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By

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The biology of the plaice, *Limanda yokohamae* (GÜNTHER), collected in the Bay of Sendai were already published in 1953 concerning the growth and the reproduction (2) and in 1954 on the feeding habits (3). Lately, a feeding experiment was undertaken at "Matsushima Aquarium" situated on the shore of the Bay of Sendai to determine the relation between growth and food consumption in this plaice. With available data, some studies were made on the amount of food necessary for the yearly growth of the individual fish. The account is given in this report.

The feeding experiments were performed at each season during the period from the summer of 1955 to the spring of 1956. Specimens, caught by a pound trap, "Sudate", set in the Bay of Matsushima, ranged between 0- and 3-year-old fish and between 42 and 279 g in body weight. About 20 individuals, each tagged with vinyl ribbon, were reared for one time in a concrete aquarium, measuring 1.7 m long, 1.7 m wide and 45 cm deep, and provided with running water. Before the experiment, the fish were held for about 15 days in the aquarium to become adapted to the new environment.

For food annelid worms, *Tylorrhynchus heterochaetus*, weighing 0.2 to 3.0 g each, or shucked clams, *Venerupis japonica*, weighing 0.7 to 3.8 g each, were used. Fish were fed sufficiently once a day and the amount of food taken by each individual fish were recorded daily. Fish were weighed and measured once per 10 days or sometimes once a week. Temperatures and salinities of the sea water in the aquarium were recorded daily.

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Stomach Contents

According to the previous report (3), each food item in weight in the stomach of the plaice, ranging between 10 and 24 cm long, throughout the

investigational period between June and December, were as follows: annelids amounted to 84.9 per cent, molluscs to 8.3 per cent, large crustaceans to 5.9 per cent, small crustaceans to 0.8 per cent and digested fragments to 3.6 per cent. Since the foods consisted of more than 90 per cent of their weight with annelids and small bivalves, the whole weight of the stomach contents against the body weight indicates nearly the standing rate of feeding on benthic worms under the natural conditions. The percentage weights of stomach contents to the body weight were calculated from the data obtained in 1952 and shown in Table 1 separately for the ages and the dates of collections.

Table 1. Percentage weights of stomach contents against body weight in *Limanda yokohamae* in the Bay of Sendai, 1952.

Date	0-year-old			1-year-old			2-year-old			3-year-old		
	Numb.	Ave. weight (g)	Rate of feeding (%)	Numb.	Ave. weight (g)	Rate of feeding (%)	Numb.	Ave. weight (g)	Rate of feeding (%)	Numb.	Ave. weight (g)	Rate of feeding (%)
June 10,'52				8	60.5	1.47	1	82.0	1.59			
July 1, "				5	102.2	0.48	2	178.0	0.79	1	228.0	0.92
July 25, "	4	5.0	1.98	6	94.2	1.04	1	175.0	0.91			
Aug. 14, "				3	138.3	2.34	6	165.8	2.06			
Sep. 25, "							9	102.2	0.34	4	130.0	1.35
Dec. 6, "				5	76.4	0	7	126.4	0	4	244.0	0
Dec. 24, "	6	58.8	1.28	5	133.2	0.62	4	178.5	0.66	4	249.0	0.59

The maximum rate of feeding in Table 1 was 2.34 per cent of the body weight in the one-year-old fish collected on Aug. 14. The considerable variations in the amount of foods are partly due to the collecting time in a day, since the empty stomach can be more often found among the specimens collected before dawn than those in day time, namely the plaice stop feeding at night. The feeding also stopped during a short time in the most active spawning period.

In short, the foods of this plaice throughout the year are mainly constituted with benthic worms such as annelids or small bivalves, and their rates of feeding in standing amount were useful at least to know the minimum standard for the daily ration of this plaice under the natural conditions.

Feeding Experiments

The temperature variations in the habitat of this plaice, measured by the bottom temperatures in the fishing grounds (from 25 to 69 m deep), showed 12.3°C in January, 10.2° in February, 9.8° in March, 12.2° in April, 15.0° in May, 17.5° in June, 18.7° in July, 19.3° in August, 18.9° in September, 17.5° in October, 15.0° in November and 12.7° in December. The feeding experiments were performed repeating three times, each during the period when the aquarium tem-

perature showed the same with the higher, the lower and the intermediate temperature in the state of nature respectively.

