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Present status of an intensive cod-rearing experiment at AUSTEVOLL, NORWAY.

By

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ABSTRACT

The experiences from this season's experiments with mass production of cod fry in plastic pens are summed up. The rotifer Brachionus plicatilis was cultured for the first time in Norway. Hatching experiments were partly destroyed by fungus infections. Total production of cod fry was 5000. Ideal stocking densities seemed to be less than 1.6 cod larvae per l in the start feeding pens when using inner plankton gauze bags the first 12 days.

INTRUDUCTION

Research and development concerning mass production of cod fry in intensive system has been going on at Austevoll Marine Aquaculture Station since 1979, (Jensen et al. 1979, Huse and Jensen 1980,1981). The goal of this work has been to launch a release program, and to supply prospective cod farmers with fry.

Floating pens of PVC-coated fabric have been used as rearing units, and the larvae have been fed natural plankton collected with a propeller pump and a filtering system (Jensen et al. 1978, Huse and Jensen 1980, 1981).

The results have varied from a promising start in 1979, with one per cent survival and 600 fry produced, via a five per cent survival and 3000 fry produced in 1980, to a total disaster in 1981.

This year's experiments have included the use of cultured rotifers (Brachionus plicatilis) to stabilize the food supply. Several technical modifications have also been made on the pens and the plankton collecting system.

MATERIALS AND METHODS

Technique.

The pens and the plankton collecting system were described by Jensen et al. (1979) and Huse and Jensen (1980,1981). This season both the spawning pen and the big production pens were supplied with conical roofs of the same material as the pens. The water exchange system in the start feeding pens floating in the production pens was improved by replacing the surface sieve with a midwater drainage filter.

Several mesh sizes have been tried for the filtering cones of the plankton collecting system. This season we settled for 90 μ in the outer cone and 250 μ in the inner cone. Rotifers were cultured according to the technique used at Centre Oceanologique de Bretagne, France. Dry feed based on spray dried Spirulina was supplied by I.N.R.A., France.

Spawning.

95 spawners, 56 females and 39 males were transferred to the 175 m^3 spawning pen 11th of February. 53 spawners died later due to oxygen depletion caused by too little water supply. A pump was mounted on the water supply line and 15 extra females were transferred to the spawning pen.

Hatching experiments.

Two hatching experiments were carried out. Hatching directly in the start feeding pens was compared to hatching in the lab incubators described by Jensen et al. (1979). 0.5 l of eggs from the same group was incubated in each of two incubators and two start feeding pens. The amount of dead eggs was measured every day. The larvae were counted at 100% hatching. A vitality test was carried out on the larvae, anesthsizing them with relatively strong doses of MS-222 and counting the number of non reviving larvae.

Different hatching densities with and without aeration were tested in the lab incubators. Four densities were tested. The two highest densities had paralels with aeration.

Start feeding experiments.

Two main start feeding experiments were carried out. Four of the 15 m^3 start feeding pens were used in the first experiment. Two of the pens had a three m^3 inner bag of plankton gauze (Huse and Jensen 1981), while the other two had no inner bags. Approximately 80 000 nearly hatched eggs were transferred to each og the four bags. Both rotifers and wild plankton were supplied from day four after hatching. Growth and mortality was monitored during the experiment. The plankton gauze bags were removed after 12 days.

The second start feeding experiment had two groups with different larval densities and equal food densities. Two 15 m^3 start feeding pens with plankton gauze bags were used as experimental units. The plankton gauze bags were removed after 12 days. Initial larval densities were 41 and 8 pr l. Growth and mortality was measured.

A comparison between rotifers, natural plankton, and a mixture of both as start feed was also attempted but tecnical problems stopped this experiment.

RESULTS AND DISCUSSION

Technique.

