International Council for
the Exploration of the Sea

C.M. 1980/L:29
Biological
Oceanography
Committee

Experimental determination of size specific growth rate of larval turbot.

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ABSTRACT

Growth rates of laboratory-reared turbot larvae in the size range of o.o5 to 35 mg weight have been studied. The growth rate determination is based on a method in which the larvae is measured and sorted in narrow size groups. The growth rate is found to increase with size until the larvae attains a dry weight of approx. 12 mg after which it is constant. The specific growth rate has a maximum value at a size of o.2 mg dry weight.

INTRODUCTION

Laboratory studies of larval fish growth are usually designed to provide an empirical understanding of the underlying mechanisms. Most studies so far have focused on growth in relation to age.

Larval fish of the same age, however, may differ with more than a factor of 2 in length and this is believed to cause considerable variations in feeding behaviour, preferred food size (Beyer, 1980), food consumption, etc. and thus in different growth patterns among the members of the same age group. As a first step of gaining some insight into the size effect on larval growth this study deals with an experimental determination of size specific growth rate of larval turbot (Scophthalmus maximus).

MATERIALS AND METHODS

Egg Supply and Hatching Procedure.

Fertilized turbot eggs were received from Shearwater Fish Farming LTD., Port Erin, Isle of Man. The eggs were incubated in 34 % sea water and kept at 13.5°C. In order to reduce bacterial infections 50 i.u. of penicillin and streptomycin were added per ml and the eggs were kept suspended by a gentle aeration. After hatching the temperature were raised to 15°C as this is the temperature where the most effective yolk absorption takes place (Jones, 1972).

Control of food concentration.

As food organism were used Brachionus Plicalitis and Artemia nauplii. Brachionus was grown on caked yeast but was

transferred to a mixed algal diet (Phaeodactylum, Isocrysis and Dunaliella) 24-48 hours prior to feeding in order to improve the fatty acid composition (Watanabe,1979). Only newly hatched, less than 24 hours old, Artemia nauplii were used as the nutritional value is known to deteriorate with age (Benijts et al, 1975).

The desired concentrations of food items per ml were as follows:

Day	3-8	9-11	12-34
Brachionus	7	7	-
Artemia	-	0.5	2

Assuming a random distribution of the food organisms it is possible to compute the sample size needed in order to achieve a certain precision (Beyer & Laurence, 1979). As a deviation of 15 % of the desired concentration was accepted, it was decided to take 50 ml samples during the Brachionus phase (day 3 to 11) and 250 ml samples during the Artemia phase (day 12 unward).

The sampling was carried out by taking 10-20 subsamples from different parts of the tank. Each subsample was taken with a plastic tube carried down to the buttom thereby ensuring that all parts of the water column were equally sampled. The subsamples were pooled, concentrated and the numbers of food organisms were counted using a microscope.

The food concentration was kept in an interval of the desired level ± 50 %, i.e. between 4 and 10 Brachionus per ml and 1 and 3 Artemia per ml.

Rearing conditions.

During the experimental period 6 series of experiments were made. The rearing conditions differt somewhat between the series as shown below:

Serie	No of experiment	Start of experiments (days after hatching)	Duration of experiments (days)	Food organism	Light intensity at surface (Lux)
A	2	4	4	Brachionus	1800-2200
C	6	8	4	Brachionus / Artemia	800-1200
D	7	12	6	Artemia	800-1200
E	10	18	6	Artemia	800-1200
F	10	24	6	Artemia	800-1200
G	10	30	4	Artemia	800-1200

The experiments were carried out in grey cylindrical PVC tanks containing 5, 10, 15 or 20 litres. In the bottom of the tanks was mounted an outlet tube covered by an 180 µm plankton net, which prevented any loss of Artemia nauplii.

During the A and C experimental series, when Brachionus was used as food, no water circulation was applied. In the later series the water was replaced with fresh water at a rate increasing from 1 to 10 turnovers per day.

A continuous lighting by two 40 W cool-white fluorescent tubes was used. The temperature was kept between 18 and 20°C. Due to problems with temperature control, the temperature accidentally rose to 22°C in a short period in the experimental serie E.

Sorting procedure.

Before the experiments the length of all larvae were measured. Measurements were made on living larvae. The larvae were gently transferred to a small petri dish and measured using a ocular micrometer. No anaesthetic was used. The error of the length measurement was estimated by repetitative trials to ± 1 per cent.

