First feeding of Perch (*Perca fluviatilis*) larvae

(Startfodring af aborrelarver)

by

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INTRODUCTION

One of the main bottlenecks in intensive commercial perch aquaculture is the cost to produce juveniles (Tamzouzt, 1995). Compared to e.g. salmonids, perch produce a relatively small larva, hatching out at approx. 5.4mm (0.7-0.8mg) that requires live feed in the initial stages, which can be costly and time consuming to produce. The larvae are also very fragile in the beginning and are prone to problems such as failure to inflate their swimbladder (around day six after hatching) and thereafter cannibalism can take over, particularly at the weaning stage. This can reduce survival and therefore increase cost per larvae produced.

The main objectives were to produce weaned fish for ongrowing, to assess the performance during larval rearing in terms of growth and survival and to assess the potential to spare live feed with the use of a compound feed during larval rearing.

2003: MATERIALS AND METHODS

During the first attempts to produce perch juveniles at Bornholms Lakseklækkeri different feeding regimes using live feed and dry feed were employed to a) ensure some survival and b) to obtain preliminary data about which feeding strategy would be most successful. Therefore larvae hatched from eggstrings from groups named Tange II, Guldager II and Guldager IV were used in these preliminary investigations. The Tange II egg string was collected in Lake Tange near Bjerringbro, central Jutland. Guldager II and IV eggstrings were collected in Lake Guldager near Hjørring, Northern Jutland.

Tange II /Guldager II

Larvae hatched from Guldager II and Tange II eggstrings were held separately in their own 580l tanks from day of hatching until day 14 post hatch. During this period the larvae were fed with high HUFA strain of *Artemia salina* five times a day (feeding at: 8.00, 11.00, 14.00, 17.00 and 20.00). It was observed that the larvae could eat *Artemia* directly after hatching. After day 14, the larvae from each group were divided into two subgroups and placed into two tanks. One subgroup from Tange and one subgroup from Guldager were fed *Artemia*, the other two subgroups were fed a mixture of dry feed (Nippai® , Tokyo, Japan) and *Artemia*. The feeding regime using a combination of dry food and *Artemia* involved dry feed being administered during the morning feeds (9.00 and 11.00), a mixture of *Artemia* and dry feed in the afternoon

(14.00 and 17.00) and finally only *Artemia* during the last feed of the day (20.00) . The subgroups fed exclusively with *Artemia* were fed at same time schedule. (Refer to fig. 1 for overview of experiment). Samples of larvae were collected every 3 days and placed in 0.5% formalin solution. After 24 day post hatch the larvae were weaned onto commercial diet (Dan-Ex 1362 0.4mm, Danafeed).

Guldager IV

Perch larvae hatched from the Guldager IV eggstring were held in one 580 l tank for nine days. During this period they were fed only *Artemia*. From day nine after hatching the larvae were split into three 580 l tanks and subjected to three different feeding regimes. The control group were continued on a diet of *Artemia*. The second treatment involved a feeding a regime of rotifers and *Artemia*, where rotifers were added to the diet during kl.11.00 and kl.17.00 feeds. The final group were fed a combination of dry feed (Nippai) and *Artemia* as described for the Tange II and Guldager II groups (fig. 2).

Larvae were sampled from each group approximately every three days. The sampled larvae were preserved in 4% formalin solution.

Measurements on larvae

Preserved larvae from all feeding trials were sent to DIFRES (Danish Institute for Fisheries Research), Hirtshals, where total length (mm), wet weight (mg), dry weight (mg) and % dry matter were measured. Total length was measured using the image analysis software Global Lab Image®. Wet weight was measured after removal of excess water with a paper tissue. Dry weight was measured to µg on a Mettler® type MT5 microbalance after drying at 58°C for 24 hours. Percentage dry matter was calculated from the wet weight and dry weight measurements.

