeding in Table 1 indicates at least the minimum daily ration of this plaice under the natural conditions.

Feeding Experiments

Experiment No. 1

Experiment No. 1 continued for a period of 22 days between November 16 and December 8, 1955, at a low temperature range between 6.9° and 13.0°C (8.2°C as average). The 7 fish used in this experiment, ranged between 104.5 g and 302 g in weight. The temperatures held coincided nearly with the habitat temperature of this plaice in winter. Details of the feeding with clams and the growth made during the experiment No. 1 are given in Table 2.

The statistics of the 7 fish in the experiment No. 1 are, the daily rates of feeding ranged between 1.21 and 4.46 per cent, the daily rates of growth between 0.09 and 0.81 per cent and the efficiencies of conversion between 7.45 and 20.83 per cent. On an energy basis, the plaice showed 1.14 kcal per gram and the clam 0.68 kcal per gram, hence the feeding rates and the efficiencies

Table 2. Feeding and growth of *Kareius bicoloratus*, fed with clams under the low temperature range (Exp. No. 1).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Daily rate of feeding		Growth made	Daily growth	Growth rate	Efficiency of conversion	
		Initial	Final	Ave.									
	days	g	g	g	g	g	%	on cal.	g	g	%	%	on cal.
1	22	102	107	104.5	60.8	2.76	2.64	1.57	5	0.23	0.22	8.22	13.78
2	,,	105	123	114.0	113.8	5.08	4.46	2.66	18	0.82	0.72	16.10	26.99
3	,,	107	122	114.5	85.6	3.89	3.40	2.03	15	0.68	0.59	17.52	29.37
4	,,	130	143	136.5	62.4	2.84	2.08	1.24	13	0.59	0.43	20.83	34.92
5	,,	129	154	141.5	121.2	5.51	3.89	2.72	25	1.14	0.81	20.63	34.59
6	,,	167	175	171.0	95.5	4.34	2.54	1.52	8	0.36	0.21	8.38	14.05
7	,,	299	305	302.0	80.5	3.66	1.21	0.72	6	0.27	0.09	7.45	12.49

of conversion were also expressed by the calorie equivalence. Since the various aspects on feeding and growth differ by size, the 7 fish were divided into two groups by body weight and the means in each group were as follows:

Range of body weight	Average body weight	Number of fish	Daily rate of feeding (on kcal)	Daily rate of growth	Efficiency of conversion (on kcal)
104.5–171.0 g	130.3 g	6	3.17%(1.89%)	0.50%	15.28%(25.62%)
302 g	302 g	1	1.21%(0.72%)	0.09%	7.45%(12.49%)

Experiment No. 2

Experiment No. 2 A continued for a period of 30 days from May 21 to June 20, 1956, at an intermediate temperature range between 14.4° and 17.9°C (16.7°C as average), using 5 fish ranging between 140.0 g and 199.5 g in weight. The temperatures held in this period correspond nearly to the inhabiting temperatures of this plaice in spring or autumn. Details of the feeding on clams and the growth made during the experiment No. 2 A are given in Table 3.

Table 3. Feeding and growth of *Kareius bicoloratus*, fed with clams under the intermediate temperature range (Exp. No. 2A).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Daily rate of feeding		Growth made	Daily growth	Growth rate	Efficiency of conversion	
		Initial	Final	Ave.									
	days	g	g	g	g	g	%	on cal.	g	g	%	%	on cal.
8	30	120	160	140.0	229.9	7.66	5.47	3.26	40	1.33	0.95	17.40	29.17
9	,,	136	165	150.5	164.0	5.47	3.63	2.17	29	0.97	0.64	17.68	29.64
10	,,	144	170	157.0	102.1	3.40	2.17	1.29	26	0.87	0.55	25.47	42.70
11	,,	177	195	186.0	98.8	3.29	1.77	1.06	18	0.60	0.32	18.22	30.55
12	,,	187	212	199.5	217.3	7.24	3.63	2.17	25	0.83	0.42	11.50	19.29

The statistics of the 5 fish in the experiment No. 2 A are, the daily rates of feeding ranged between 1.77 and 5.47 per cent (or 1.06 and 3.26 per cent on the calorie basis), the daily rates of growth between 0.32 and 0.95 per cent and

the efficiencies of conversion between 11.50 and 25.47 per cent (or 19.29 and 42.70 per cent on the calorie basis). When the 5 fish were divided into two groups by size, the mean values in each group were as follows:

Range of body weight	Average body weight	Number of fish	Daily rate of feeding (on kcal)	Daily rate of growth	Efficiency of conversion (on kcal)
140.0–157.0 g	149.2 g	3	3.77%(2.25%)	0.71%	20.18%(33.83%)
186.0–199.5 g	192.8 g	2	2.70%(1.61%)	0.37%	14.86%(24.91%)

At nearly the same period as the above experiment, experiment No. 2 B was performed using annelids instead of clams as foods, to know the differences in growth by different foods and also to compare the results with the case of *Limanda yokohamae* fed with annelids. This experiment continued for a period of 50 days from May 1 to June 20, 1956, under an intermediate temperature range between 10.9° and 18.0°C (14.7°C as average), using 6 fish ranging between 128.0 g and 210.5 g in weight. The water temperature held through the experiments No. 2 A and No. 2 B can be considered to be nearly the average of the temperatures in the habitat of this plaice throughout the year. Details of the exp. No. 2 B are given in Table 4.

Table 4. Feeding and growth of *Kareius bicoloratus*, fed with annelids under the intermediate temperature range (Exp. No. 2B).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Daily rate of feeding		Growth made	Daily growth	Growth rate	Efficiency of conversion	
		Initial	Final	Ave.									
	days	g	g	g	g	g	%	on cal.	g	g	%	%	on cal.
13	40	87	169	128.0	353.5	8.84	6.91	4.97	82	2.05	1.60	23.20	32.25
14	50	120	209	164.5	492.4	9.85	5.99	4.30	89	1.78	1.08	18.07	25.12
15	40	149	180	164.5	202.2	5.06	3.08	2.22	31	0.78	0.47	15.33	21.31
16	30	152	199	175.5	198.8	6.63	3.78	2.72	47	1.57	0.89	23.64	36.86
17	40	156	225	190.5	365.6	9.14	4.80	3.45	69	1.73	0.91	18.87	26.23
18	40	187	234	210.5	268.8	6.72	3.19	2.29	47	1.18	0.56	17.49	24.31

The statistics of the 6 fish in the experiment No. 2 B are, the daily rates of feeding ranged between 3.08 and 6.91 per cent, the daily rates of growth between 0.47 and 1.60 per cent and the efficiencies of conversion between 15.33 and 23.64 per cent. On an energy basis, the annelids showed 0.82 kcal per gram, hence the above rates are expressed as between 2.22 and 4.97 per cent for the feeding and as between 21.31 and 32.86 per cent for the conversion. When the 6 fish were divided into two groups by size, the means in each group were as follows;

Range of bodyweight	Average body weight	Number of fish	Daily rate of feeding (on kcal)	Daily rate of growth	Efficiency of conversion (on kcal)
128.0–175.5 g	158.1 g	4	4.94%(3.55%)	1.01%	20.12%(27.97%)
190.5–210.5 g	200.5 g	2	4.00%(2.87%)	0.74%	18.18%(25.27%)

Experiment No. 3

Experiment No. 3 A continued for a period of 19 days between July 2 and July 21, 1956, at a high temperature range between 18.0° and 19.5°C (18.7°C as average), using 5 fish ranging between 86.0 g and 252.5 g in weight. The temperatures held coincide with the habitat temperature of the plaice in summer. Details of the feeding on clams and the growth made during the experiment No. 3 A are given in Table 5.

Table 5. Feeding and growth of *Kareius bicoloratus*, fed with clams under the high temperature range (Exp. No. 3A).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Daily rate of feeding		Growth made	Daily growth	Growth rate	Efficiency of conversion	
		Initial	Final	Ave.									
	days	g	g	g	g	g	%	on cal.	g	g	%	%	on cal.
19	19	72	100	86.0	107.8	5.67	6.59	3.93	28	1.47	1.71	25.97	43.54
20	19	93	115	104.0	123.9	6.52	6.27	3.74	22	1.16	1.12	17.76	29.77
21	9	177	188	182.5	47.2	5.24	2.87	1.71	11	1.22	0.67	23.31	39.08
22	19	230	260	245.0	197.1	10.37	4.23	2.52	30	1.58	0.64	15.22	25.52
23	19	230	275	252.5	288.5	15.18	6.17	3.68	45	2.37	0.94	15.60	26.15