The new water exhange system in the start feeding pens functioned quite well. The monitoring of oxygen and ammonia levels showed constant satisfactory values. The main problem with the pens has been and is buoyancy. The supply water used is mainly taken from 55 m depth, with a quite stable salinity of 31 - 32 $^{o}/oo$. The salinity of the water surrounding the big pens, howewer, is fluctuating between 20 and 30 $^{o}/oo$, nescessitating large buoyancy reserves to keep the pens afloat, especially as the filters have a tendency to clog. The start feeding pens floating in the big pens have equal salinities inside and outside. Here, however, the clogging of filters is the main problem, and start feeding pens regularly go partly under despite very frequent filter cleaning. Wave action inside the big pens can also be vicious and cause considderable amounts of water to splash into or out of the start feeding pens. The problem can partly be overcome by adding buoyancy and heightening fences, but the pen system will always need very careful attention during operation.

The plankton collecting system now functions quite well. The mesh size combination of 90 and 250 µ proved to be very effective both in holding back most useful feed objects and in excluding unwanted organisms like big copepodites. Clogging of the gauze cones is a persistent problem, especially during algal blooms. The cones must normally be hosed down at least twice a day. A total evaluation of the system has not yet been carried out since it has constantly been under modification. A premature conclusion may, howewer, be that it is an effective way og getting hold of different size fractions of plankton, when this is required and possible. The weakness of the total concept is that the abundance of different types of plankton vary very much over time.

About ten million rotifers per day were cultured during the start feeding season. The total culture volume was 600 l, and 150 l was harvested every day. This was the first attempt to culture rotifers in Norway and no grave problems arose. It was, howewer, difficult to maintain densities above 100 rotifers pr ml. This may be explained by a rather high abundance of ciliates in the cultures.

Spawning.

The brood stock was transferred to the spawning pen 11th of February, two weeks later than the 1981 season. The last day of egg collection was 20th of April, ten days later than the 1981 season. This indicates that the length of the spawning period is more or less constant for a given group of cod, while the start point, and thus also the end point of the spawning period, is influenced by the transfer to the spawning pen.

Total egg production was 120 l compared to 230 l in 1981. The decrease was of course due to the fact that more than half the spawning population died around 10th of March. A new filter in the water supply line to the spawning pen had reduced pressure enough to bring the oxygen supply below the consumption level. The mortality did not, howewer, affect the experiments as the egg production still was sufficient to cover the requierments.

Hatching experiments.

The results of the comparison between the start feeding pens and the lab incubators as hatching units are given in table 1.

Table 1. Hatching success with different incubator types.

	Eggs incub.	Dead eggs	Larvae	Hatching percentage
Start feeding pen 1	269 000	93 000	137 000	53%
Start feeding pen 2	260 000	83 000	131 000	50%
Lab incubator 1	260 000	154 000	13 000	5%
Lab incubator 2	260 000	169 000	14 000	5%

The results were very convincingly in favour of the start feeding pens, although the hatching frequency even in these units was poor. However, a new sample eight days later gave 20 000 and 2000 larvae respectively in the two pens, while there had been no mortality in the lab incubators. All the egg groups in this experiment were infected by fungi during the incubation period. It is possible that this infection also killed the larvae in the start feeding pens after hatching. In the lab incubators the greater part of the egg mortality occured at or close to hatching, while in the start feeding pens most eggs died early in the incubation period.

The vitality test with MS-222 gave quite good single results, but it was impossible to reproduce the results. The age of the larvae also seemed to be a very critical factor. The method was therefore abadoned.

The results of the hatching experiment with different densities and aeration are given in table 2.