Experiment No. 1:

Expriment No. 1 continued for a period of 18 days between June 16 and July 4, 1955, at a high temperature range between 16.7° and 21.2°C (19.0° as average), and the 15 specimens used, ranged between 42 and 209 g in weight. The average temperature held coincides with the temperature in the summer habitat of this plaice. Details of the feeding on annelids and the growth made during the experiment No. 1 are given in Table 2. Here, the daily rate of feeding means the rate of the mean daily ration against the mean body weight during the experimental period, the daily rate of growth is the rate of the mean daily growth against the mean body weight and the efficiency of conversion is the rate of the growth made against the food eaten.

Table 2. Feeding and growth of *Limanda yokohamae*, fed with annelids under the high temperature range (Exp. No. 1).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Rate of feeding	Growth made	Daily growth	Rate of growth	Eff. of conversion
		Initial	Final	Ave.							
	days	g	g	g	g	g	%	g	g	%	%
1	18	42	60	51.0	68.3	3.79	7.43	18	1.00	1.96	26.35
2	18	51	59	55.0	45.9	2.55	4.64	8	0.44	0.80	17.43
3	18	54	65	59.5	56.4	3.13	5.26	11	0.61	1.03	19.50
4	18	55	65	60.0	50.5	2.81	4.68	10	0.56	0.93	19.80
5	18	58	63	60.5	48.2	2.68	4.43	5	0.28	0.46	10.37
6	9	105	112	108.5	21.9	2.43	2.24	7	0.78	0.72	31.96
7	18	111	120	116.0	57.7	3.21	2.76	9	0.50	0.43	15.60
8	9	139	140	139.5	27.3	3.03	2.17	1	0.11	0.08	3.66
9	18	131	146	139.0	67.7	3.76	2.71	15	0.83	0.60	22.16
10	9	143	145	144.0	25.8	2.87	1.99	2	0.22	0.15	7.75
11	18	140	160	150.0	98.6	5.48	3.65	20	1.11	0.74	20.28
12	18	144	170	157.0	160.2	8.90	5.67	26	1.44	0.92	16.23
13	9	163	170	166.5	41.5	4.61	2.77	7	0.78	0.47	16.87
14	9	192	197	194.5	43.7	4.86	2.50	5	0.56	0.29	11.44
15	9	209	215	212.0	54.4	6.04	2.85	6	0.67	0.32	11.03

The statistics of the 15 fish used in the experiment No. 1 are, the daily rates of feeding ranged between 1.99 and 7.43 per cent, the daily rates of growth between 0.08 and 1.96 per cent and the efficiencies of conversion between 3.66 and 31.96 per cent. All these coefficients showed a tendency to decrease according to the fish size. Hence, the 15 fish were divided into two groups by body weight. The mean values in the respective group are as follows:

Range of body weight	Average body weight	Number	Daily rate of feeding	Daily rate of growth	Efficiency of conversion
51–116 g	72.9 g	7	4.49 %	0.90 %	20.14 %
139.5–212 g	162.8 g	8	3.04 %	0.45 %	13.68 %

Experiment No. 2:

The experiment No. 2 continued for a period of 22 days from November 16 to December 18, 1955, at a low temperature range between 7.7° and 9.5°C (8.4°C as average) and the 15 specimens used, ranged between 74 and 195 g in weight. The average temperature held coincides with the lower limit of the temperature in the habitat of this plaice. Details of the feeding on annelids and the growth made during the experiment No. 2 are given in Table 3.