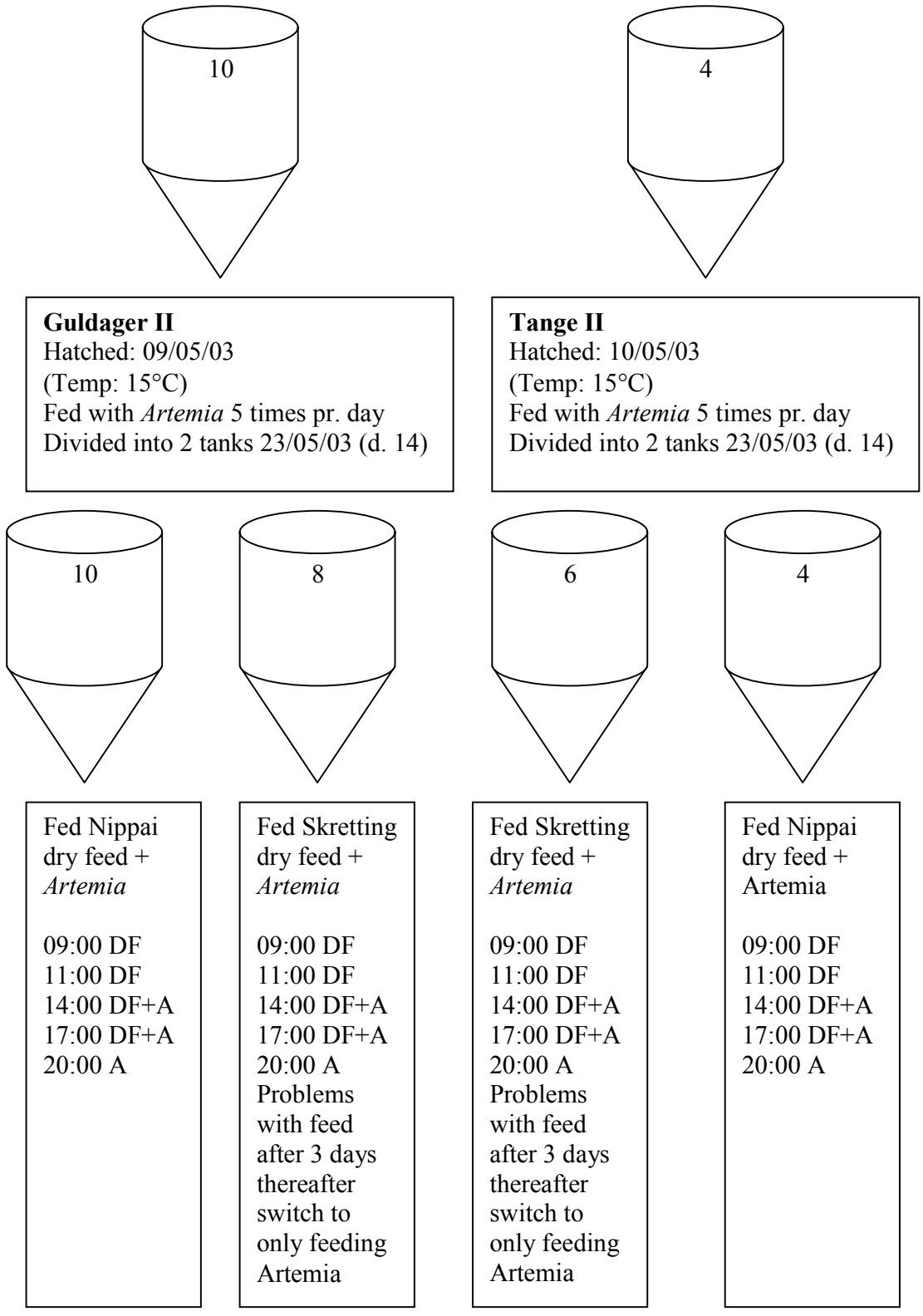


Figure 1: Larval feeding regimes for Tange II perch larvae, May 2003.

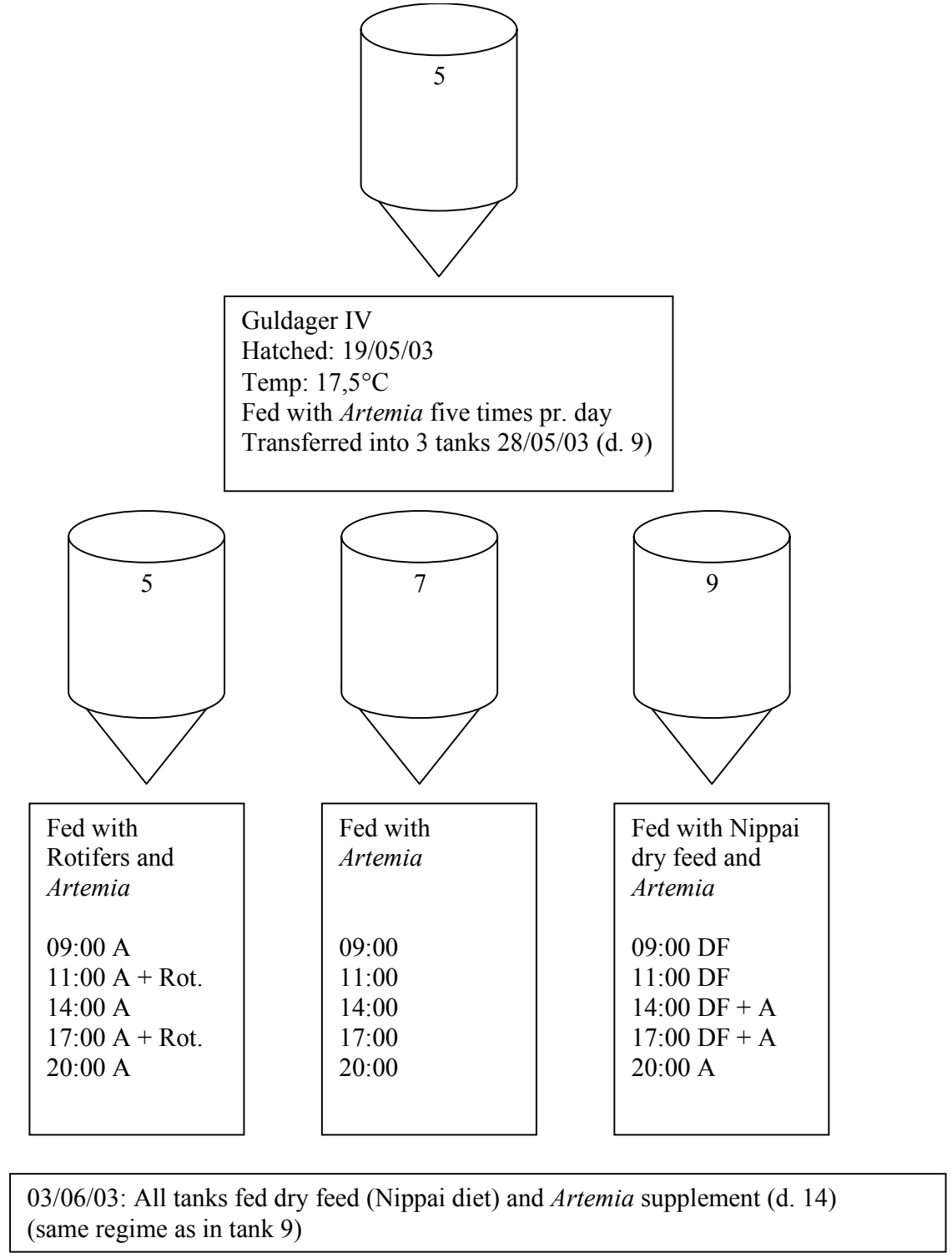


Figure 2: Larval feeding regimes for Guldager II perch larvae, May 2003

Mean and standard deviations for total length, wet weight, dry weight and % dry matter for Tange II, Guldager II and Guldager IV groups were plotted against days after hatching. For each sampling period the means for comparative feeding treatments were tested for significant difference at P=0.05 using the unpaired t test. Where data sets failed tests for normality and/or equal variance the Mann-Whitney rank sum test was applied.

Total specific growth rate as the percentage increase in body weight per day was calculated using fresh weight of larvae for each weighing interval for different feeding regimes within Tange II, Guldager II and Guldager IV groups. Specific growth rate in this instance is denoted by the following equation;

$$\left[\left(\frac{LnW_f - LnW_i}{D}\right) - 1\right] * 100$$

where W_i is the initial mean weight, W_f is the final mean weight and D is the number of days for the growth period of interest.