Incubator	Eggs incubated	Dead eggs	Larvae	Hatching percentage
1	51 000	37 000	2 400	5%
2	206 000	89 000	27 000	13%
3	413 000	229 000	67 000	16%
4	620 000	338 000	73 000	12%
5*	413 000	250 000	20 000	5%
6*	620 000	340 000	32 000	5%

* with aeration

In this experiment also infection of fungi caused heavy mortalities. There seemed to be no density dependant mortality as the group with the lowest density had the lowest hatching percentage. The first week of the incubation period there was substantially less mortality in the groups with aeration than in other groups. Later in the period it was the other way around, and in the end the aeration groups came out with a very low hatching percentage. One explanation might be that the aeration spread the fungi very effectively from the heavily infected sedimenting dead eggs. If fungus infections can be avoided aeration might therefore still be a good solution where high density incubation is required, even in incubators with open circulation.

Both incubation experients were greatly damaged by fungus infection and will have to be repeated next season.

Start feeding experiments.

The reason for testing the start feeding pens with the inner bags of plankton gauze was that it would concentrate larvae and feed in a smaller volume during first feeding. This would facilitate a much higher food density, partly because the food supply normally is a limiting factor, and partly because patchiness would be reduced. On the other hand it is a well known experience from many laboratory studies that gadoid larvae should not be stocked at higher densities than 5 - 10 per l due to intraspecific interaction. To minimize this interaction the inner bags were removed by day 12.

The growth results of this experiment are given in fig.1 which clearly indicates higher growth rates in the pens without inner bags. Table 3 gives the development in number of cod larvae in the same bags.

Table 3. Mortality patterns of the gauze bag experiment.

Bag nr.	Number of larv.at start	Day 9	Day 12	Day 17	Day 20	Day 29	Day 90
1	78 000	62 000	42 000	39 000	41 000	23 000	918
2	82 000	26 000	44 000	43 000	18 000	7 000	
3*	88 000	17 000	12 000	35 000	16 000	28 000	541
4*	85 000	13 000	13 000	1 000	5 000	1 000	388

* Without inner bags

The first five days after transfer of larvae the overflow filters in the pens without inner bags had too large mesh size. During this period the larvae occupy the surface layer, and a substantial number of larvae in pens 3 and 4 must have disappeared through the overflow filter. If we, however, considder the samples from day 9 and 12 as being representative for the populations in the pens the most favourable development seems to have been in pen no.3. As fig.1 shows, growth also was best in this pen.

The final results of day 90 are mainly a demonstration of the results of cannibalism. Despite more than sufficient feeding, a group of cod fry will reduce itself to almost nothing in a short time. In a cannibalism experiment starting out with 980 62-day old cod fry only 31 fish were left one month later. 90 fry died during this period, the others were eaten despite the fact that the fry were fed to satiation twice daily.

The conclusion of the gauze bag experiment must be that if start feed is abundant the results will be better without the bags.

The purpose of the second start feeding experiment was to find out something more about density dependant growth and mortality in the start feeding pens. Growth results are given in fig.2 while the mortality development is given in table 4.

Table 4. Mortality development with different initial larval densities.

Pen No.	Day 6	Day 12	Day 15	Day 19	Day 25	Day 70
1	123,000	71,000	72,000	74,000	14,000	1,200
2	24,000	17,000	11,000	12,000	12,000	500

Fig. 2 shows that the growth development was not significantly different in the two groups the first month. Table 4, however, indicates clearly that a density dependant mortality occurred in pen no.1. As the population in pen no. 1 was reduced to the same level as the population in pen no.2 the conclusion must be that under the present conditions the initial number of larvae in pen no.2 was at least high enough. This indicates a stocking density of less than 1.6 larvae per l for the whole pen volume, and less than 8 larvae per liter for the gauze bag. Since there seems to have been little reduction of growth

in pen no.1, however, some degree of overstocking might be advisable to buffer against unexpected mortality.

The present experiments are carried out in pilot scale production units, and the main emphasize has been on development work. The precision is therefore below normal expectancy for laboratory experiments.