The statistics of the 5 fish in the experiment No. 3 A are, the daily rates of feeding ranged between 2.87 and 6.59 per cent (or 1.71 and 3.93 per cent on the calorie basis), the daily rates of growth between 0.64 and 1.71 per cent and the efficiencies of conversion between 15.22 and 25.97 per cent (or 25.52 and 43.54 per cent on the calorie basis). When the 5 fish were divided into two groups by size, the averages in each group were as follows:

Range of body weight	Average body weight	Number of fish	Daily rate of feeding (on kcal)	Daily rate of growth	Efficiency of conversion (on kcal)
86.0–104.0 g	95.0 g	2	6.43%(3.84%)	1.42%	21.87%(36.66%)
182.5–252.5 g	226.7 g	3	4.42%(2.64%)	0.75%	18.04%(30.23%)

Experiment No. 3 B was performed using the flesh of mackerels for food instead of clams parallel with the above experiment at the same period and under the same temperature conditions. The 9 fish used, ranged between 177.5 g and 209.5 g in weight. Details of the experiment No. 3 B are given in Table 6.

The statistics of the 9 fish in the experiment No. 3 B are, the daily rates of feeding ranged between 2.50 and 4.21 per cent (or 3.14 and 5.28 per cent on the calorie basis calculated from the flesh of mackerels taken as 1.43 kcal per gram), the daily rates of growth between 0.53 and 1.59 per cent and the efficiencies of conversion between 20.21 and 43.69 per cent (or 16.11 and 34.83 per cent on the calorie basis). When the 9 fish were divided into two groups by size, the averages in each group were as follows:

Range of body weight	Average body weight	Number of fish	Daily rate of feeding (on kcal)	Daily rate of growth	Efficiency of conversion (on kcal)
177.5–188.5 g	183.7 g	5	3.26%(4.09%)	1.05%	31.30%(24.95%)
202.5–209.5 g	206.7 g	4	3.17%(3.98%)	0.98%	30.57%(24.37%)

Table 6. Feeding and growth of *Kareius bicoloratus*, fed with mackerels under the high temperature range (Exp. No. 3B).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Daily rate of feeding		Growth made	Daily growth	Growth rate	Efficiency of conversion	
		Initial	Final	Ave.									
	days	g	g	g	g	g	%	on cal.	g	g	%	%	on cal.
24	19	160	195	177.5	104.3	5.59	3.15	3.95	35	1.84	1.04	33.56	26.75
25	,,	162	199	180.5	131.1	6.90	3.82	4.79	37	1.95	1.14	28.22	22.50
26	,,	174	195	184.5	87.6	4.61	2.50	3.14	21	1.11	0.60	23.97	19.11
27	,,	172	203	187.5	94.1	4.95	2.64	3.31	31	1.63	0.87	32.94	26.26
28	,,	160	217	188.5	150.8	7.94	4.21	5.28	57	3.00	1.59	37.80	30.13
29	,,	185	220	202.5	146.8	7.73	3.82	4.79	35	1.84	0.91	23.84	19.01
30	,,	175	237	206.0	141.9	7.47	3.63	4.55	62	3.26	1.58	43.69	34.83
31	,,	191	227	209.0	104.3	5.49	2.63	3.30	36	1.89	0.90	34.52	27.52
32	,,	199	220	209.5	103.9	5.47	2.61	3.29	21	1.11	0.53	20.21	16.11

From the above experiments, the growth of the fish is revealed to be affected greatly by the water temperatures held, hence the results of the experiment No. 1, No. 2 A and No. 3 A, which were all fed with the same food (clams) under different temperatures, were compared with one another as shown in Fig. 1.

Each of the daily rate of feeding, the daily rate of growth and the efficiencies of conversion increased as the temperatures became high within the experimental conditions. Inclinations to decrease in these values according to the size are nearly parallel with one another in the different temperature conditions. A somewhat irregular result in the intermediate temperature range (Exp. No. 2 A) may probably be due to the small number of the fishes used. The variation in the efficiencies of conversion by temperature are probably related to the variations in the digestive processes under different temperature conditions, although a more acurate physiological experiment is necessary.