RESULTS

Table I (p. 11) and figures 3 –6 show mean and standard deviations for total length (mm), wet weight (mg), dry weight (mg) and % dry matter during larval rearing of perch from Tange and Guldager lakes using different feeding regimes. As expected there is a steady increase in length and weight during the period of larval rearing, denoting a steady growth in all groups. In Guldager II and Tange II groups, no significant differences between feeding regimes were found for length or wet weight until day 31 and day 37 after hatching, respectively. However, in Tange II the larvae in the group fed *Artemia* were significantly larger than in the group fed *Artemia* and Nippai, whereas with Guldager II the reverse was observed. Therefore nothing conclusive can be stated about, whether mixed dry food/*Artemia* diet is better or worse than solely feeding with *Artemia*. Percentage dry matter was very variable between groups already from day 16 and day 24 after hatching for Tange II and Guldager II groups respectively. However there is no progressive trend that can be explained in these results. With respect to the Guldager IV trial (table I, figure xx) it was also observed that the use of *Artemia* or

Artemia/Nippai resulted in similar growth performance. However the larvae fed a diet of rotifers and *Artemia* performed significantly worse than the other two feeding regimes especially from days 13 to 22 after hatching.

Specific growth rates (as shown in table II) for Guldager II group were higher for larvae fed a combination of dry feed and Artemia compared to larvae fed exclusively *Artemia*.

This improved growth rate was not observed in Tange II group where growth rates were the same. With respect to Guldager IV group, the results supported the Guldager II group with slightly better growth rates for combined Artemia and dry feed. The specific growth rates also supported the observations of mean lengths and weights i.e. the rotifer Artemia combined diet produced poorer SGRs than for Artemia and Artemia/ dry feed groups.

Table II: Specific growth rate (SGR) (% * d^{-1}) of perch larvae in different feeding regimes.

Group:	**Age period (days)**	***Artemia***	**Nippai/*Artemia***	**Rotifers/*Artemia***
Guldager II	18 - 24	17,9	19,3	
Guldager IV	8 - 29	21,4	21,7	20,9
Tange II	13 - 38	20,1	20,1	

DISCUSSION

The observation in this study where larvae fed directly after hatching has not been noted before in the literature. First feeding is generally observed two days after hatching, where *Artemia* are found in the gut contents (Vlavonou *et al*., 1995). This corresponds to the detection of gastric enzymes during this period as evidence of digestion of *Artemia* from two days after hatching and onwards (Kestamont *et al*., 1996). One explanation for this feeding directly after hatching could be the result of delayed hatching. This could have resulted in the larvae exhausting yolk sac resources before hatching and are therefore larger and more developed than standard hatched larvae, finishing the gastric development process in the egg stage. The fact that the

larvae could also feed directly off *Artemia* and did not require a rotifer stage is significant for aquaculture purposes where the production of rotifers is a complex and time consuming affair, especially when rotifers are required for only the first three days of perch larval production. Gape size and gut size determines the size of prey fish larvae are able to consume. Mouth gape size for newly hatched perch larvae has been measured to be 360µm. When related to body size (Treasurer, 1990: Tamazouzt, 1995) it is suggested that perch larvae should be able to digest *Artemia* of 420-48µm by day three after hatching. In our trials however we used a smaller strain of *Artemia* (hatching size 380µm) which may have been small enough for larvae to feed off after at the most one day after hatching. Kestemont *et al*. (1995) have suggested that there is an improvement in overall survival and performance of larvae if they are fed rotifers for the first two days and thereafter fed *Artemia* compared to being fed exclusively *Artemia*. However, their report suggests that they did not use particularly small *Artemia* as was administered in the present study. In addition, a high HUFA (Highly Unsaturated Fatty Acids) strain of *Artemia* was used. HUFAs have been proven to be important in larval development.

With reference to the pilot trials in 2003 (i.e. the first attempt to produce perch juveniles at BL) only small fragments of eggstrings were hatched out and therefore the amount of larvae to carry out experiments was somewhat limited. Thus only a restricted sampling of larvae was possible from each group during the larval rearing period. Moreover, numbers of larvae were not assessed at the beginning and division of larvae to different treatments was a rough estimation. This restricted number of individuals' sampled and non standardisation of larval stocking density makes it difficult to draw conclusions from different feeding regimes, particularly with reference to overall survival, but it does give us some initial indication as to the growth potential of larvae in recirculated systems and some initial experience with rearing and sampling the larvae. Growth rates observed in the present experiments were comparable to those observed by Kestemont *et al.* (1995).

There was no advantage gained from feeding rotifers in this experiment. This is most likely due to feeding with rotifers taking place after day 6 post hatch. As mentioned earlier, perch larvae are specific in selecting food particle size (Tamzaouzt *et al*. 1993). Kestemont *et al*. (2003) showed that rotifers were beneficial to perch larvae from 1-3 days after hatching when

the mouth size is too small for *Artemia*. Therefore it is possible that the perch larvae did not actively feed off rotifers as the small body size made them uninteresting as prey items. Moreover, salt water strains of rotifers were used (*Brachyonus plicatilis*) which require salt water to survive. Once placed in freshwater their mortality may have been instant resulting in rotifers becoming inert particles in the water. The movement of live prey is known to be important in prey selection by fish larvae. Therefore, possible a freshwater strain of rotifers would be more successful (e.g. *Brachyonus calyciflorus*).

Guldager II

Days after hatching	Number of individuals (n)		Total length (mm) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	Fresh weight (mg) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	Dry weight (mg) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	% dry matter Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)
	Artemia	Nip/Art																
18	6		8,22	0,88			4,14	1,71			0,71	0,33			17,01	1,53		
20	5	5	10,34	0,25	9,87	0,55	8,78	0,72	6,98	0,89	1,30	0,22	1,04	0,22	14,75	1,52	14,85	1,23
22	5	5	11,10	1,49	11,56	0,73	11,90	5,46	10,57	3,18	1,73	0,91	1,58	0,41	14,20	1,01	15,16	0,81
24	5	5	13,10	1,61	12,75	1,49	24,64	11,52	17,23	8,52	3,66	1,86	2,74	1,40	14.66*	0,61	15.79*	0,46
27	5	6	13,71	1,58	14,40	0,88	28,67	10,17	26,20	5,44	4,16	1,55	4,15	0,91	14.45*	0,64	15.82*	0,84
30	5	5	18,08	2,23	19,20	2,41	61,68	26,04	74,77	26,76	10,12	4,23	12,10	5,02	16,43	1,36	15,90	1,01
34	5	5	21,14	1,86	20,82	3,33	103,45	21,60	119,50	39,99	17,73	4,73	20,17	7,17	16,33	1,11	16,72	1,36
37	5	4	20.14*	1,68	24.65*	2,33	94.82*	21,84	171.46*	44,14	15.87*	4,84	29.80*	8,88	16,53	1,56	17,25	0,87
44	5	5	28.24*	1,93	30.72*	1,34	299.62*	66,39	405.65*	44,42	56.42*	14,06	78.51*	10,54	18,74	0,85	19,32	0,62