The larvae were sorted in different size groups according to the length. The size groups used in the experiments are shown in Table 1.

After termination of the experiments all surviving larvae were measured again. From all series a sample of approximately 40 larvae covering the total size span was selected for measurement of body height, mouth width and dry weight.

The height/length ratios, the length/weight key and the length/mouth-width key are reported elsewhere (Christensen og Hansen, 1980).

RESULTS

The length is a questionable measure of larvae size because the growth is not isometric. Instead is used the dry weight derived from the length/weight key.

Since no size measurement is available between the start and the end of an experiment the true growth pattern during this period is not known. By assuming an exponential growth, the growth rate will be proportional to the instantaneous weight, i.e.

$$\frac{dW}{dt} = rW$$

where r (the specific growth rate) is estimated as

$r = \ln (W_{T2}-W_{T1})/(T2-T1)$ where W_{T1}, W_{T2} is the mean weight at time T1 and T2.

The mean weight of the larval population in the middle of the time interval T1-T2 is determined as

$$W_{T1.5} = W_{T1}\, e^{r(T2-T1)/2}$$

and the growth rate in the middle of the time interval is then

$$\frac{dw}{dt} = W_{T1.5}\, r$$

The growth rates versus mean larval size are shown in fig. 1.

It appears that the change in growth rate is decreasing as dry weight increases and tends to stabilize at a constant value of approx. 1.8 mg dry weight per day when the larvae attains a dry weight of more than 12-13 mg. A constant growth rate is equivalent to linear growth.

The specific growth rate increases as the larval mean weight approaches 0.2 mg dry weight after which it declines again, as shown in fig. 2.

DISCUSSION

There are certain advantages arising from measuring growth by the above mentioned method compared to the standard method in which samples of larvae are taken out and weighed at daily intervals. First of all it seems reasonable to relate growth to weight instead of age since many of the factors - which ultimately control the growth i.e. respiration, consumption, swimming speed - are thought to be depended on size. In this connection it is interesting to ascertain that when comparing larvae of same size but of different age (e.g. experiment C6 and D3) no distinct age dependence is found.

Secondly, when working with narrow size groups will an effect of a size depended death rate - which can blur the true growth pattern in a batch culture - be highly reduced. At last, as the same larvae are used for determining the starting and final weights, there are no problems with respect to taking out representative samples.

There is a major uncertainty concerning the interpretation of the results as to whether the handling of the larvae alters their growth performance. Another drawback is the determination of weight by a length/weight key which was applied as no methods for the weighting of living fish larvae are available.

As a new method is applied it is not possible to compare the results directly with others. Nevertheless specific growth rates calculated from data presented by Person-Le Royet et al (1978) and own batch culture data (Christensen and Hansen, 1980) show the greatest values for turbot larvae at ages of 10-15 days i.e. when the mean larval size is about .15-.4 mg dry weight. A similar conclusion about a maximum specific growth rate after only a short lifespan might be postulated for the winter flounder on basis of data from Laurence (1975) although the author reaches another conclusion. A lineary

growth of older plaice larvae, as described by Ryland (1966) would also be in accordance with the growth pattern shown in fig. 1.

From the growth pattern depictured in fig. 2 it was further possible to predict the development in the coefficient of variation in a batch experiment. This was done by simulating the growth of a small and a big larvae from day 4 to day 32, having initial weights of 0.0275 mg and 0.0525 respectively. The fraction W_{big}/W_{small} is then used as an index of the coefficient of variation. This index is then compared with observed coefficients of variations from batch experiments carried out by Christensen and Hansen, 1980, as shown in fig. 3. The two indices have similar trends.

The results of these experiments shows that by sorting the larvae by size new aspects of the growth pattern is exposed. The two descriptions of growth, the one relating to size and the other to age may thus supplement each other in future studies.

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Table 1.