Table 3. Feeding and growth of *Limanda yokohamae*, fed with annelids under the lower temperature range (Exp. No. 2).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Rate of feeding	Growth made	Daily growth	Rate of growth	Eff. of conversion
		Initial	Final	Ave.							
	days	g	g	g	g	g	%	g	g	%	%
16	22	74	86	80.0	55.5	2.52	3.15	12	0.55	0.69	21.62
17	,,	81	85	83.0	35.8	1.63	1.96	4	0.18	0.22	11.17
18	,,	80	91	85.5	80.9	3.68	4.30	11	0.50	0.58	13.60
19	15	85	92	88.5	33.2	2.21	2.50	7	0.47	0.53	21.08
20	22	85	101	93.0	99.3	4.51	4.85	16	0.73	0.78	16.11
21	,,	95	100	97.5	58.1	2.64	2.71	5	0.23	0.24	8.61
22	,,	90	107	98.5	80.5	3.66	3.72	17	0.77	0.78	21.12
23	,,	129	137	133.0	83.8	3.81	2.86	8	0.36	0.27	9.55
24	,,	132	148	140.0	88.2	4.01	2.86	16	0.73	0.52	18.14
25	,,	140	155	147.5	134.6	6.12	4.15	15	0.68	0.46	11.14
26	,,	158	162	160.0	67.2	3.05	1.91	4	0.18	0.11	5.95
27	,,	170	175	172.5	65.5	2.98	1.73	5	0.23	0.13	7.63
28	8	199	204	201.5	50.3	6.29	3.12	5	0.63	0.31	9.94
29	22	192	210	201.0	179.8	8.17	4.06	18	0.82	0.41	10.01
30	,,	195	227	211.0	169.7	7.71	3.65	32	1.45	0.69	18.86

The statistics of the 15 fish used in the experiment No. 2 are, the daily rates of feeding ranged between 1.73 and 4.85 per cent, the daily rates of growth between 0.11 and 0.78 per cent and the efficiencies of conversion between 5.95 and 21.62 per cent. When the 15 fish were divided into two groups by size, the mean values in each group was as follows:

Range of body weight	Average body weight	Number	Daily rate of feeding	Daily rate of growth	Efficiency of conversion
80.0–98.5 g	89.4 g	7	3.29 %	0.55 %	16.19 %
133–211 g	170.8 g	8	3.04 %	0.36 %	11.39 %

Experiment No. 3:

The experiment No. 3 continued for a period of 30 days from May 1 to May 31, 1956, at an intermediate temperature range recorded from 10.9° to 15.2°C (13.1°C as average) and the 21 specimens used, ranged between 68 and 259 g in weight. The average temperature held coincides with the temperature in spring or autumn habitat. Details of the feeding on annelids and the growth made during the experiment No. 3A are given in Table 4.

Table 4. Feeding and growth of *Limanda yokohamae*, fed with annelids under the intermediate temperature range (Exp. No. 3A).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Rate of feeding	Growth made	Daily growth	Rate of growth	Eff. of conversion
		Initial	Final	Ave.							
	days	g	g	g	g	g	%	g	g	%	%
31	20	68	87	77.5	87.2	4.36	5.63	19	0.95	1.23	21.79
32	10	79	82	80.5	12.5	1.25	1.55	3	0.30	0.37	24.00
33	10	93	99	96.0	32.7	3.27	3.40	6	0.60	0.62	18.00
34	30	91	102	96.5	100.4	3.24	3.36	11	0.35	0.36	10.96
35	20	95	110	102.5	71.0	3.55	3.46	15	0.75	0.73	21.13
36	30	97	124	110.5	198.6	6.41	5.80	27	0.87	0.79	13.60
37	30	89	138	113.5	257.9	8.32	7.33	49	1.58	1.39	19.00
38	20	120	127	123.5	75.9	3.80	3.08	7	0.35	0.28	9.22
39	20	128	144	136.0	84.5	4.23	3.11	16	0.80	0.59	18.93
40	10	137	139	138.0	22.4	2.24	1.62	2	0.20	0.15	8.90
41	30	127	158	142.5	198.5	6.40	4.49	31	1.00	0.70	15.62
42	10	142	145	143.5	34.3	3.43	2.39	3	0.30	0.21	8.70
43	30	146	165	155.5	140.9	4.55	2.93	19	0.61	0.39	13.48
44	20	148	163	156.5	95.7	4.79	3.06	15	0.75	0.48	15.67
45	10	173	177	175.0	24.0	2.40	1.37	4	0.40	0.23	16.70
46	20	175	186	180.5	94.5	4.73	2.62	11	0.55	0.30	11.64
47	20	182	192	187.0	83.0	4.15	2.22	10	0.50	0.27	12.05
48	30	185	207	196.0	216.8	6.99	3.57	22	0.71	0.36	10.15
49	20	193	210	201.5	134.5	6.73	3.34	17	0.85	0.42	12.64
50	30	223	234	228.5	170.5	5.50	2.41	11	0.35	0.15	6.45
51	20	259	279	269.0	163.4	8.17	3.04	20	1.00	0.37	12.24