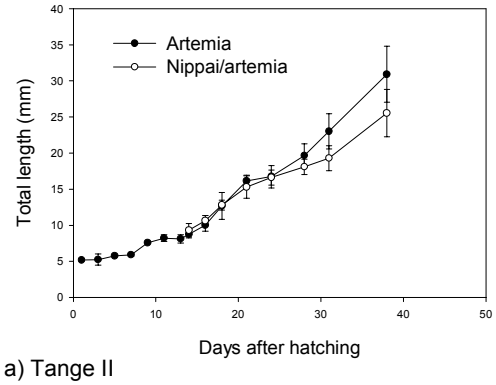
GuldagerIV

Days after hatching	Nr. of individuals (n)			Total length (mm) Rotifer/artemia Mean	SD±	Artemia Mean	SD±	Nippai/Artemia Mean	SD±	Fresh weight (mg) Rotifer/Artemia Mean	SD±	Artemia Mean	SD±	Nippai/Artemia Mean	SD±	Dry weight (mg) Rotifer/Artemia Mean	SD±	Artemia Mean	SD±	Nippai/Artemia Mean	SD±	% Dry Matter Rotifer/Artemia Mean	SD±	Artemia Mean	SD±	Nippai/Artemia Mean	SD±
	Artemia	Rot/art	Nip/Art																								
8	6					8,52	0,40					3,63	0,72					0,49	0,09					14,29	0,54		
10	6	6	5	9,28	0,89	9,62	0,37	9,58	0,70	5,69	2,66	6,15	1,19	5,76	1,43	0,77	0,37	0,86	0,14	0,84	0,26	13,50	1,18	13,99	0,75	14,44	1,33
13	8	7	8	12.95*	0,78	12.11*	0,60	12,47	0,76	17,99	3,95	16,34	2,48	17,34	3,68	2,56	0,53	2,44	0,44	2,66	0,58	14.29*	0,59	14,91	0,93	15.35*	0,80
15	9	8	9	12.93*†	1,05	14.20*	1,15	15.16†	1,05	21.31*†	5,85	29.83*	9,25	36.62†	8,93	2.97*†	0,87	4.77*	1,57	5.78†	1,38	13.85*†	0,37	15.90*	0,86	15.80†	0,52
19	10	11	9	17.19*	1,75	19.79*†	0,75	18.04†	1,96	51.39*	13,53	80.27*†	8,20	61.28†	18,03	7.73*†	2,33	12.44*	1,45	10.41†	3,10	14.92†	0,90	15.48*	0,60	16.96*†	0,67
22	8	8	8	19,60	1,53	21,89	2,71	20,35	2,01	76.44*	17,90	106.55*	30,03	88,57	25,77	11.69*	3,17	16.86*	5,12	13,85	4,28	15,23	1,11	15,73	0,52	15,56	0,36
29	5	6	6	25,77	1,94	26,70	3,48	27,23	1,53	193,78	40,79	211,51	79,28	222,80	51,25	35,02	6,94	37,61	15,55	40,88	8,38	18,13	0,89	17,58	0,95	18,76	0,83

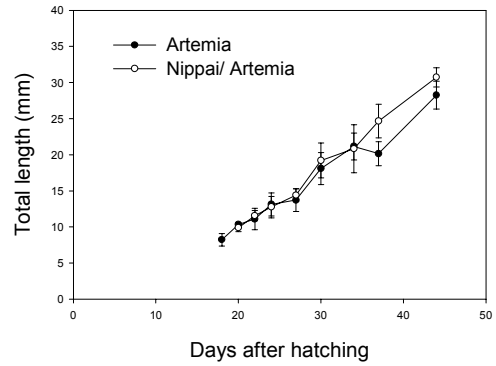
Tange II

Days after hatching	Number of individuals (n)		Total length (mm) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	Fresh weight (mg) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	Dry weight (mg) Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)	% dry matter Artemia Mean	SD (±)	Nippai/Artemia Mean	SD (±)
	Artemia	Nip/Art																
1	12		5,18	0,16			0,63	0,12			0,15	0,02			25,34	6,64		
3	3		5,24	0,76			0,62	0,12			0,12	0,04			19,48	3,93		
5	4		5,74	0,07			0,61	0,04			0,10	0,00			16,77	1,40		
7	3		5,91	0,21			0,55	0,05			0,09	0,00			16,49	1,71		
9	2		7,58	0,04			2,13	0,32			0,28	0,01			13,13	1,69		
11	7		8,20	0,46			3,43	0,66			0,54	0,10			15,69	0,99		
13	6		8,12	0,57			3,56	0,95			0,53	0,15			15,07	0,81		
14	5	5	8,74	0,50	9,29	0,94	4,80	0,69	6,36	2,91	0,70	0,13	0,90	0,42	14,28	0,89	14,09	0,81
16	7	5	10,02	0,82	10,63	0,71	8,10	2,32	9,09	2,16	1,05	0,39	1,33	0,34	12.68*	1,64	14.52*	0,38
18	6	6	12,68	1,86	12,80	0,68	18,33	6,76	14,39	2,22	2,72	1,06	2,36	0,41	14.72**	0,68	16.34**	0,52
21	5	6	16,14	0,80	15,30	1,55	38,89	7,87	30,80	8,82	6,52	1,41	4,91	1,51	16.73*	0,56	15.85*	0,64
24	5	5	16,74	1,55	16,60	1,03	45,35	9,85	43,85	10,11	7,43	1,69	6,58	1,50	16.35*	0,35	15.03*	0,90
28	5	6	19,66	1,61	18,10	1,05	73,78	19,41	54,80	9,51	10,67	2,71	7,86	1,48	14,51	0,68	14,32	0,64
31	4	4	23.00*	2,44	19.30*	1,73	122,08	45,99	68,19	21,02	22,28	8,70	11,22	4,02	18.11*	0,75	16.32*	1,20
38	5	5	30.90*	3,88	25.54*	3,27	347,94	141,50	186,08	69,01	69.26*	26,55	35.27*	15,99	20,00	0,89	18,77	1,85