Experiment	Day of start	Day of end	Numbers of larvae at start	Numbers of larvae at end	Volume litres	Larval lengt start Min. mm	Larval lengt start Max. mm	Larval length end Min. mm	Larval length end Max mm	Mean larval weight at Start mg	Mean larval weight at end mg	Spec. growth rate pr day	Growth pr.day mg
A 1	4	8	143	75	1o	3,21	3,56	3;33	4,55	o,o35	o.o64	o.15	o.oo7
A 2	-	-	216	178	15	3,6o	3,84	3,64	4,83	o,o43	o,1o6	o.22	o.o15
C 1	9	12	21	7	5	3,29	3,56	3,25	4,24	o,o33	o,66	o.17	o.oo8
C 2	-	-	74	49	15	3,6o	3,88	3,52	4,51	o,o5o	o,o86	o.13	o.oo9
C 3	-	-	99	77	2o	3,92	4,2o	3,88	5,94	o,o75	o,212	o.26	o.o33
C 4	-	-	113	98	2o	4,24	4,51	4,67	6,18	o,11o	o,339	o.28	o.o54
C 5	-	-	62	51	15	4,55	4,83	4,83	7,o5	o,154	o,469	o.28	o.o74
C 6	-	-	24	19	5	4,87	5,43	5,7o	7,44	o,212	o,641	o.28	o.1o2
D 1	12	18	4o	2o	15	3,52	4,2o	3,72	6,18	o,o7o	o,299	o.24	o.o35
D 2	-	-	7o	61	5	4,24	4,83	4,91	8,oo	o,141	o,72o	o.27	o.o86
D 3	-	-	58	57	2o	4,83	5,15	6,o2	9,o2	o,227	1,12	o.27	o.134
D 4	-	-	52	46	2o	5,23	5,46	6,26	9,5o	o,3o4	1,44	o.26	o.172
D 5	-	-	21	2o	5	5,54	5,62	7,44	9,11	o,374	1,55	o.24	o.18o
D 6	-	-	67	58	2o	5,7o	6,1o	7,13	1o,3	o,437	2,o1	o.25	o.239
D 7	-	-	61	58	2o	6,18	7,44	6,97	11,9	o,644	2,66	o.24	o.3o9
E 1	18	24	19	18	5	5,7o	6,1o	6,97	9,66	o,459	1,43	o.19	o.154
E 2	-	-	18	13	5	6,18	7,o5	6,97	1o,6	o,6o2	1,81	o.18	o.192
E 3	-	-	37	35	15	6,65	7,37	7,76	12,2	o,873	2,84	o.2o	o.31o
E 4[x]	-	-	31	3	15	7,44	8,oo	1o,5	1o,9	1,12	3,o4	-	-
E 5	-	-	52	44	2o	8,o8	8,63	9,98	13,6	1,44	4,59	o.19	o.496
E 6	-	-	5o	47	2o	8,71	9,27	9,5o	13,9	1,8o	5,63	o.19	o.6o5
E 7	-	-	51	46	2o	9,35	9,9o	11,9	17,3	2,22	7,82	o.21	o.876
E 8	-	-	3o	29	15	9,98	11,9	14,1	17,4	3,o6	1o,6	o.21	1.184
E 9	-	-	34	3o	25	9,98	12,o	14,3	18,4	3,31	11,7	o.21	1.3o7
Elo	-	-	8	8	5	12,3	13,1	16,2	18,1	5,22	13,6	o.16	1.336
F 1	24	3o	1o	5	5	6,7	7,9	8,4	12,4	o,982	3,11	o.16	1.231
F 2	-	-	17	1o	5	8,1	9,2	1o,5	13,9	1,56	5,26	o.15	1.547
F 3	-	-	12	7	5	9,3	9,8	12,7	14,1	2,15	6,15	o.13	1.720
F 4	-	-	43	4o	2o	1o,o	11,7	13,5	16,3	3,29	9,o5	o.11	1.763
F 5	-	-	39	37	2o	11,9	13,o	15,2	18,4	5,o4	13,1	o.o7	1.526
F 6	-	-	27	24	15	13,1	13,6	16,3	18,7	6,15	13,9	o.o8	1.975
F 7	-	-	43	4o	2o	13,8	14,9	17,3	19,8	7,7o	17,6	o.o8	2.o94
F 8	-	-	41	38	2o	15,1	16,2	18,2	2o,4	9,7o	2o,2	o.o7	2.1o7
F 9	-	-	46	45	2o	16,3	18,1	19,3	21,9	13,3	23,8	o.o6	1.835
Flo	-	-	15	15	5	18,2	19,6	2o,6	22,3	17,3	26,6	o.o4	1.45o
G 1	3o	34	15	14	5	12,o	13,6	15,o	16,3	5,57	1o,6	o.19	o.335
G 2	-	-	15	14	5	13,8	14,9	16,6	18,1	7,76	14,o	o.2o	o.581
G 3	-	-	25	25	15	15,o	16,2	16,6	19,3	9,84	16,8	o.18	o.637
G 4	-	-	48	48	2o	16,3	18,1	18,4	21,1	13,5	2o,6	o.17	o.92o
G 5	-	-	45	45	2o	18,2	19,3	18,8	21,5	17,7	23,8	o.16	1.287
G 6	-	-	2o	2o	2o	19,5	2o,o	2o,4	22,8	2o,3	28,2	o.14	1.259
G 7	-	-	22	22	2o	2o,1	2o,6	21,9	23,3	22,4	3o,8	o.14	1.6o8
G 8	-	-	2o	2o	2o	2o,8	21,2	22,2	23,6	24,6	33,o	o.12	1.7o5
G 9	-	-	9	9	5	21,5	21,9	22,5	24,6	27,6	34,9	o.1o	1.736
Glo	-	-	7	7	5	22,o	22,3	22,7	24,4	29,5	35,5	o.o7	1.541