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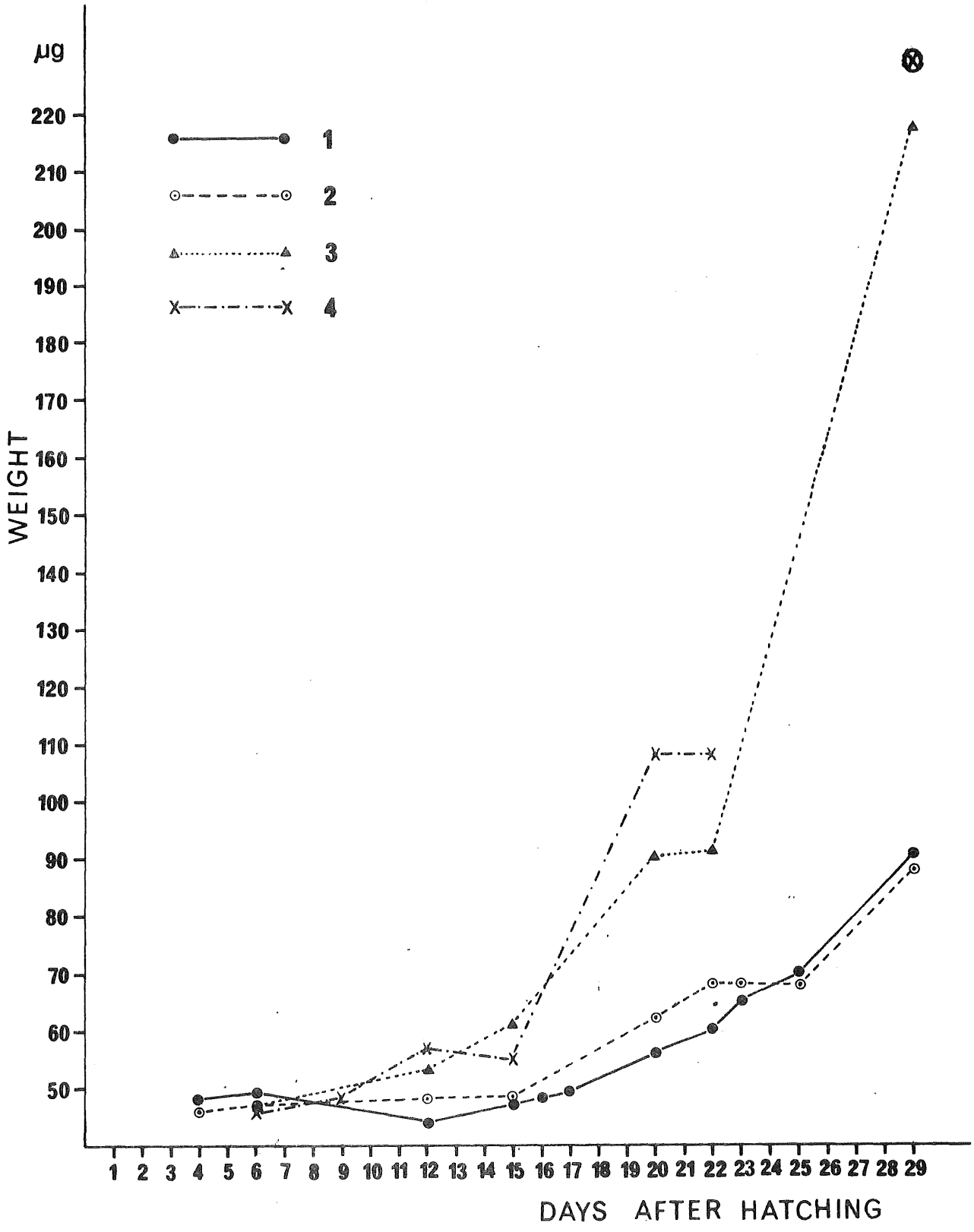

Fig.1. Growth (µg dry weight means) of cod larvae, start fed in pens with (1,2) and without (3,4) gauze bags.