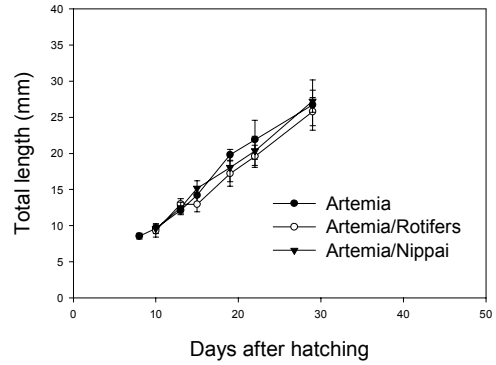
Table I: Growth of perch larvae in 2003 using different start feeding strategies. *= $p<0.05$, **= $p<0.01$.



a) Tange II

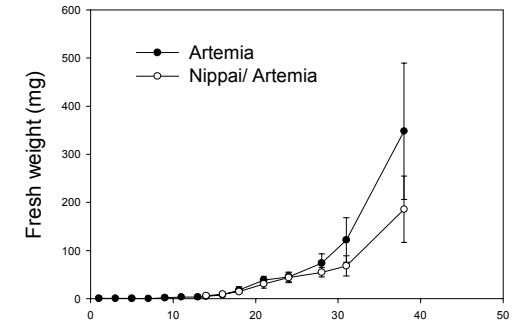


b) Guldager II

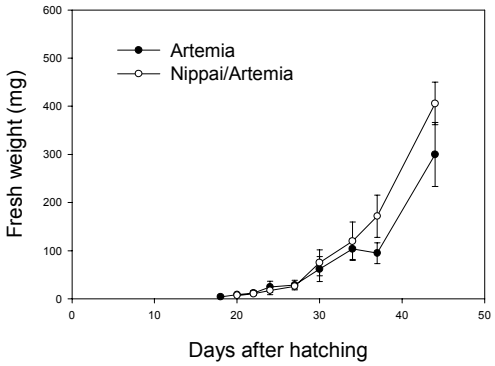


C) Guldager IV

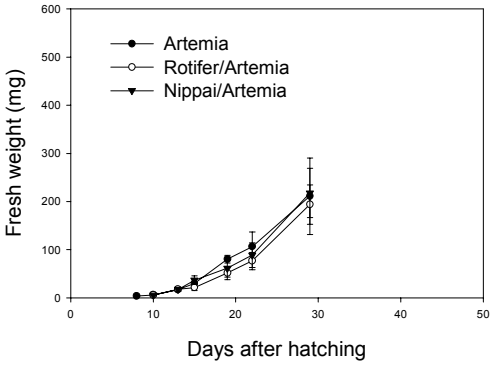
Figure 3: Mean total length (mm) and standard deviations for Eurasian perch larvae from a) Tange II, b) Guldager II and c) Guldager IV groups during the period of larval rearing, Bornholms Lakseklækkeri, Denmark (May, 2003).



b) Tange II

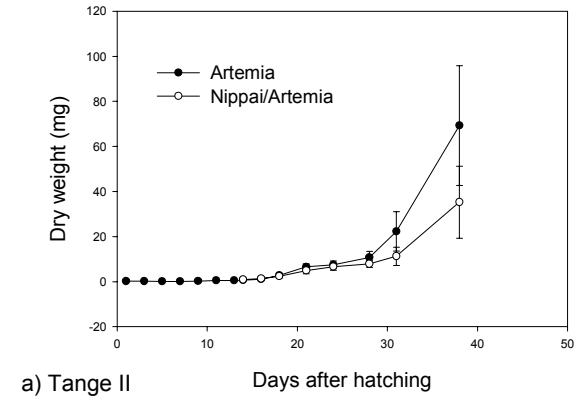


b) Guldager II

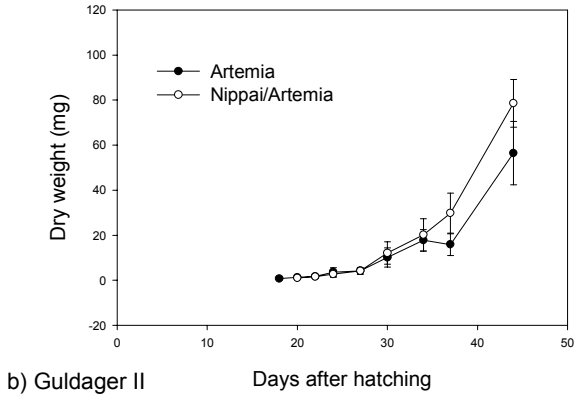


c) Guldager IV

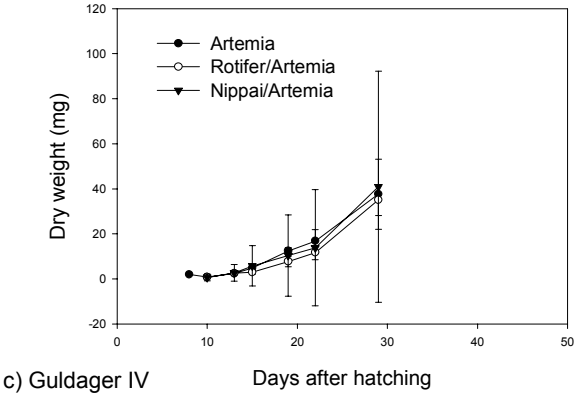
Figure 4. Mean fresh weights (mg) and standard deviations for Eurasian perch larvae from a) Tange II, b) Guldager II and c) Guldager IV during the period of larval rearing, Bornholms Lakseklækkeri, Denmark (May 2003).



