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Successfully early weaning of Atlantic halibut (*Hippoglossus hippoglossus* L.) in small shallow raceway systems.

by

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ABSTRACT

Small raceways were used in a weaning experiment with Atlantic halibut larvae. The size of the tanks were 1.0 x 0.4 m with water level of 1-2 cm. Duplicate larval groups were tranferred to the raceways from circular first feeding tanks at 0.07, 0.10 and 0.16 g wet weight, while recommended weaning size of this species is 0.2 - 0.3 g. During the 7 first days of weaning, *Artemia* was used as food supplement in combination with the formulated dry feed. Therafter only dry feed was used. The dry feed used in this experiment was produced by a special heat technique. The 0.07, 0.10 and 0.16 g larval groups were evaluated after 31, 25 and 17 days, respectively, obtaining an average survival of 81.5, 78.0 and 97.1 % and a specific daily growth rate of 3.13, 3.16 and 2.35 %, respectively. In the *Artemia* control group a survival rate of 96.0 % and a growth rate of 5.27 % was acchieved. The successful weaning at these small sizes considerably reduced the live food period. Based on the present knowledge of the energetic demands of this species it is calculated that weaning at 0.07 g compared with 0.25 g will reduce the amount of *Artemia* needed by approximately 70 %. No differences in pigmentation or degree of completed eye migration was detected between groups, indicating this to be determined at earlier developmental stages.

Introduction

A major bottleneck in the present commercial production of Atlantic halibut is the initial live food period of uptil two months. Weaning to dry feed take place at 0.2 - 0.3 g wet weight, as recommended by Opstad (1995). Both wild zooplankton and *Artemia* are generally used in the live food period, but the problems to obtain sufficient amount of adequate stages and species of the zooplankton still result in reduced juvenile quality (pigmentation, eye migration). In a fully controlled juvenile production of halibut an earlier transitition to a formulated diet is highly appreciated.

Apart from having a dry feed with the optimal physical, chemical and nutritional qualities, early weaning of halibut requires appropriate production systems for this developmental stages of fish. In this study, both a new formulated feed composed to meet the nutritional demands of halibut larvae and small raceways designed for an early weaning, were evaluated. The raceways were similar and were operated mainly as described in Strand et al. (1995). This research group has successfully used such systems for weaning and ongrowing of several marine fish species (e.g. Strand & Øiestad 1997).

Material and methods

Halibut larvae were startfed with DHA Selco enriched *Artemia* in 1.5 m indoor circular tanks according to standard methods developed at IMR Austevoll Aquaculture Research Station, Norway (Harboe et al. in press). When the larvae reached the specific experimental sizes of, 0.07, 0.10 and 0.15 g wet weight (fresh weight), respectively, they were transferred to indoor 1.0 x 0.4 m black shallow raceways where the weaning experiment took place (Table 1). At transfer the water level was 5 cm, but this was gradually reduced during the first week to 1 - 2 cm. The raceways were supplied with sand filtered sea water of approx. 34 ppt, 12 ±0.5°C and flow rates of 3-5 L/min. All groups were exposed with 24 h light. Oxygen saturation in outlet was measured daily and varied between 93 and 99 %. The first two days the larvae were adapted to the new system and fed *Artemia* only. The fishes which did not commence feeding *Artemia* after transfer were excluded before the experiment began. During the 7 first days, *Artemia* were used as food supplement in combination with the formulated dry feed. Thereafter only dry feed was used. Each experimental groups consisted of two replicate tanks apart from a single control group continuously fed on enriched *Artemia*. A number of 100 - 150 individuals were stocked in each tank. The dry feed used in this experiment was produced by a specific heat technique and was formulated according to available knowledge of nutritional and energetic demands of larval halibut. It was based on fish muscle, bounded by a protein matrix and had very low leaking properties. In addition, the feed was protected against lipid oxidation. With this techique it is possible to include water soluble components in the feed without using binders or coating which can reduce the absorbtion of nutrients. Two particle sizes were used, from 0.30 - 0.58 mm during the first part of the experiment gradually substituted by 0.58 - 0.8 mm particles when those were preferred. Apart from hand feeding to satisfaction during daytime, automates were active every third hour. The 0.07, 0.10 and 0.16 g larval groups were evaluated after 31, 25 and 17 days, respecively. Thereafter the experiment continued for 22 days on a commercial dry diet (from the Norwegian Herring Meal and Oil Industry Research Institute, Bergen, Norway, (SSF)) to evaluate the success of the weaning period. If the juveniles successfully grew onwards on the commercial diet, weaning was regarded as completed. To check any effect of the early weaning on juvenile quality, the percentage of fish with fully ocular side pigmentation and degree of completed eye migration were evaluated. For the latter analysis, the index of Næss & Lie (in press) was used. Individuals with no sign of eye migration are given the number zero and completed eye migration the number 3. Daily specific growth rate (SGR) was calculated according to the the exponential growth model of Ricker (1958).