The statistics of the 21 fish used in the experiment No. 3 A are, the daily rates of feeding ranged between 1.37 and 7.33 per cent, the daily rates of growth between 0.15 and 1.39 per cent and the efficiencies of conversion between 6.45 and 24.00 per cent. When the 21 fish were divided into three groups by size, the mean values in each group was as follows:

Range of body weight	Average body weight	Number	Daily rate of feeding	Daily rate of growth	Efficiency of conversion
77.5–110.5 g	93.9 g	6	3.87 %	0.68 %	18.20 %
113.5–196.0 g	154.0 g	12	3.15 %	0.45 %	13.34 %
201.5–269.0 g	233.0 g	3	2.93 %	0.31 %	10.44 %

In the course of the above experiment, 6 individuals among the 21 fish were fed successively, changing the food, with shucked clams for a period of 20 days from May 21 to June 6, 1956. Details of feeding and growth in the experiment No. 3 B are given in Table 5. The statistics of the 6 fish are, from 117.5 to 216.0 g in weight (165.5g as average), the daily rates of feeding ranged between 1.80 and 5.94 per cent (3.15 per cent as average), the daily rates of growth ranged between 0.08 and 0.99 per cent (0.50 per cent as average) and the efficiencies of conversion between 4.30 and 22.58 per cent (13.45 per cent as average).

Table 5. Feeding and growth of *Limanda yokohamae*, fed with clams under the intermediate temperature range (Exp. No. 3 B).

Fish No.	Duration of exp.	Weight of fish			Food eaten	Daily ration	Rate of feeding	Growth made	Daily growth	Rate of growth	Eff. of conversion
		Initial	Final	Ave.							
	days	g	g	g	g	g	%	g	g	%	%
35	20	110	125	117.5	84.0	4.20	3.57	15	0.75	0.64	17.86
38	,,	127	155	141.0	167.7	8.38	5.94	28	1.40	0.99	16.70
42	,,	145	155	150.0	61.6	3.08	2.05	10	0.50	0.33	8.12
44	,,	163	187	175.0	106.3	5.32	3.04	24	1.20	0.69	22.58
47	,,	192	195	193.5	69.8	3.49	1.80	3	0.15	0.08	4.30
49	,,	210	222	216.0	107.8	5.39	2.50	12	0.60	0.28	11.13

From the results of the above three experiments the fish fed with the same food under different temperature conditions, the rates of feeding, the rates of growth and the efficiencies of conversion, each expressed by the average for the respective size range are plotted in Fig. 1. Both the rates of feeding and growth or the coefficient of conversion decreased apparently as the fish grew larger. In the case of the smaller sized fish from 70 to 100 g in weight, the rates of feeding differed markedly with one another by temperature and the same was observed in the rates of growth or in the efficiencies of conversion. In the case of the fish from 150 to 160 g in weight, the rates of feeding showed only a small difference by temperature and also little change was observed in the rates of growth or in the efficiencies of conversion between the two different temperature conditions except for the low temperature. The rate of growth in the low temperature (Exp. No. 2) were considerably inferior compared with those in the experiment No. 1 or No. 3. A conspicuous low rate of growth in winter observed among the fish of this size, under nearly the same ration with the other seasons, due perhaps to the energy dislocation for the formation of the gonads. The gonads formation was apparently observed on the fish in the aquarium in the course of the experiment No. 2.

No marked difference was observed between the two different sorts of food, namely annelids and clams, on the rates of feeding, on the rates of growth or on the efficiencies of food conversion so far as the experiment showed. On an energy basis, the annelids showed 0.82 kcal per gram and the clams 0.68 kcal per gram. Hence, smaller rates of feeding and higher efficiencies of conversion on the calorie basis are observed in the feeding with clams than with annelids.