a) Tange II

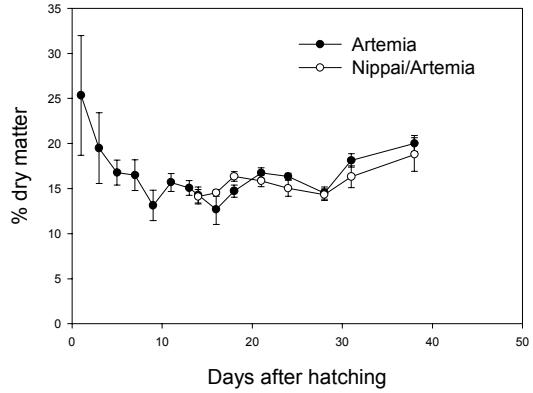


b) Guldager II

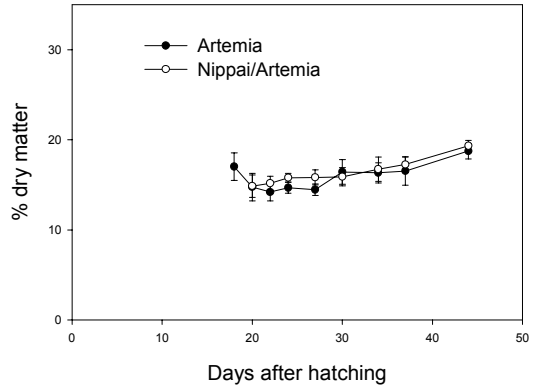


c) Guldager IV

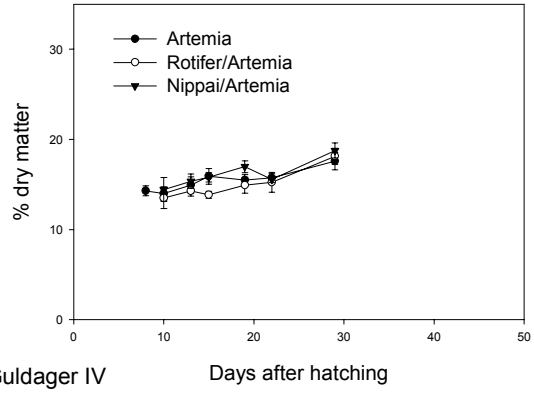
Figure 5: Mean dry matter (mg) and standard deviations for Eurasian perch larvae from a) Tange II, b) Guldager II and c) Guldager IV groups, during the period of larval rearing, Bornholms Lakseklækkeri, Denmark (May, 2003).



a) Tange II



b) Guldager II



c) Guldager IV

Figure 6: Mean % dry matter and standard deviations for Eurasian perch larvae from a) Tange II, b) Guldager II c) and Guldager IV groups during the period of larval rearing, Bornholms Lakseklækkeri, Denmark (May 2003).

2004: Larval rearing experiments – The effects of sparing *Artemia* with the use of formulated dry feed on larval perch growth and survival in a recirculated system.

MATERIALS AND METHODS

Perch eggstrings were collected from lake Tange (north Jutland) and transferred by road to Bornholms Lakseklækkeri, arriving on 28th April 2004. On arrival eggs were disinfected with 0.5% Actomar30® for 12 minutes, rinsed and then placed in plastic baskets within the incubation tanks (see fig. 7). Once the eggs were observed to be close to hatching (full pigmentation in eyes, fig 8) the eggs were transferred to hatching tanks with fine mesh (510µm) and allowed to hatch out naturally. All larvae had hatched out by 1st May 2004. The larvae were then fed saltwater rotifers (*Brachionus plicatilis*) for three days. All hatched larvae were collected into a large basin and the total number of larvae was calculated from repeat sampling. One hundred and ten thousand 2-3 day larvae were available for experimentation. The larvae were divided into 10 x 580l cylindroconical tanks where the water volume was held at 500l (11,000 larvae per tank equal to a stocking density of 22 larvae per litre).

The 10 tanks with perch larvae were divided into five feeding strategies (two replicates per strategy). A control group was fed only *Artemia* from day 1 until weaning onto dry feed. The other four groups comprised of 1. feeding of dry feed only, 2. early weaning (i.e. *Artemia* until day 10, thereafter switching the diet totally to dry feed. 3. early weaning, thereafter switching the diet to a mixture of dry feed and *Artemia* and 4. Feeding with a mixture of dry feed and *Artemia* during the entire larval rearing process. Nippai dry feed (see box 1 for contents) was chosen as the compound diet due to a) its success in rearing larvae in 2003 trials and b) its dry nature minimises the amount of oil forming on the surface of the water (important especially during the period of swimbladder inflation where perch larvae must gulp air from the water surface in order to inflate their swimbladders). Nippai also has the optimal protein requirement for larvae with the best SGR as demonstrated by Kestemont *et al*. (1996). Nutritional content can vary between strains of *Artemia*. In this case a high HUFA strain of *Artemia*, which produces small nauplii was chosen (High HUFA 410 *Artemia* cysts, SBS International, USA).

Figure 7: Baskets used to hold eggs during incubation, April 2004.

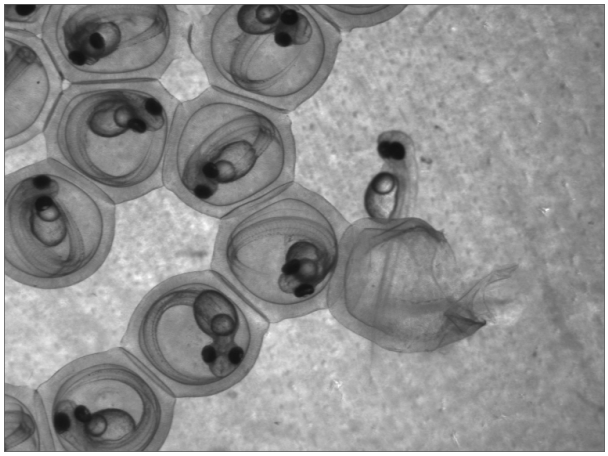


Figure 8: Perch larvae at point of hatching, May 2004

This high HUFA strain of *Artemia* is relatively expensive therefore after 15 days of larval rearing the *Artemia* source was changed to a cheaper strain of *Artemia* with larger nauplii for the remainder of the experiment (Salt Lake Aquafeed *Artemia* cysts (Global Aquafeed Inc., USA).

Nippai feed (Nippon Formula feed MFG., Co., LTD., Japan)
Type no. 1, 2 and 3.

