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Food consumption and growth of artificially produced Japanese red porgy young *Pagrus major*[*]

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Abstract: Artificially produced youngs of the Japanese red porgy *Pagrus major* are reared in laboratory and the interrelationships between food consumption and growth are examined. The maintenance ration and food conversion efficiency are also obtained.

1. Introduction

The interrelationship between food consumption and growth is one of the fundamentally important problems in ecology as well as in the fish culture development. To realize such importance, the interrelationships are examined on artificially produced youngs of the Japanese red porgy *Pagrus major* (T. & S.), and the maintenance ration and food conversion efficiency are also obtained.

After WARREN and DAVIS (1967) the utilization and losses of the energy in the food consumed by an animal are represented by the following equation:

$$Q_c - Q_w = Q_g + Q_s + Q_d + Q_a,$$

where the energy values are given as;

Q_c, for food consumed;
Q_w, for faeces and nitrogenous excretion;
Q_g, for materials laid down as growth;
Q_s, for standard metabolism;
Q_d, for specific dynamic action;
Q_a, for activity.

For the purposes of the present experiment, the three energies, Q_s, Q_d and Q_a are considered together as the energy used in the total metabolism, and Q_g is the part of the ingested energy Q_c used for increasing the body weight; the remaining Q_w is included in both total metabolism and Q_g.

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2. Material and method

The young fish used for the present experiment were artificially produced 6-months-old red porgy of 9.0–12.5 cm length. They were obtained from a floating net cage at the Fisheries Experimental Station of Fukui Prefecture and transported to the Kominato Marine Biological Laboratory of Tokyo University of Fisheries, Chiba Prefecture.

On arrival, the fish were placed in an indoor concrete tank (190 cm long, 90 cm wide and 50 cm deep) with running water and fed to satiation on pieces of jack mackerel (*Trachurus japonicus*) meat once a day.

After 12-days acclimatization 56 fish of approximately the same size were selected and deprived of food for 2 days. After this treatment their body weight was measured and they were divided into four groups A, B, C and D of 14 fish each. They were placed in four indoor concrete tanks of equal size and shape (85 cm long, 90 cm wide and 50 cm deep) with running water and kept for 30 days from 3 November to 2 December 1975. They were fed with pieces of jack mackerel meat. The food was given a little at a time to avoid leftovers. The Group A fish were fed to satiation once a day at about 11:00 a.m. The Groups B and C fish were fed with the food of 2/3 and 1/3 respectively of the satiation ration of the Group A fish, while the Group D fish were left to starve. After 30 days of feeding the fish were deprived of food again for 2 days and their final body weight was measured.

Using the results of the experiment, the relation between daily rate of feeding (food consumption/day/body weight) and daily rate of

Table 1. Initial total body weight (W_0), initial number of fish (N_0), final total body weight (W_t), final number of fish (N_t), food consumption (F), daily rate of feeding (f), daily rate of growth (g), and gross efficiency (g/f) for young red porgy fed on jack mackerel meat for 30 days from 3 November to 2 December 1975 at water temperatures ranging from 17.0 to 21.5°C (mean 19.8°C) and water flow of about 15 liters/min.

Group*	W_0 (g)	N_0	W_0/N_0 (g)	W_t (g)	N_t	W_t/N_t (g)	F (g)	f**	g***	g/f
A	395.8	14	28.3	491.3 (72.8)	12 (2)	40.9 (36.4)	728.0	0.0506	0.0177	0.2312
B	397.6	14	28.4	507.1	14	36.2	484.4	0.0357	0.0081	0.2269
C	403.7	14	28.8	405.8 (31.3)	13 (1)	31.2 (31.3)	241.6	0.0192	0.0026	0.1354
D	399.3	14	28.5	359.6	14	25.7	0	0	−0.0035	——

* Group A, satiation ration for one feeding a day; Group B, 2/3 satiation ration; Group C, 1/3 satiation ration; Group D, starvation. **$f=F/[(t/2)\ (W_0+W_t)]$; ***$g=(W_t-W_0)/[(t/2)(W_0+W_t)]$; figures in parentheses, dead fish applying to equations: $f'=F/[(t/2)(W_0+W_t+W')]$ and $g'=(W_t+W'-W_0)/[(t/2)(W_0+W_t+W')]$, where W' is body weight of dead fish.

growth (increase in weight/day/body weight) was examined. At the same time the maintenance ration and food conversion efficiency were calculated.