The relations between the food consumed and the growth made separately for the different temperatures are shown in Fig. 2. As can be known from the results of investigations on the plaice, *Pleuronectes plattesa*, by Dawes (1), the individual fish shows generally considerable variation in respects to feeding and growth. Moreover, many other factors may have contributed to the variations

in feeding and growth in this experiment. Since the fish were fed once per day in this experiment, the amount of food given may have been insufficient especially for the smaller sized fish. Under the rations as low as those that the maintenance ration is slightly overed, the rates of growth become higher on account of the higher efficiencies with the smaller rations. It is possible that the rates of growth in the smaller sized fish in this experiment are generally higher than the case with the larger ration. However, the daily ration for the larger sized fish in this experiment is considered sometimes to be excessive.

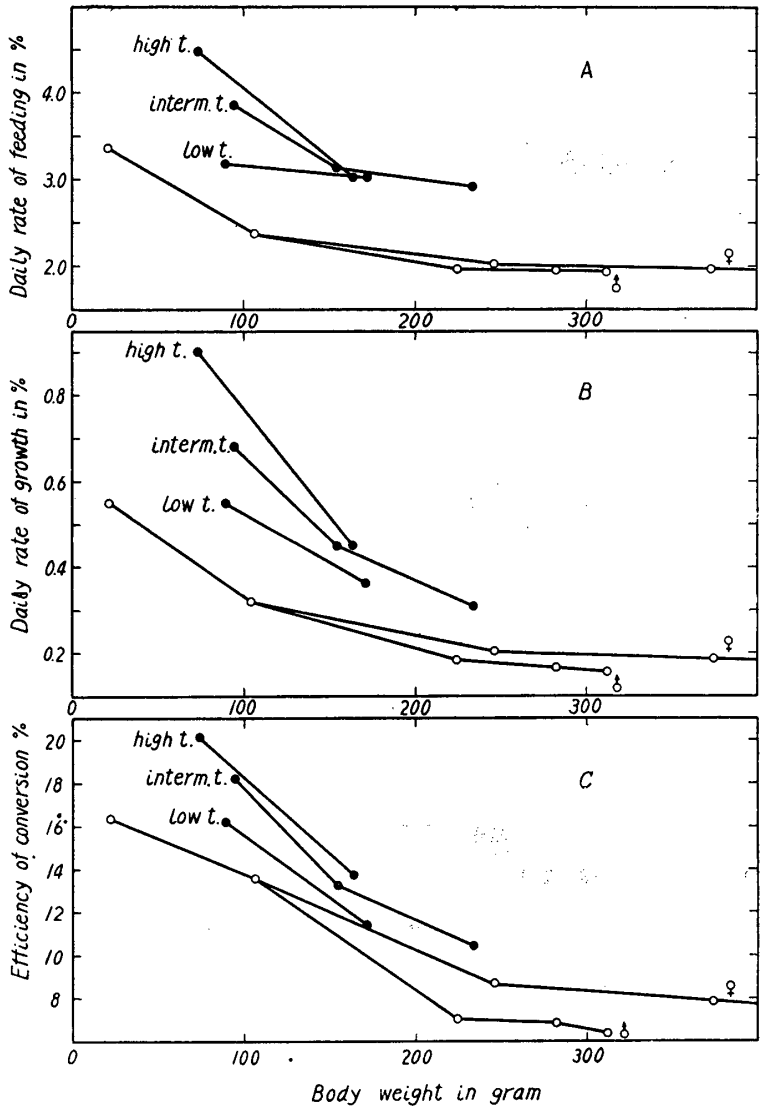

Fig. 1. The average rates of feeding (A), the average rates of growth (B) and the average efficiencies of conversion (C) plotted against the weight of fish separately for the different temperature conditions, fed with the same food (annelids). Open circles represent the calculated rates under natural conditions stated in the following paragraph.

In this case the growth rate for a given ration becomes low. On account of such reasons, the relations between the food consumed and the growth made become somewhat confused, but the figures were plotted with all available data obtained.