[x]The growth rates are not computed due to the verry high mortality.

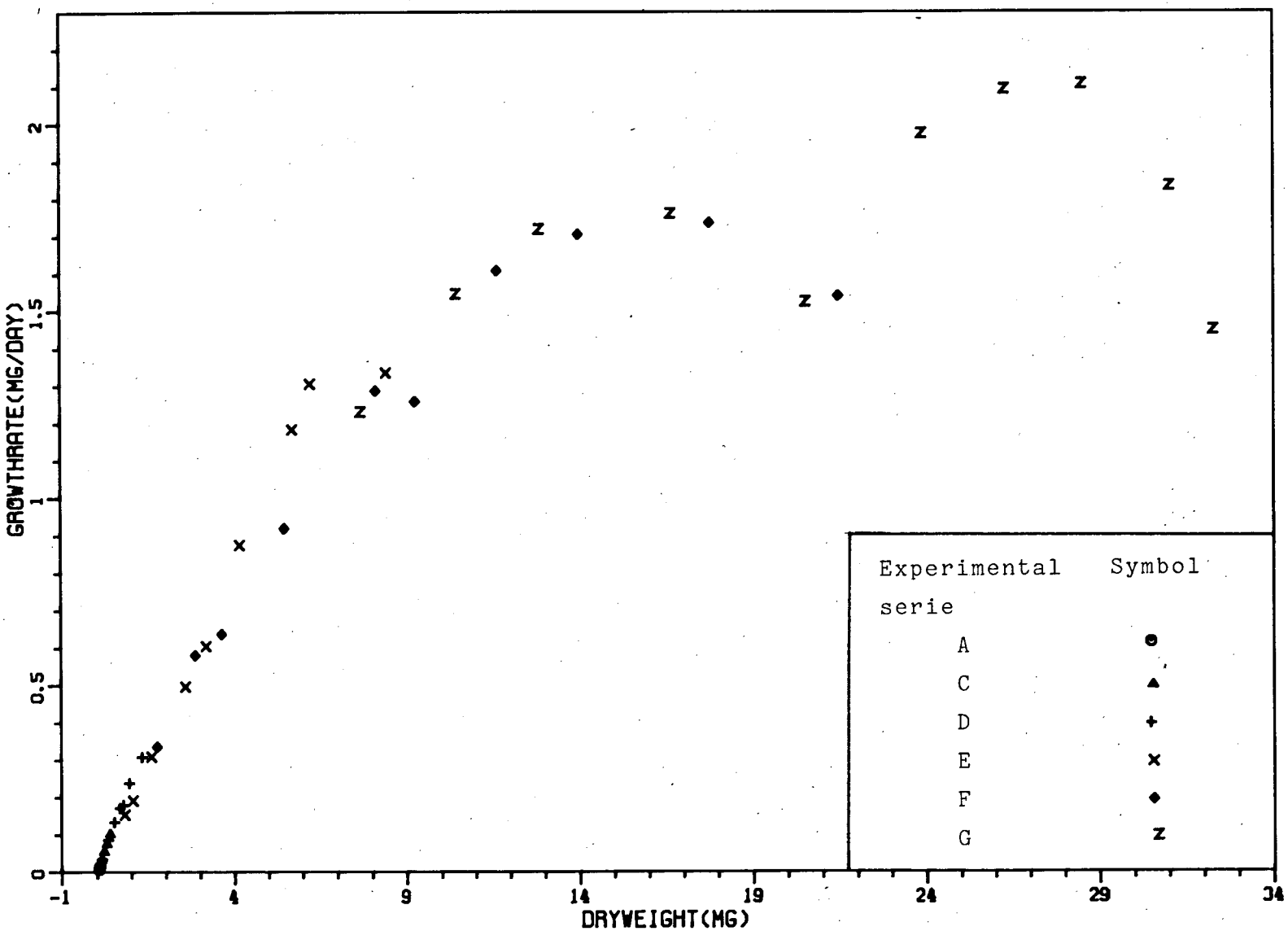

Fig. 1 The relationship between daily growth and larval size