In general the results of the above experiments are in harmony with those of *Limanda yokohamae* (6), and it is apparent that the growth in the plaice is subject to change according to the size of the fish and to the temperatures held.

The kinds of foods used also affect the growth of the fish and on an energy basis the daily rates of feeding were found to be highest in feeding with mackerel, followed by annelids and clams in this order. Under the respective feeding rate, the daily rates of growth were best by feeding with mackerel but there was found no conspicuous difference in the growth rate by feeding either annelids

or clams if the temperature conditions are the same. The efficiencies of conversion were more inferior in feeding with the mackerel than with the annelids. The annelids showed nearly equal efficiencies to the clams.

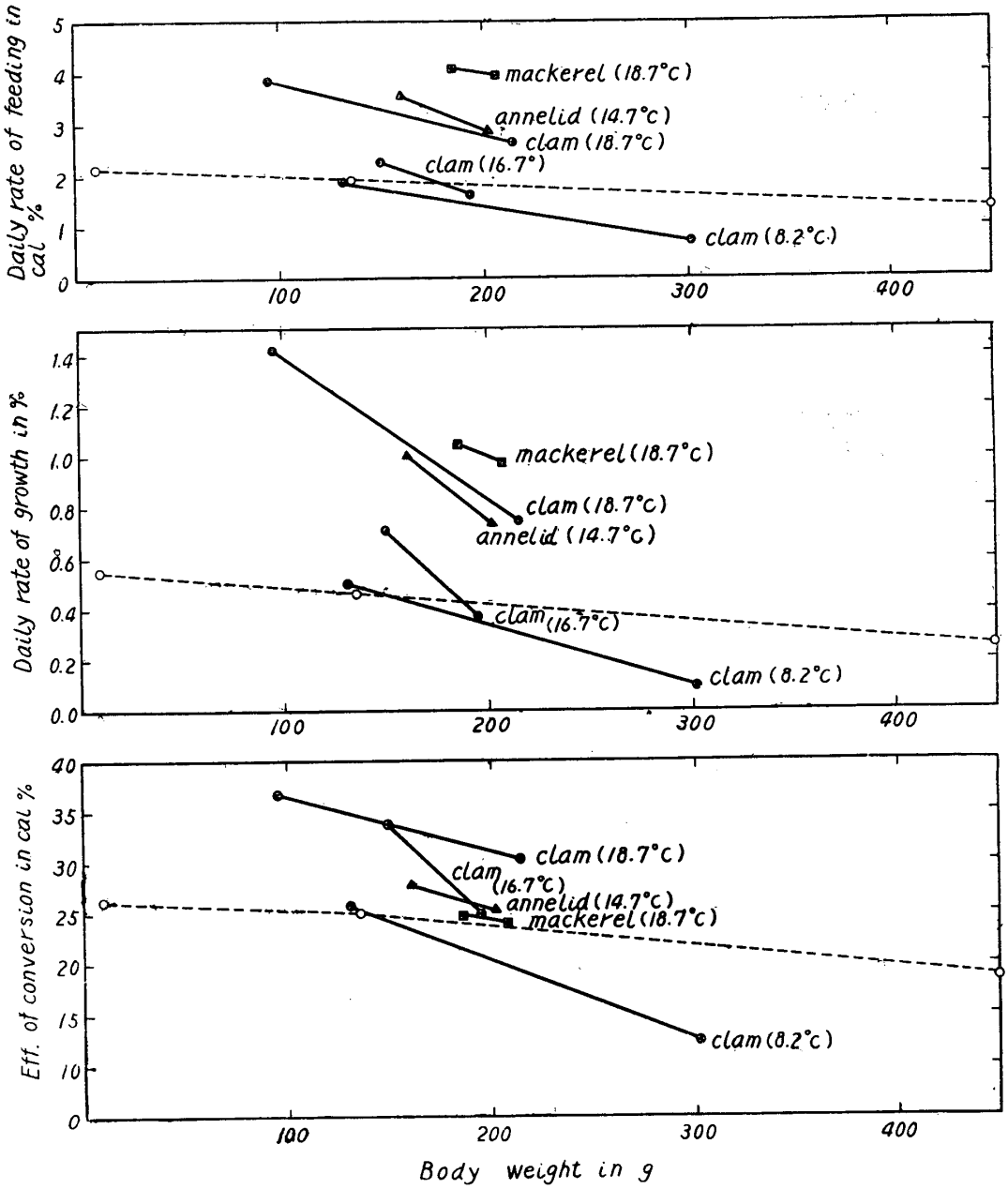

Fig. 1. Daily rates of feeding, daily rates of growth and efficiencies of conversion as averages among various ranges of body weight fed with various kinds of food under different temperature conditions. The open circles represent the calculated values under the natural conditions stated in the next section.