	Content:
Particle size:	raw protein: 56%
Type1: 100-250 µm	raw fat: 8.3%
Type2: 180-400 µm	raw fibres: 1.4%
Type3: 300-700 µm	raw ash: 13%
	water content: 10%

Box 1 : Information on dry feed used in experimentation

Feeding took place five times daily (08.00, 11.00, 14.00, 17.00 and 20.00). With respect to *Artemia*, dry cysts were weighed out, hydrated for one hour in freshwater before being placed in 30ppt. artificial salt water with constant aeration and light (water temperature ca. 29ºC). Incubation of *Artemia* started at around 14.00 and the newly hatched larvae were ready for harvesting for the first feeding the following day. Samples of the *Artemia* tapped from the hatching cones allowed concentration of hatched nauplii to be assessed. Equal amounts were added to all tanks that should receive *Artemia*. *Artemia* were fed to the perch larvae in excess. The amount of dry food was weighed for each meal, with the same amount of food being administered to each tank. After 14 days from the start of the experiment it was evident that relatively few larvae had survived on solely being fed dry feed. Therefore, in this group the amount of Nippai given to the tank was reduced in order to avoid compromising water quality.

Water quality was monitored during the whole rearing process. Temperature started at 15°C and then was raised during the culture period to 20°C. Salinity remained at 0 ppt. Oxygen concentration was held above 8mg l^{-1} with the use of constant aeration and a water flow of

12,5l minute^{-1}. Nitrogenous waste products (NH_3, NO_2^-, and NO_3^{2+}) were monitored three times weekly. These were held below negligible levels during the entire rearing period. Daily siphoning of the tank walls and floor to remove dead larvae and waste food was essential. All siphoned water was placed in a white bucket so that any larvae inadvertently siphoned could be returned to the respective tanks.

Fifteen larvae were sampled from siphoned larvae. Sampling took place before feeding. These samples were then frozen at -30°C before being transferred to Danmarks Fiskeriundersøgelser, North Sea Centre for weighing and measuring.

After 19 days post hatch, cannibalism was observed in several tanks. At this point the experiment was ended. All postlarvae were counted. Percent survival could be calculated from initial stocking and final numbers counted at the end of the larval rearing period. From the final numbers produced cost per larvae could be calculated by dividing the total cost of food used per tank by the number of weaned individuals produced.

RESULTS AND DISCUSSION

Results on growth are presently being analysed and will be included in the DFU report when finished.

Table III summarises the number of individuals and the percent survival for the different larval feeding strategies used along with the cost to produce each larvae with that particular feeding regime.

It was observed that some survival was possible with feeding dry feed only although survival was low (5-7%) compared with the other feeding strategies where live feed was also used (25 – 85 %). From personal observation most of the deaths occurred within the first two weeks.

Table III: Number of weaned postlarvae remaining, % survival and cost to produce perch fingerlings using 5 different feeding strategies using live feed (*Artemia salina*) and Dry feed (Nippai), Bornholms Lakseklækkeri, (May 2004).

Group:	**1**		**2**		**3**		**4**		**5**	
Food: Day 1-9	**Nippai**		**Nippai + *Artemia***		***Artemia***		***Artemia***		***Artemia***	
Food: Day 10-26	**Nippai**		**Nippai + *Artemia***		**Nippai + *Artemia***		**Nippai**		***Artemia***	
No. survived	561	854	9453	4583	5697	5758	5547	2755	4839	4648
% survival	5.1	7.8	85.9	41.7	51.8	52.3	50.4	25.0	44.0	42.3
Cost of food used (€)	15.49	15.49	56.83	56.83	64.44	64.44	39.82	39.82	83.03	83.03
Cost of food per weaned larvae(€)	0.03	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02
Cost of food per. weaned larvae (kr.)	0.21	0.13	0.04	0.09	0.08	0.08	0.05	0.11	0.13	0.13
Cost of el., heat, water etc. (kr.)	759.30	759.30	759.30	759.30	759.30	759.30	759.30	759.30	759.30	759.30
Cost of labour (kr.)	2500	2500	2500	2500	2500	2500	2500	2500	2500	2500
Total cost per. larvae (€)	0.81	0.53	0.05	0.11	0.09	0.09	0.09	0.17	0.11	0.11
Total cost per. larvae (kr.)	6.01	3.95	0.39	0.80	0.66	0.65	0.64	1.29	0.80	0.83

The main cause of these deaths was most likely starvation. This can be supported by observations of 100% mortality after a starvation period of 13 days for unfed larvae from the same spawning batch held in the laboratory (Tamazouzt *et al*. 1998 observed 100% mortality due to starvation after 10 days post hatch). Those that survived could be the larger individuals (possibly those that hatched out first) feeding on smaller individuals and supplementing their diet with dry feed. Stomach content was not one of the parameters studied in this experiment. The survival observed in the present study is higher than obtained by Dryer (1987) and Awaiss *et al*. (1992) who observed survival of 4% within 10 days of hatching. It is also possible that particle size and or contents of dry feed and its residence time in the water column may determine survival of larvae. Tamazouzt *et al*. (1996) observed maximum survival of 25% up to day 15 post hatch feeding dry feed to perch larvae using particle size 80µm -125µm. The cost of production (0.53 -0.81€ per larvae) suggests that feeding exclusively with dry feed is not economically feasible. Yet even when dry feed is significantly cheaper than *Artemia*, the relative costs of labour and equipment to the total operating costs is so high that the disadvantage of the lower survival outweighs the advantage of a lower feed cost. This balance may change when production systems are technically optimized.

When considering the cost per larvae in terms of food, this experiment revealed that sparing *Artemia* with the use of dry feed during larval rearing was a worthwhile strategy, where the sparing of *Artemia* with dry feed proved to half the cost of feeding. However, in this instance, overall drift

revealed that food is only a small percentage of total expenditure (3.7%). In Denmark, manpower is the most demanding cost to absorb in the price of larvae. *Artemia* are time consuming to produce but the time taken to weigh out dry feed was as time consuming as weighing out *Artemia* cysts and starting up the culture tanks to produce the *Artemia*. However, in a scaled up production the use of both *Artemia* and dry feed combined might double up on time resources. The majority of manpower costs were attributed to cleaning tanks on a daily basis. On average two hours were required to siphon out debris, regardless if the larvae had been fed dry feed or live feed.

Of the mixed dry feed and *Artemia* strategies, the combination of dry feed and *Artemia* from the start of feeding gave the highest survival and therefore cheapest production costs per post larvae. However, the results proved to be more consistent when *Artemia* and dry feed in combination commenced after day 10. Average operating cost of producing larvae was calculated to be around 0.10€/fish where Artemia or Artemia/ Nippai strategies were used.