3. Results

The results of the experiment are shown in Table 1. The water temperature during the experiment ranged from 17.0 to 21.5°C with a mean value of 19.8°C, while the water flow was about 15 liters/min.

Based on such data the relation between daily rates of feeding (f) and growth (g) is shown in Fig. 1, which assumes that an equation of the first degree ($g=Af-B$) would provide an adequate fit to the data. The fitted equation is calculated by the method of least squares as:

$$g=0.3045f-0.0033. \qquad (1)$$

The data also show that, below the satiation ration for one feeding a day, an increase in daily rate of feeding produces an increase in daily rate of growth. From equation (1) $f=0.0108$, if $g=0$. Therefore, to maintain 1 g of body weight per day 10.8 mg of jack mackerel meat are required, or an amount of food intake is equal to 1.08 % of the body weight. Furthermore, in the case of starvation ($f=0$), $g=-0.0033$, which means that 3.3 mg per gram of body weight per day are lost. This is equal to 0.33 % of the body weight.

From the equation (1) we can also obtain

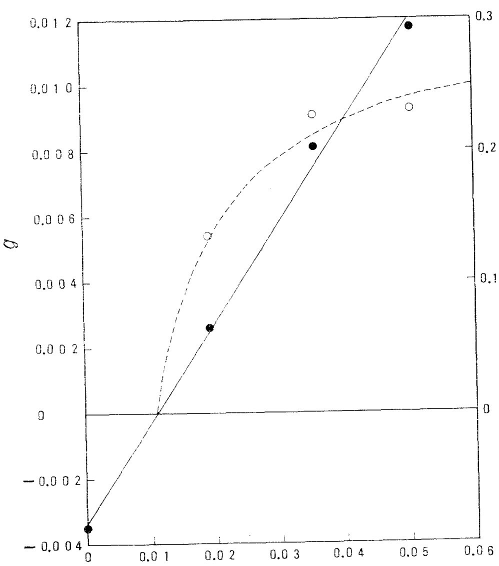

Fig. 1. Relationships between daily rate of feeding (f), daily rate of growth (g, solid circle), and gross efficiency (g/f, open circle). $g=0.3045\,f-0.0033$.

$$g/f=0.3045-0.0033\,(1/f)\,, \qquad (2)$$

where g/f is the gross efficiency. From the equation (2) it is clear that, as the daily rate of feeding (f) increases, the gross efficiency ($E_g=g/f$) does not increase proportionately, but may approach asymptotically the maximum value of 0.3045 (Fig. 1). The experimental values of the gross efficiency at any change of the daily rate of feeding are calculated as follows: when $f=0.0192$, $g/f=0.1354$, when $f=0.0357$, $g/f=0.2269$ and when $f=0.0506$, $g/f=0.2312$. As noted above, the maintenance ration per gram of body weight per day (m) was found to be equal to 0.0108 g. So, the net efficiency $[E_n=g/(f-m)]$ can be calculated and its values are found to be 0.3095 when $f=0.0192$, 0.3253 when $f=0.0357$ and 0.2940 when $f=0.0506$. As it can be seen, the net efficiency is almost constant at every value of the daily rate of feeding.

4. Discussion

From the experimental data the relation between daily rate of feeding (f) and daily rate of growth (g) can be expressed as:

$$g=Af-B. \qquad (3)$$

From equation (3) when $g=0$, the value of f is the amount of food intake required to maintain 1 g of body weight per day.

Table 2. Values of f and $(1/t)\log(W_t/W_0)$.

Group	f	$(1/t)\log(W_t/W_0)$
A	0.0506	0.0051
B	0.0357	0.0035
C	0.0192	0.0012
D	0	−0.0015

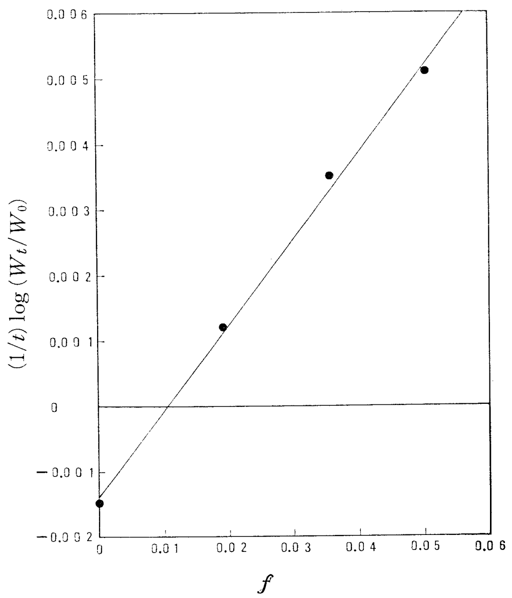

Fig. 2, Relationship between f and $(1/t)\log(W_t/W_0)$. $(1/t)\log(W_t/W_0)=0.1317f-0.0014$.