The relations between the food consumed and the growth were obtained basing on the data of the experiments No. 2 A and No. 2 B. The result is

given in Fig. 2.

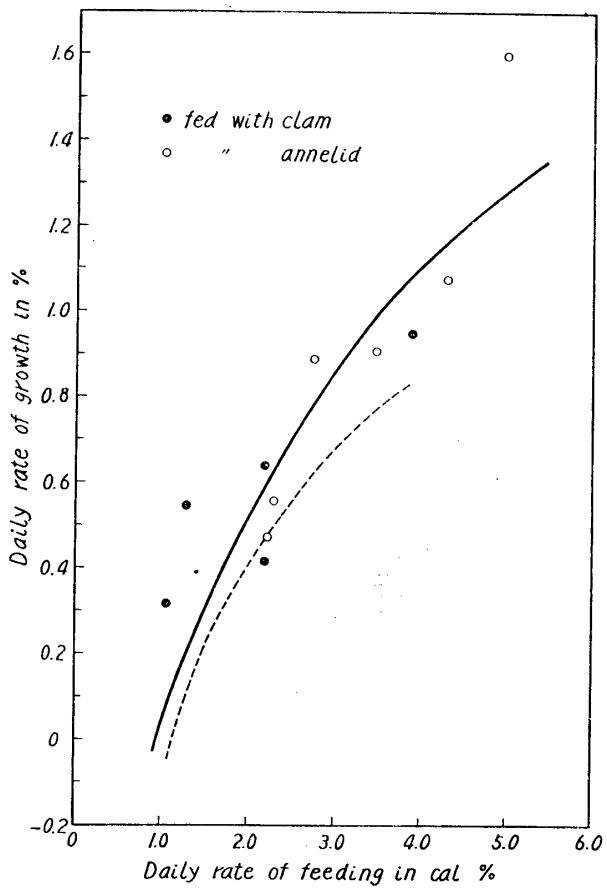

Fig. 2. The relation of the calorie basis between growth and food consumption under the intermediate temperature range. The broken line shows the relation in the case of *Limanda yokohamae*.

The maintenance ration showed 0.95 per cent to the body weight per day, while the same in the case of *Limanda yokohamae* was 1.12 per cent at the temperature of 13.1°C. It is obvious that *K. bicoloratus* can maintain the body weight at a smaller ration than *L. yokohamae*. As seen in Fig. 2, the decline of increase in growth rate as the feeding rates become higher is more remarkable in *L. yokohamae* than in *K. bicoloratus*. In other words, the efficiencies of conversion in *L. yokohamae* more rapidly decrease as the feeding rates becomes higher compared with *K. bicoloratus*.

It was ascertained that *K. bicoloratus* grows more rapidly than *L. yokohamae* when the two plaice are fed with the same food (annelids) under the same temperature conditions. For instance, in the case of *L. yokohamae* of 154 g in average weight of 12 fish fed with annelids under the temperature of 13.1°C, the daily rate of feeding showed 3.15 per cent, the daily rate of growth 0.45 per cent and the efficiency of conversion 13.34 per cent (6). While in the case

of *K. bicoloratus* of 158.1 g in average weight of 4 fish fed with the same food under the temperature of 14.7°C (Exp. No. 2 B), the daily rate of feeding showed 4.94 per cent, the daily rate of growth 1.01 per cent and the efficiency of conversion 20.12 per cent — all on the calorie basis.

Obviously there are numerous variations in experimental technique. For example, some fish whose growth were very poor or decreased in weight owing to the very small or no ration during the experiments of this plaice were excluded from the above data as a technical error. The space of the aquarium may not necessarily be sufficient for the feeding and growth of the larger fish used in the experiment. Sex difference in the various aspects of growth and food consumption was not recognized in the experiments. For the calculations on the calorie basis, seasonal variations of the calories per gram of the body weight in both the plaice and the foods were neglected, so that some corrections in concern shall be made in the future.