Cuvier-Peres and Kestemont (2002) have showed that intestinal and pancreatic enzymes are fairly well developed early in larval development and there is no reason why dry feed could not be fed earlier in larval rearing, as long as the vital lipids EPA and DHA are present in sufficient amounts to support optimal larval development and growth (Abi-Ayad *et al*., 2003). Possibly trials on other starter diets including investigation into varying particle size and nutritional content may result in better survivals.

The total cost of larvae in this study included those juveniles that may also be lacking swimbladders. In juvenile production these would be sorted out at the time of transfer from hatchery to nursery facilities at about 0.5g size. Failure to inflate swimbladders can account for up to 40% of all fish. Thus the price per "good quality" larvae could be higher. The current market price for perch fingerlings is around 0.5 € although it is expected that the price can be reduced to 0.15€ per larvae in a commercial production scenario. In an EU project to develop the culture of perch (FAIR project), the cost of production of larvae in ponds was compared to the cost in recirculated water systems. Including depreciation of plant and facilities over 15 years, the cost to produce fingerlings in ponds was calculated to be much cheaper (0.02€/fish) compared to fish produced in recirculation (0.10 €/fish). However, the indoor recirculation provided consistently high quality fish that were completely weaned onto dry feed. Moreover, the certification of disease

free fish is possible with indoors recirculation, and with heated water systems combined with out of season or delayed spawning, a constant supply of juveniles all year round is more likely to be achieved with a recirculated water indoor system.

CANNIBALISM

Cannibalism was observed in both larval rearing years (2003 and 2004). Signs of cannibalism include the obvious damage to the caudal fins, half eaten larvae and active hunting after other smaller larvae in the tank. Other signs are black faeces on the bottom of the tank (compared to the orange brown colour of faeces from larvae feeding off *Artemia* and dry diet). During sorting, cannibalistic fish are easy to identify and remove. Their body form is elongated and torpedo shaped. They are also significantly larger than the other larvae and their gut is black in colour (when observed through the body wall). In 2004, the first cannibalistic fish were noticed 11 days after hatching, a significant number by day 13 after hatching (see figure 9). Although a study was not made to accurately record cannibalism, most frequent attacks on other larvae were observed in those tanks where the fish were fed on exclusively *Artemia*.

At Bornholms Lakseklækkeri, cannibalism was also observed in juvenile fish, particularly where there was a noticeable variation in size. Cannibalistic fish remain close to the bottom of the tank and prey on the others from below, particularly at feeding time where the smaller fish are distracted by food entering the tank. Thus grading is of vital importance in perch culture in order to avoid dramatic losses due to cannibalism.

Cannibalism is a significant problem for many cultured species. Cannibalism usually occurs where there is heterogeneity in size of fish, the stocking density is either too low or too high and food resources are lacking or difficult to catch/handle.

Our observations similar to reports in the literature where Kestemont *et al*. (2003) observed cannibalism around 10 days post hatch, where up to 50% losses were reported from this point and two weeks following. Baras *et al*. (2003) observed so called type I cannibalism (i.e. tail biting and incomplete consumption of prey) from day 10 to day 16 post hatch where larvae attacked their prey tail first. This type of cannibalism caused 2% losses. From day 12 post hatch and onwards cannibals

switched to total consumption of their prey, ingesting their prey head first (type II cannibalism). This caused greater losses (up to 53% of stock).

Methods used to avoid and reduce cannibalism include, holding larvae togther from the same hatching date and same eggstring (Hey *et al*., 1996), early grading of post larvae (removing those individuals that have cannibalistic behaviour and are significantly larger than other post larvae, improved diets of the appropriate partical size and feeding technique (frequency of feeding). Reducing water clarity using clay particles has also been proved successful during the rearing of Walleye juveniles (Bristow *et al*., 1996).

Figure 9: Cannibalism of perch larvae 19 days post hatch, Bornholms Laskeklækkeri, May 2004

NON-INFLATION OF SWIMBLADDER (NSB)

Although no measurement was made on the percentage of weaned juveniles that had non-inflated swimbladder, it was noted that a significant proportion of juveniles produced in some tanks had this condition. It is also important to note as one of the main challenges faced in perch production. As with most hard spined fish species, perch have a small window of opportunity to inflate their swimbladders. This takes place during the larval stage, just after yolk sac absorbtion. Air is gulped from the surface and forced into a temporary opening (the pneumatic duct) into the swimbladder. This duct is closed permanently 6-12 days after hatching. Failure to inflate the swimbladder can be due an oily film or barrier on the water surface restricting the larvae's access to air or due to bacterial infection of the lining of the swimbladder (bacterial aerocycstitis) from heavy bacterial loading in the water or on the water surface (Sommerfelt, 1996). NSB results in mortality, larval deformity (lordosis or stunting), slow growth and increasing susceptibility to cannibalism. Fish without swimbladders cannot maintain their position in the water column and therefore must constantly swim to stop them from sinking, making it difficult to feed and requires significant energy reserves. However, in aquaculture NSB fish can survive to adulthood, if they are not graded out.

CONCLUSIONS AND RECOMMENDATIONS

1. The Danish strain of freshwater perch are able to feed on small strain *Artemia* directly after hatching. Therefore the use of rotifers for the first three days of feeding could possibly be avoided from the larval rearing process. The role of rotifers in larval production of perch should be investigated further.
2. Differences in larval size and stage of development between geographic locations may account for the differences in ability to eat live feed of different sizes. Comparisons of these parameters with respect to larval performance are important in terms of strain selection.
3. It is possible to produce juveniles without the use of live feeds. However, the low survival rates mean that this strategy is not economically viable at the moment.
4. However, it is possible to reduce or shorten the period of live feeding by sparing with dry feeds. Combination of *Artemia* and dry feed reduces the feed costs by 50% and improves survival to weaning.

5. Cannibalism is a significant cause of mortality especially from day 13 after hatching. Early grading of post larvae and increased feeding frequency with a dry diet that has the right nutritional content and correct particle size is important in order to reduce losses due to cannibalism to a minimum. Analysis of particle size and larval nutrition with respect to reducing cannibalism still needs to be investigated.
6. The majority of operating costs were due to the time required to keep the tanks clean. With better technology and tank design these costs could be reduced.
7. Production of larvae is a viable option for farmers as long as there is a demand for perch fingerlings for further ongrowing. A production cost of 0.10€/fish should be achievable in the coming years.

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