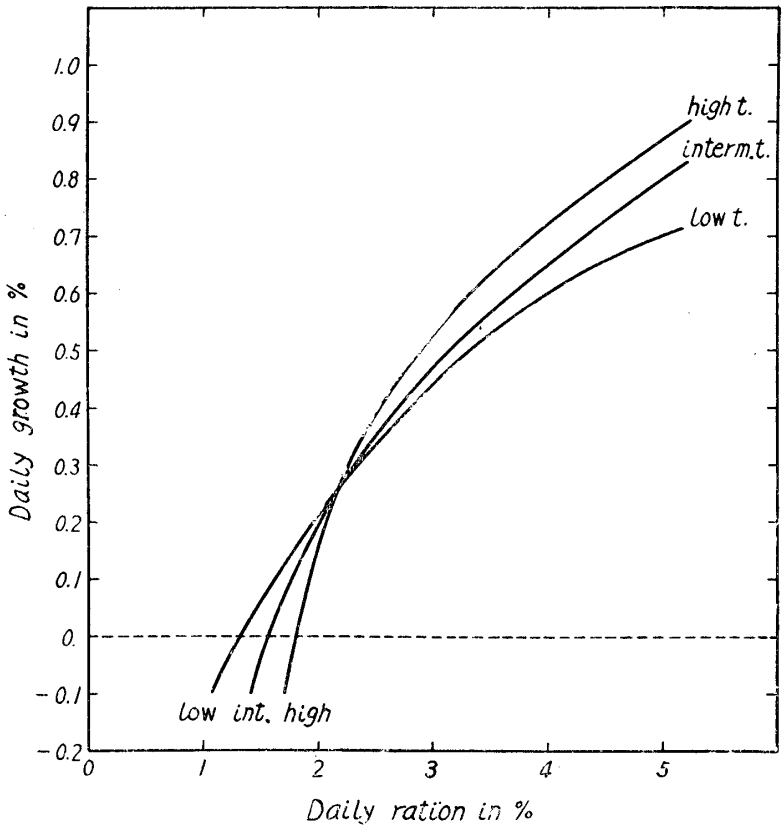

Fig. 2. The relations between the food consumed and the growth made separately for the different temperature conditions, fed with annelids.

The maintenance rations showed a range between 1.3 and 1.8 per cent to the body weight, indicating a low value under the low temperature and a higher under high temperature. But under the higher rates of feeding (4–5 per cent), better growth was observed at the high temperature than at the low one. This is perhaps related to the differential digestibilities of food under various temperatures.

Growth and Food Consumption

According to the previous report (2), the most active spawning of this plaice occurs in the middle part of December in the Bay of Sendai and almost all the fish complete spawning before the beginning of the year. Hence, the actual age of the fish begins at the beginning of the year. The fish in the Bay of Sendai in 1952 grew up to 43 g in an average weight at the end of

the 0-year-old fish and to 167 g at the end of the one-year-old fish. Thereafter the growth differs by sex and moreover 70 per cent of the females and 90 per cent of the males at the end of the two- and 100 per cent of both the sexes at the end of the three-year-old fish and upwards attain to the sexual maturity and spawn. In weight before spawning, the female fish attains 325 g at the end of the two-, to 480 g at the end of the three-, to 630 g at the end of the four- and to 800 g at the end of the five-year-old fish, while the male fish attains 280 g at the end of the two-, to 350 g at the end of the three-, to 390 g at the end of the four- and to 425 g at the end of the five-year-old fish.

The monthly growth of the one-year-old fish were calculated from the growth rate in body length, previously reported (2), and shown in Table 6. When the initial body weight is W_1, the final body weight W_2 and the number of days during the period n, the daily rate of growth (r) was calculated from the following equation:

$$r = \frac{W_2 - W_1}{n \cdot \frac{W_1 + W_2}{2}} \quad \cdots\cdots (1)$$

The daily rate of growth calculated from the above equation each month under the natural conditions are given in the second line of Table 6. The rates in the warm season coincide well with those obtained by the feeding experiment No. 1 (the high temperature), but in the cool season they were considerably lower than those in the feeding experiment No. 2 (the low temperature). It was presumed that the amounts of foods in the Bay of Sendai in the cool season are less than those under the experimental conditions, though taking into consideration the difference of the maintenance ration probably existing between them. From the relation between food consumed and growth made under the experimental conditions, the daily rates of feeding corresponding to the daily rates of growth above stated can be known and is given in the third line of Table 6. The monthly amount of food consumed were calculated from the mean body weight of each month multiplied by the daily rate of feeding and the number of days in each month, as is given in the last line of Table 6.

