Ongrowing of Perch (*Perca fluviatilis*) Juveniles

(Videreopdræt af aborreyngel)

by

Julia Lynne Overton & Helge Paulsen

Danmarks Fiskeriundersøgelser
Afdeling for Havøkologi og Akvakultur
Bornholms Lakseklækkeri
3730 Nexø
ISBN: 87-90968-85-9 DFU-rapport 151-05

CONTENT

ONGROWING OF PERCH JUVENILES

Introduction

Ongrowing of perch has traditionally taken place in outdoor ponds and reservoirs under an extensive polyculture system (Tamazouzt *et al*., 1993). However, conditions for more intensive aquaculture of European perch have been investigated over recent years (Melard *et al*., 1995, 1996). With regards to yellow perch culture in the United States, the interest has always been with earthen pond culture (Malison *et al*., 2003). Large areas of relatively cheap land make it possible to undergo such a culture strategy. With European perch, particularly in countries where land is expensive and/or building on green sites is restricted, studies have been conducted looking at alternatives to pond culture such as cage culture (Fontaine *et al*., 1996) and the use of warm effluent water to grow perch. In recent years, interest has also extended to recirculation systems. The advantages that promote the use of recirculation include the possibility to contain and further treat waste products, to provide optimal growing conditions all year round and the ability to reduce the impacts of disease with the recycling and treatment of incoming water (Melard *et al*., 1996).

A demonstration of ongrowing of Eurasian perch in recirculation systems was carried out at Bornholms Lakseklækkeri during 2003 and 2004. The main objective was to measure and record growth performance and health status of fish under production.

As yet no commercial diet has been produced for perch; therefore ongrowing experiments using commercial diets currently available with varying lipid content took place in 2004.

ONGROWING 2003

In 2003 the nursery phase of production (i.e. from weaned fish to 1.5g juveniles) took place in section 4. After a period of weaning from *Artemia* to dry formulated feed, the juvenile perch were fed a cod diet (Dan-EX 1362, Danafeed A/S). Pellet size was increased from 0.4mm (between 29th May and 2nd June) to 0.6mm (six days later), 1.0mm (23 days later) and finally to 1.3mm diet (combined with 1mm diet). Due to a modest number of individuals surviving to weaning and a restricted number of tanks, grading did not take place. However this resulted in cannibalism having a detrimental effect on survival.

Juveniles from Tange I, Guldager I, Tange II, Guldager II, Guldager IV groups and large fish from the Guldager IV group were graded by hand on 29th July 2003 and thereafter transferred from section 4 to section 2b of the hatchery for ongrowing. Each group was placed in a 2x2m fiberglass tank (volume = $4m^3$), except for Guldager IV, where all fish were stocked in a 3m diameter circular tank (volume = $7m^3$). On 26^{th} November 2003, the Guldager IV group was divided into two 3m diameter tanks (total volume = 14 m^3) . Number of individuals, average size and stocking density are shown in table 1.

Food was calculated as percentage of body weight (bw). Dan- Ex 1362 (Danafeed A/S, Crude protein = 62%, Crude lipid = 13%, Carbohydrate = 7%) was used up until 1.8mm and then food type was replaced by Dan-Ex 1344 which is produced in larger pellet sizes (Danafeed A/S, Crude protein = 44%, Crude lipid = 13%, Carbohydrate = 25%). Percentage of body weight food fed and feed conversion ratio according to fish size is summarized in table 2.

Table 2: Fish size, % body weight food fed, feed conversion ratio used to calculated food for perch juveniles, Bornholms Lakseklækkeri, 2003.

Fish weight (g)	**% food fed**	**Food conversion ratio**
5-20	5	1
20-25	3	1.3
25-50	2	1.5
50-70	1.5	1.6
>70	1	1.7

Table 1: Summary of initial and final number of individuals, average body weight (g), total weight (g) stocking density and final density (fish m^{-3} and kg m^{-3}) for perch juveniles moved from section 4 to ongrowing facility (section 2b). Feed conversion efficiency and specific growth rate (SGR) are also included.

Group	Guldager I	Tange I	Guldager II	Tange II	Guldager IV	Guldager IV (stor)
Hatching date	01.05.03	02.05.03	10.05.03	09.05.03	19.05.03	19.05.03
Transfer date	22.07.03	22.07.03	24.07.03	29.07.03	15.09.03	29.07.03
Nr. of Individuals	32	210	967	838	1410	44
Total weight (g)	248	1688	3364	3332	19307	675
Average body weight (g)	8.690	8.040	3.480	4.100	13.693	15.340
Stocking density (fish m^{-3})	16.0	105.0	483.5	419.0	199.4	22.0
Stocking density (kg m^{-3})	0.12	0.84	1.68	1.67	2.73	0.34
Date	22.12.03	22.12.03	15.09.03	15.09.03	22.12.03	22.12.03
Days from transfer	153	153	55	55	93	146
Nr. of individuals	25	180	794	963	1373*	39
% survival	78.1	85.7	94.7	99.5	97.4*	88.6
Average body weight (g)	135.000	76.940	22.364	17.429	72.110*	126.540
Density (fish m^{-3})	12.5	90.0	397.0	481.5	97.1*	19.5
Density (kg m^{-3})	1.69	6.93	8.88	8.39	7.00*	2.47
Food conversion ratio	1.58	1.70	1.03	1.43	1.84*	1.87
Specific growth rate (% bw d^{-1})	1.72	1.39	3.09	2.97	1.25*	1.37

* Data averaged from two tanks

The fish were fed to satiation. If feed spill was observed the feeding percentage was cut down the following day. Once the fish reached 75g, feeding everyday was altered to feeding very second day. This feeding strategy resulted in enough food administered to overcome any dominance by large fish over the feeder and allowed the fish a resting period for full digestion of food eaten.