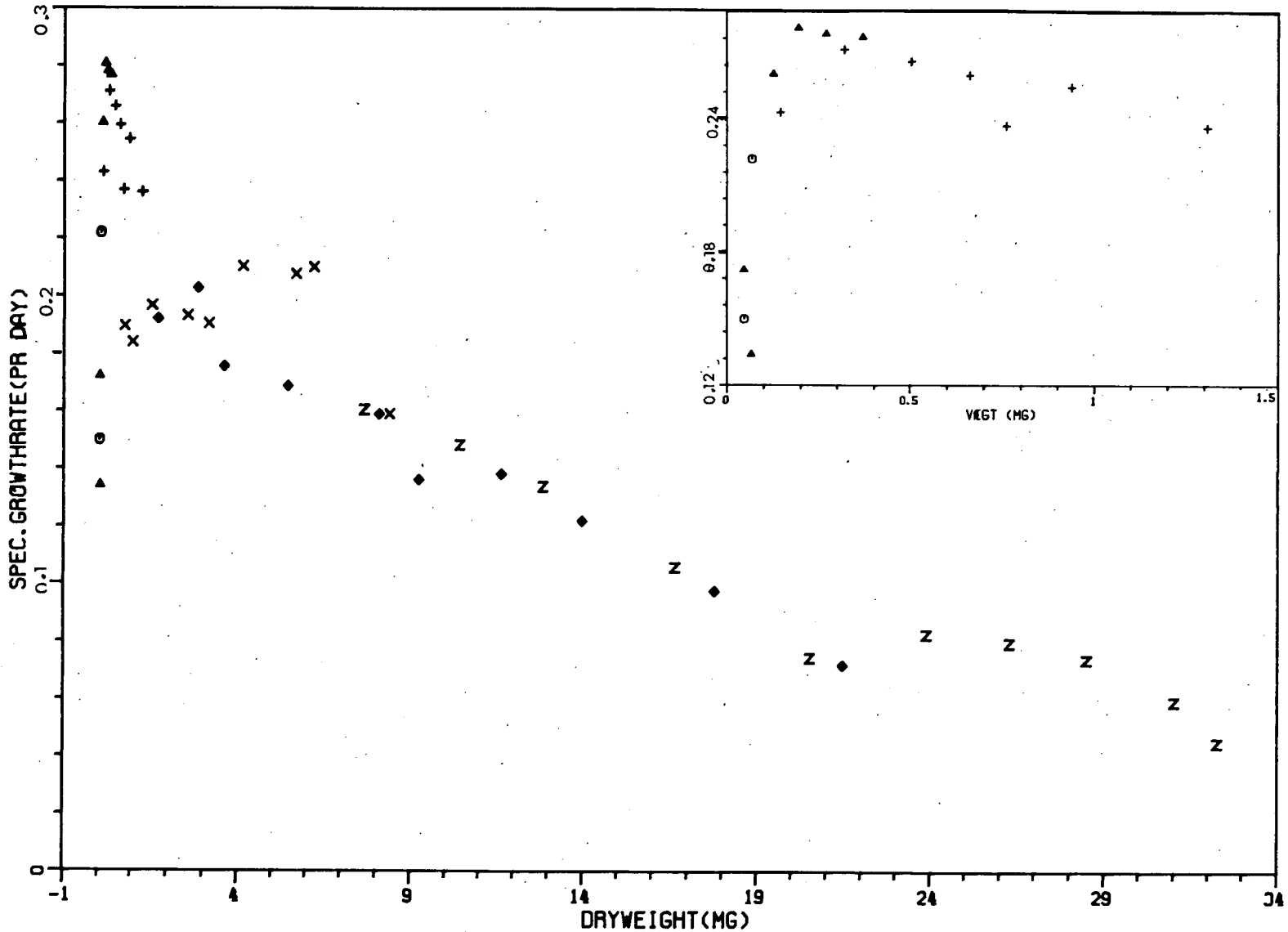

Fig. 2 Specific growth rate as a function of larval size. Inset shows the results of the three first experimental series on an expanded scale. Symbols as in fig. 1 .