Table 6. The monthly growth, daily rates of growth, daily rates of feeding and monthly amount of food consumed in the one-year-old fish in the Bay of Sendai.

	beg. of Jan.	end of Jan.	" Feb.	" Mar.	" Apr.	" May	" June	" July	" Aug.	" Sept.	" Oct.	" Nov.	" Dec.
Body weight (g)	43	47	52	59	67	77	90	108	128	145	155	162	167
Daily rate of growth (%)		0.29	0.36	0.41	0.42	0.45	0.52	0.59	0.54	0.42	0.22	0.15	0.10
Daily rate of feeding (%)		2.35	2.35	2.75	2.80	2.90	3.25	3.25	3.05	2.65	2.10	1.90	1.65
Monthly amount of feeding (g)		32.8	36.7	47.3	52.9	64.7	81.4	99.7	111.6	108.5	97.7	90.3	84.1

When the yearly growth was considered as a geometrical progression, the amount of food consumed in a year by the one-year-old fish attained 907.7 g in weight similar to annelids. When the yearly growth was considered as an arithmetical progression, the daily rate of growth can be calculated from the equation (1) as a mean in a year, and the result was 0.324 per cent. The daily rate of feeding corresponding to this rate of growth is 2.38 per cent at the intermediate temperature of the feeding experiment, hence the amount of food consumed in a year comes to 912 g (105 g × 0.0238 × 365). Since this is nearly the same with that calculated by the summation of the monthly amount of food consumed, the yearly food consumption at each age of the fish was calculated hereafter by the latter method.

On an energy basis, the plaice, including muscles, bones, viscera and integument altogether, showed 1.1 kcal per gram and, as stated before, for the annelids it was 0.82 kcal per gram. Hence, the efficiency of conversion result in 18.24 per cent in calorie equivalence [(1.1 kcal × 124) / (0.82 kcal × 912)]. When the calculations are similarly made on the 0-year-old fish, the daily rate of growth (0.55 per cent), the daily rate of feeding (2.50 per cent) and the efficiency of conversion (21.90 per cent) can be obtained.

Concerning the amounts of food consumed by the two-year-old fish and upwards, considerations must be given to the sex difference in growth and in maturity rate, and also to the energy dislocation by the gonads formation and to the weight loss after spawning. The gonads weight in an average was 25 per cent to the body weight for the female and 30 per cent for the male. According to Kariya and Shirahata (1955) (5), the matured ovary of this plaice in the Bay of Sendai showed 1.6 kcal per gram. On the energy basis, the two-year-old female attains 398.1 kcal (1.1 kcal × 325 × 0.75 + 1.6 kcal × 325 × 0.25) at the end of the year, making a start of the growth frow 183.7 kcal. From the equation (1), the mean daily rate of growth results in 0.20 per cent, hence the daily rate of feeding in 2.02 per cent. The yearly amount of food consumed by the two-year-old female attains 1814 g in weight similar to annelids. For the two-year-old male, the food consumption was calculated after presuming the male gonads retain a similar calorie with the female gonads.

In the case of the three-year-old fish, 30 per cent of the females and 10 per cent of the males do not spawn at the end of the previous year, leaving the gonads in mature states. These fish, of course, makes a start of their growth from the body weight at the end of the two-year-old fish. But the spawned fish must have decreased their weight as much as the discharged amount of the gonads. Then, 70 per cent of the three-year-old female makes a start of the growth from the body weight of 244 g and the rest from 325 g, therefore the growth of the three-year-old female as a whole begins at the body weight of 268 g. Similarly the three-year-old male begin their growth at 204 g in weight.