Growth and Food Consumption

According to the previous report (3), the most active spawning of this plaice in the Bay of Sendai occurs in early December, and most of the fish complete spawning before the end of the year. The plaice grows to 20 g in weight at the end of the first year of life. The retarded growth in this period may perhaps be caused by the habitat conditions of living along beaches of shallow bays. Later, the growth differs by the sexes, and females attain, making a rapid growth by living offshore in the Bay of Sendai, to 250 g in weight at the end of the one year, 650 g at the end of the two years, 950 g at the end of the three years, 1130 g at the end of the four years and to 1250 g at the end of the five years of age. While the males attain to 230 g at the end of the one year, 420 g at the end of the two years, 550 g at the end of the three years of age, scarcely surviving over this age. The fish mature and spawn at the end of two years of age in both sexes. The gonads weight showed 10 per cent to the body weight as an average for the females and 5 per cent for the males.

The monthly growths during the period of the one-year-old female are shown in Table 7. From the daily rate of growth each month, calculated from the growth of the respective month, the daily rates of feeding can be obtained basing on the relation between growth and food consumption in the feeding experiments performed under the various temperature conditions. Details of the growth and the food consumption in the one-year-old female are given in Table 7.

The daily rates of growth under the natural conditions are more inferior to those obtained in the feeding experiments especially in winter. This will indicate an insufficient state of foods for the growth of the plaice in the Bay of Sendai in winter, although some differences may exist in the maintenance

Table 7. Monthly growth in the one-year-old female of *Kareius bicoloratus*, and the daily rate of growth, the daily rate of feeding and the food consumed in each month of the year in the Bay of Sendai.

	Beg. of Jan.	End of Jan.	" Feb.	" Mar.	" Apr.	" May	" June	" July	" Aug.	" Sep.	" Oct.	" Nov.	" Dec.
Body weight g	20	24	30	39	52	72	100	135	170	200	223	240	250
Growth made g		4	6	9	13	20	28	35	35	30	23	17	10
Ave. weight g		22.0	27.0	34.5	45.5	62.0	86.0	117.5	152.5	185.0	211.5	231.5	245.0
Ave. cal. kcal		25.1	30.8	39.3	51.9	70.7	98.0	134.0	173.9	210.9	241.1	263.9	279.3
Daily grow. rate%		0.59	0.79	0.87	0.95	1.04	1.09	0.96	0.74	0.54	0.35	0.24	0.13
Daily feed. rate %		2.40	3.15	3.60	3.40	3.77	4.00	2.85	2.30	1.90	1.58	1.35	1.15
Food eaten g		18.7	27.2	43.9	52.9	82.6	117.6	118.4	124.0	120.2	118.1	106.9	99.6

Table 8. Growth and Food consumption in *Kareius bicoloratus* in the Bay of Sendai.

Age	Weight of fish			Growth made	Gonads weight	Daily growth rate	Daily feeding rate	Food consumed	Food ÷ body cal.	Eff. of conversion
	Initial	Final	Ave.							
	g (kcal)	g (kcal)	g (kcal)	g (kcal)	g (kcal)	kcal %	kcal %	kcal		kcal %
0 year	0 (0)	20 (22.8)	10 (11.4)	20 (22.8)	0	0.548	2.10	87.4	7.7	26.09
Female										
1 year	20 (22.8)	250 (285.0)	135 (153.9)	230 (262.2)	0	0.467	1.87	1050.4	6.8	24.96
2 years	250 (285.0)	650 (770.9)	450 (528.0)	400 (486.0)	65 (104)	0.250	1.37	2640.0	5.0	18.41
3 years	585 (666.9)	950(1126.7)	767.5 (898.6)	365 (459.8)	95 (152)	0.140	1.18	3862.5	4.3	11.90
4 years	855 (974.7)	1130(1340.2)	992.5(1157.5)	275 (365.5)	113 (180.8)	0.087	1.07	4520.6	3.9	8.09
5 years	1017(1159.4)	1250(1482.5)	1128.5(1321.0)	233 (323.1)	125 (200.0)	0.067	1.04	5014.5	3.8	6.44
Male										
1 year	20 (22.8)	230 (262.2)	125 (142.5)	210 (239.4)	0	0.460	1.85	962.2	6.8	24.88
2 years	230 (262.2)	420 (488.5)	325 (375.4)	190 (226.3)	21.0 (33.6)	0.165	1.22	1672.0	4.5	13.53
3 years	378 (454.9)	550 (639.7)	514 (547.3)	172 (184.8)	27.5 (44.0)	0.093	1.10	2197.4	4.0	8.41