Results

During the first days of the experiment a very frequent feeding scheme seemed necessary, e.g. every 30 min. Huge overfeeding connected with a relative high water level, 2-5 cm due to the supplemented *Artemia* feeding and low water flow, resulted in unsufficient self cleaning of the raceways and intensive manual tending was necessary. However, this was highly improved at higher flow rates and reduced water level when only a carefull manual tending once a days was needed.

The 0.07, 0.10 and 0.16 g larval groups obtained average survivals of 81.5, 78.0 and 97.1 % and specific daily growth rates of 3.18, 3.16 and 2.38 %, respectively (Table 1). In the

Artemia control group a survival rate of 96.0 % and a growth rate of 5.28 % was achieved, thus the *Artemia* control group was significantly larger at the end of the experiment. It is, however, important to note the different length of the experimental period among groups, 17 to 31 days (Table 1). The proportion of fish with fully pigmentation on the ocular side was low and no significant difference between groups could be detected.

Higher growth rate, approx. 6 %, were obtained in all experimental groups, except control, in the postfeeding period on commercial dry feed (Table 2). A small tendency of reduced growth rate with size was detected. The survival showed some differences between replicates, but averaged approx. 80 % in the 0.07, 0.10 and 0.16 g groups. Hundred percent survival was achieved in the *Artemia* group which has its weaning in this period, i.e. from 0.36 g. For the total period, survival rates of 64 % were achieved for the 0.07 and 0.10 g groups, approx. 80 % for the 0.16 g group and 96 % in the *Artemia* control group. Differences were found among replicates. The initial stage of eye migration was observed in most fish, but only a small proportion with completed eye migration. A tendency of lower eye migration index was found among the 0.07 and 0.10 g groups.

Discussion

Small shallow raceway systems can be successfully used in an early weaning of Atlantic halibut. A halibut of 0.07 g is in an early stage of the metamorphosis and swims in a sloping, but pelagic position in the water column. When exposed to 1-2 cm water depths, the larvae almost immediately settled on bottom. Only when actively seeking for food they tried to maintain their pelagic orientation. Compared with larvae of the same size in 1 m deep startfeeding tanks, which still have a pelagic behaviour, such «forced» settling could be energetically favourable for the fish.

Weaning at this small sizes will considerably reduce the live food period. To grow from 0.01 g (wet weight) at first feeding to 0.07 g, the feed demand is about 8000 *Artemia* for a halibut larva. To reach 0.25 g, 20 000 more *Artemia* need to be consumed (calculated from van der Meeren 1995). Consequently, weaning to dry feed at 0.07 g compared to 0.25 g, which is the commercially most frequently used weaning size (cf. Opstad 1995), will reduce the need of *Artemia* by approximately 70 %.

The study opens promising prospects for an even earlier weaning to a dry diet both with respect to the technological system (raceways) and the experimental diet used. However, since no significant differences in juvenile quality parameters were detected, these characteristics seem to be determined at even earlier developmental stages than tested here.

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Table 1. Characteristics of the early weaning experiment. Number of larvae at start, size (mean±SE), growth, pigmentation on ocular side and survival of the halibut groups weaned to dry feed at different larval sizes (2 replicates).

	Gr. 0.07 g		Gr. 0.10 g		Gr. 0.16 g		Artemia
	Repl 1	*Repl 2*	*Repl 1*	*Repl 2*	*Repl 1*	*Repl 2*	
Duration of experiment (d)	31	31	25	25	17	17	31
Number at start	108	116	88	74	88	86	25
Start weight (g)	0.072±0.009	0.076±0.005	0.097±0.007	0.094±0.009	0.158±0.010	0.160±0.005	0.074±0.005
Final weight (g)	0.187±0.012	0.204±0.013	0.207±0.012	0.209±0.012	0.237±0.008	0.237±0.009	0.365±0.022
SGR (%)	3.12	3.24	3.08	3.25	2.41	2.34	5.28
Pigm. (%)	28.9	17.9	23.8	19.0	23.5	32.7	29.2
Survival (%)	83.9	79.0	81.4	74.4	96.0	96.1	96.0

Table 2. Characteristics of the same juvenile groups during a 22 days postfeeding period on a commercial diet (SSF feed).

	Gr. 0.07 g		Gr. 0.10 g		Gr. 0.16 g		Artemia
	Repl 1	*Repl 2*	*Repl 1*	*Repl 2*	*Repl 1*	*Repl 2*	
Start weight (g)	0.187±0.012	0.204±0.013	0.207±0.012	0.209±0.012	0.237±0.008	0.237±0.009	0.365±0.022
Final weight (g)	0.766±0.068	0.887±0.082	0.829±0.067	0.899±0.075	0.822±0.051	0.922±0.062	0.973±0.081
SGR (%)	6.62	6.90	6.51	6.85	5.81	6.37	4.56
Survival (%)	81.3	77.2	83.3	80.0	92.9	72.6	100
Eye migration index	1.48	1.62	1.57	1.52	1.64	1.90	1.79
Total survival from start	68.5	61.2	68.2	59.5	89.8	70.9	96.0