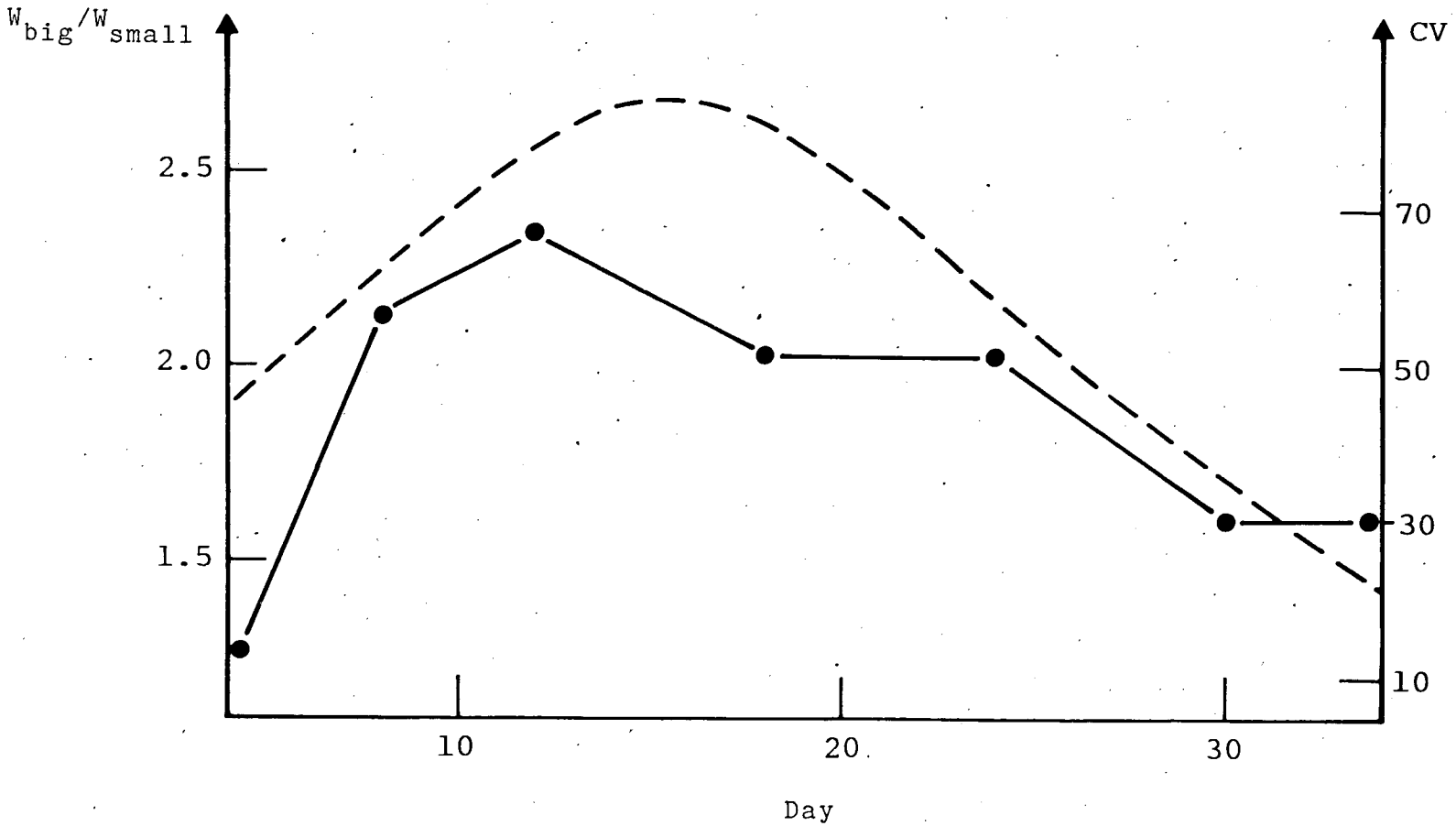

Fig.3 A comparison of the observed coefficient of variation in larval size from batch cultures,i.e. experiments where no size sorting have been carried out (full line) with an index of the coefficint of variation (W_{big}/W_{small}) calculated from the relationship between spec.growth rate and size shown in fig.2 (dotted line).