According to TAUCHI (1953), if a (g) is the amount of food intake required to maintain 1 g of body weight per day, b (g) the amount of food intake required to increase the body weight 1 g, f (g) the amount of food intake per gram of body weight per day, W (g) the total body weight of the fish being reared and t (day) the rearing period, then

$$aW+b\,dW/dt=fW, \qquad (4)$$

and this can be expressed as

$$(1/t)\log(W_t/W_0)=[(\log e)/b]f-(a/b)\log e, \qquad (5)$$

where W_0 is the initial total body weight and W_t is the final total body weight.

Using the results of the experiment given in Table 1, the values of f and $(1/t)\log(W_t/W_0)$ can be calculated (Table 2) and in the relation obtained (Fig. 2) there exists a linear regression $[(1/t)\log(W_t/W_0)=Pf-Q]$ from which the constants P and Q, calculated by the method of least squares, are found to be 0.1317 and 0.0014 respectively. From equation (5), $P=(\log e)/b$ and $Q=(a/b)\log e$. So, the values of a and b can be calculated and they are found to be 0.0106 and 3.30 respectively. That is, 10.6 mg of jack mackerel meat are required to maintain 1 g of body weight per day, while 3.30 g of the same food are needed to increase the body weight 1 g. As it can be seen here, the maintenance ration per gram of body weight per day calculated from both equations (3) and (4) has almost the same value.

Using the same method and food (jack mackerel meat), ISHIWATA (1969) pointed out on *Trachurus japonicus* and *Fugu vermicularis porphyreus*, that the daily rate of growth was proportional to the daily rate of feeding, and that the values of a and b were 13.6 mg and 2.57 g respectively for *Trachurus japonicus*, and 18.8 mg and 1.85 g respectively for *Fugu vermicularis porphyreus* at mean water temperature of about 23°C. The present authors get the values of 10.6 mg and 3.30 g respectively. Among the different species, the given results are similar together while the value of a is lower in this case. It may be due to 3°C-lower water temperature.

5. Summary

A laboratory study of the relation between food consumption and growth was carried out for 30 days from 3 November to 2 December 1975 on the artificially produced youngs of the Japanese red porgy fed on jack mackerel meat. It was found that:

1. Below the satiation ration for one feeding a day, in the relation between daily rate of feeding (f) and daily rate of growth (g) there exists a linear regression which is expressed as $g=0.3045f-0.0033$.
2. The amount of food intake required to maintain 1 g of body weight per day (m) is 10.8 mg or an amount of food intake is equal to 1.08 % of the body weight.
3. The gross efficiency (g/f) does not increase proportionately with an increase in the daily rate of feeding, but has the tendency to approach the maximum value of 0.3045, even if the net efficiency [$g/(f-m)$] is almost constant.
4. From the equation $aW+b\mathrm{d}W/\mathrm{d}t=fW$ the amount of food intake required to maintain 1 g of body weight per day (a) and to increase the body weight 1 g (b) are found to be 10.6 mg and 3.30 g respectively.

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人工生産によるマダイ若年魚の摂餌量と成長

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要旨: 人工生産したマダイ若年魚にマアジ肉の切片を与え，水温 20°C 前後で飼育し，摂餌量と増重量との関係を調べ，さらに，維持摂餌量および餌料の転換効率を求めた。日間摂餌率 (f) と日間増重率 (g) との関係は，1日1回の飽食量以下の投餌では，一次式 ($g=0.3045f-0.0033$) で示される。この式から $g=0$ のときの f の値，すなわち，体重 1g を1日維持するに必要な摂餌量 (m) は 10.8 mg となる。また，総効率 (g/f) は日間摂餌率の増加とともに一定の極限値 (0.3045) に近づくように漸増するが，純効率 [$g/(f-m)$] は日間摂餌率の値いかんにかかわらず，ほぼ一定になる。