Since the four-year-old fish and upwards spawn altogether at the end of the previous year, the calculations become simple. The results for each age of the fish separately for the sexes are collectively shown in Table 7. The mean daily rate of growth in the state of nature is clearly inferior than that under the experimental conditions even in the low temperature of the latter, but the tendency to decrease as the fish grow larger is similar with the results of the experiment and showed 0.55 per cent in the youngest and 0.15–0.16 per cent in the older fish (Fig. 1). The amount of food consumed per year resulted in about 7 times the mean body weight (5 times in calorie equiv.) at each age of the fish older than 2 years. Since the sex difference could not be found on the relations between feeding and growth, the sexes were combined in the feeding experiments and the results were collectively applied for the calculations made. Therefore, the sex differences in the efficiencies of conversion here obtained are considered to be apparent differences resulting from the growth differences between

Table 7. Growth and food consumption in *Limanda yokohamae* in the Bay of Sendai.

Age	Intial weight	Final weight	Ave. weight	Growth made	Gonads weight	Daily growth rate	Daily feeding rate	Annelids consumed	Food ÷ body weight	Eff. of conversion
	g (kcal)	g (kcal)	g (kcal)	g (kcal)	g (kcal)	g %	g% (kcal%)	g (kcal)	in g (in kcal)	in g (in kcal)
0-year-old	0 (0)	43 (47.3)	21.5 (23.7)	43 (47.3)	—	0.55	3.36 (2.50)	264 (216)	12.3 (9.1)	16.29 (21.90)
1-year-old	43 (47.3)	167 (183.7)	105 (115.5)	124 (136.4)	—	0.32	2.38 (1.77)	912 (748)	8.7 (6.5)	13.60 (18.24)
Female										
2-year-old	167 (184)	325 (398)	246 (291)	158 (214)	81 (129)	0.200	2.02 (1.51)	1814(1487)	7.4 (5.1)	8.71 (14.39)
3-year-old	268 (295)	480 (588)	374 (442)	212 (293)	120 (192)	0.186	1.97 (1.47)	2689(2205)	7.2 (5.0)	7.88 (13.29)
4-year-old	360 (396)	630 (772)	495 (584)	270 (376)	158 (253)	0.176	1.96 (1.46)	3541(2904)	7.2 (5.0)	7.62 (12.95)
5-year-old	473 (520)	800 (980)	636 (750)	327 (460)	200 (320)	0.168	1.94 (1.45)	4504(3693)	7.1 (4.9)	7.28 (12.46)
Male										
2-year-old	167 (184)	280 (350)	224 (267)	113 (176)	84 (134)	0.170	1.95 (1.45)	1594(1307)	7.1 (4.9)	7.08 (13.46)
3-year-old	204 (225)	350 (438)	282 (336)	137 (204)	105 (168)	0.166	1.93 (1.44)	1992(1633)	7.1 (4.9)	6.88 (12.49)
4-year-old	245 (270)	390 (488)	318 (379)	145 (218)	117 (187)	0.158	1.91 (1.42)	2217(1818)	7.1 (4.8)	6.40 (11.99)
5-year-old	273 (300)	425 (531)	349 (416)	152 (231)	128 (205)	0.152	1.90 (1.42)	2420(1984)	6.9 (4.8)	6.28 (11.64)

the sexes. The efficiencies of conversion (12–14 per cent) under natural conditions are slightly less than, and the inclinations according to the growth of the fish are similar with the results of the experiment. The slight differences in the efficiencies of conversion may probably be due to the differences in the maintenance rations through the differential activities under the different conditions between the aquarium and the natural state. The slow inclination in the efficiencies of conversion by age means perhaps that the thinning out of the older fish does not contribute much for improving the efficiencies in the utilization of food for the plaice population, considering the reproductive capacity of the fish collectively.

The low rates of feeding (less than 2 per cent) indicate probably that there are not always sufficient foods for the growth of the plaice under the state in the Bay of Sendai. The increase in the growth rate or in production of the plaice may perhaps be expected under the conditions in more proliferous food substances. The greatest competitor for the plaice in feeding for the benthic worms in the Bay of Sendai is considered, except for the other useful fish which will be reported in another paper of this series, to be the abundant sea-star families.

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