⊗ Single larvae

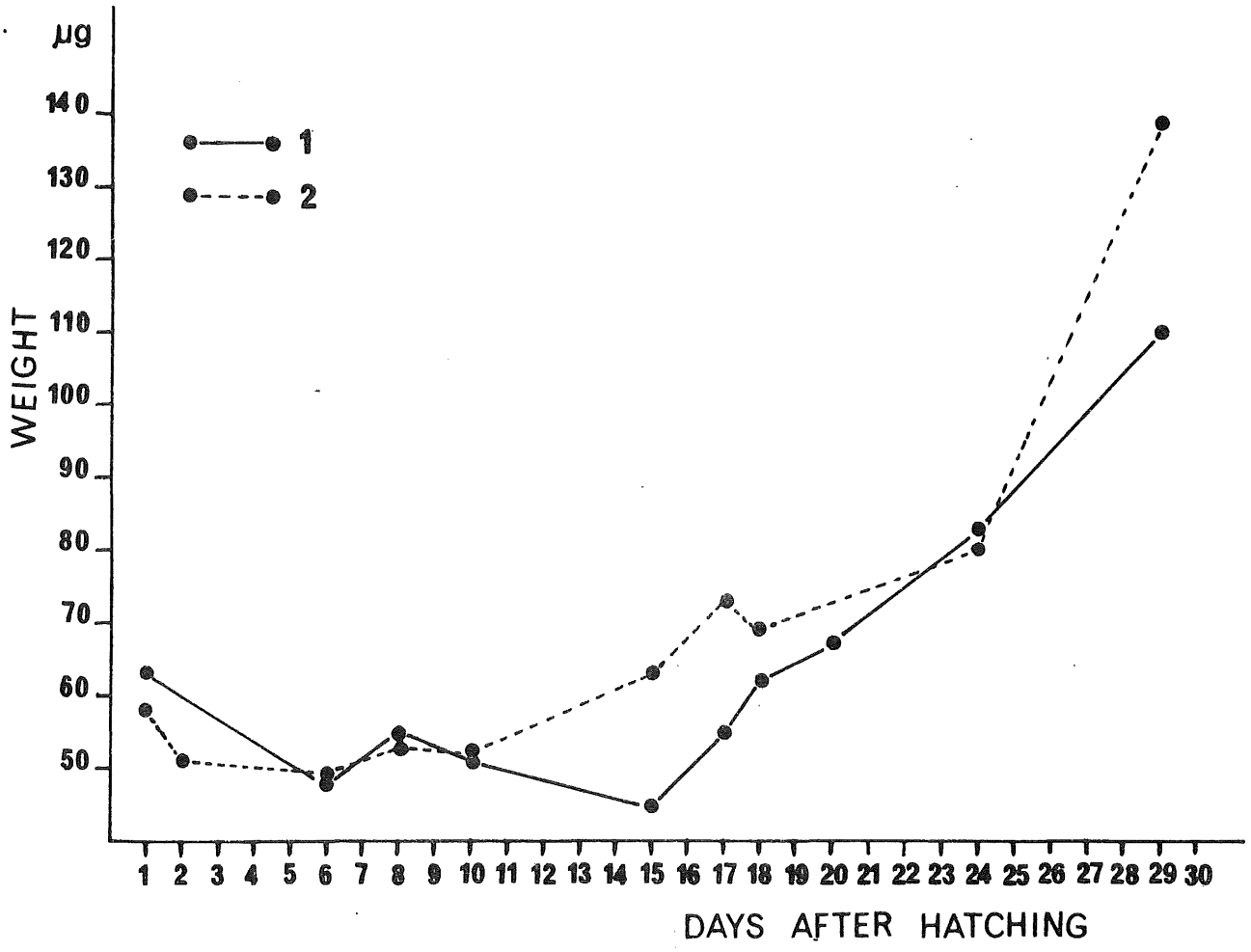

Fig.2. Growth (µg dry weight means) of cod larvae, start fed at different larval densities.
1. High density
2. Low - " -