ration between the conditions in nature and in the experiments. The amount of food consumed by the individual one-year-old female throughout the year attained 1030 kcal from the above calculations.

When the growth in the year was considered as an arithmetical progression, the daily rate of growth can be obtained from the average body weight (135.0 g or 153.9 kcal) and the growth made (230 g), and the result was 0.467 per cent. The daily rate of feeding corresponding to this growth rate is 1.87 per cent from the relation between growth and food consumption in the experiment under the intermediate temperatures. Thus the amount of food consumed in a year is 1050.4 kcal (153.9 kcal × 0.0187 × 365). This is nearly equal to the value (1030 kcal) formerly obtained, hence the food consumption for each age was calculated by the latter method.

The two-year-old female matures at the end of the year. The matured gonads were assumed here to have the same calorie (1.6 kcal per gram) as in the case of *L. yokohamae*. Therefore, the two-year-old female attains 770.9 kcal (1.14 × 650 × 0.9 + 1.6 × 650 × 0.1) at the end of the year, making a start of growth at 285 kcal, so that the growth during the year of this age is 486 kcal.

The three-year-old female, which has been delivered of the gonads (104 kcal) at the end of the two years of age, commences growth from 666.9 kcal and attains 1126.7 kcal at the end of the year.

Calculations on food consumptions, with similar considerations on the growth and the reproduction of the fish, were made for each age of the females and the males, and the results are given in Table 8.

The daily rates of feeding, the daily rates of growth and the efficiencies of conversion in this table are plotted in Fig. 1, in which the results of the feeding experiments were already given. The inclinations to decrease in the rates of feeding and of growth or the efficiencies of conversion according to the fish size were more sluggish under natural conditions than those in the feeding experiments. This is probably due to the unfavourable conditions for the larger fish in the feeding experiments, because of the restricted space of the aquarium. In general, the differences between those of the nature and the experiment are slight, so that the experiments are considered to nearly correspond to the natural conditions. The daily rates of growth showed 0.55 per cent and the daily rate of feeding 2.10 per cent in the 0-year-old fish, decreasing to 0.07 per cent and 1.04 per cent respectively in the five-year-old females. The efficiencies of conversion decreased rapidly by age from 26.09 per cent in the 0-year-old fish to 6.44 per cent in the five-year-old females.

The rapid decrease in the efficiencies of conversion among the fish in old ages perhaps means that the thinning out of the older fish may contribute for improving the efficiencies in utilizing foods for this plaice population. It is not yet unknown from the results of the experiments whether increases in

growth rate may be expected under the conditions in more proliferous food substances in nature. However, the fish will grow more rapidly in the place where the water temperatures in winter are higher, even if the available amount of food does not differ.

As to be compared with the case of *Limanda yokohamae*, the inclinations in the feeding rates, in the growth rates or in the efficiencies of conversion according to the sizes in *Kareius bicoloratus* were apparently slow in the younger ages. This is probably due to the slow growth in the 0 year period and to the rapid growth in the one, two and three years age in *K. bicoloratus*. But this is reversed among the fish in the older ages probably due to the differences in their natural terms of existence. It is apparent that the two- and the three-year-old fish, which occupy the greater part of the catch of *K. bicoloratus* in the Bay of Sendai, grow more rapidly than *L. yokohamae* living in nearly the same habitat. This is partly due to the differences in the feeding activities, which can be observed in the aquarium by mixing the plaice together with *L. yokohamae*. Moreover *K. bicoloratus* have better efficiencies in utilizing benthic worms than *L. yokohamae*. For instance, *K. bicoloratus* grows up to 950 g (or 1127 kcal) by consuming foods of 7640 kcal for three years, while *L. yokohamae* only to 630 g (or 772 kcal) at the consumption of 7560 kcal for four years.

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