Although optimal temperature for perch production has already been established to be 23°C (Melard *et al*.. 1995), water temperature was held at 20°C. This temperature proved easier to hold constant and the problems of *Saprolegnia* spp. infection was reduced markedly. Salinity was 0ppt (freshwater). Water was recycled with less than 3% exchange with new water per week. Concentration of ammonia, nitrite and nitrate were measured three times weekly. Oxygen concentration was monitored on a daily basis. Constant summertime day length was applied with L16:D8 as suggested by Huh *et al*., (1976) as optimal for growth performance in perch.

In order to monitor growth performance, the bw of the fish was measured every two to three weeks up until 4th February 2004 (i.e. 197 days after transfer to ongrowing). In the case of Guldager II and Tange II groups, an accident on 15th September 2003, where oxygen deficit resulted in substantial deaths, monitoring of ongrowing performance was halted from 55 days after transfer.

<u>Results and discussion</u>

Table 1 summarises the result obtained during the ongrowing of perch juveniles from july until December 2003. Survival was shown to be fairly good with 70 to 99% survival over the monitoring period for all perch groups. However from most groups, it was noted that recorded deaths were large individuals (bw over 200g). On investigation, it was found that the abdominal cavity of these fish was filled with perivisceral fat. Water quality and investigation of bacterial, viral and parasitic causes for death were not founded. The unknown cause of death is believed to be due to over eating and exerted pressure on the liver to process and store substantial amounts of lipid, even with the use of a relatively low fat fish feed. The switch to feeding three times weekly instead of everyday reduced the deaths observed. Aspects of fat deposition in perch were further investigated, specifically the allocation of lipid in cultured versus wild perch according to season (Mia G. Larsen and Katrine B. Hansen, Projekt arbejde, 2004) and the effects of starvation on lipid deposition (the samples from these experiments are presently being analyzed).

Figure 1 shows the growth curve according to average weight (bw) of fish against days from hatching.

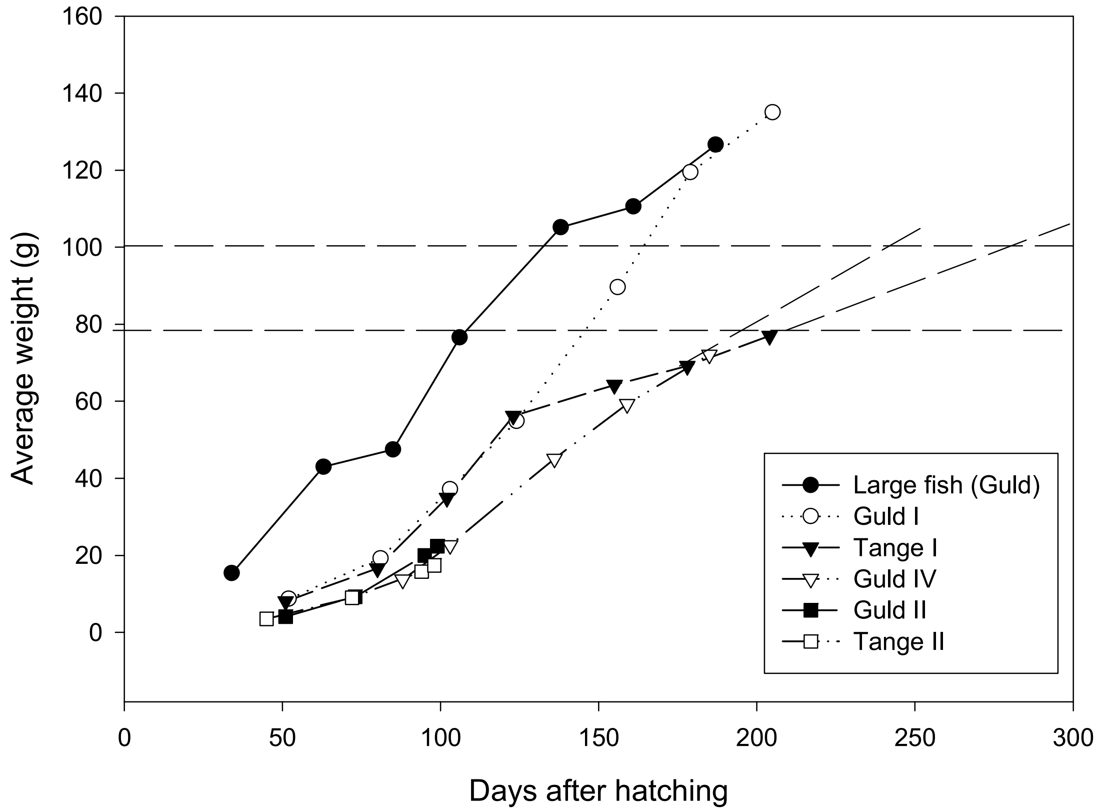


Figure 1: Growth for groups of perch juveniles (section 2b), Bornholms Lakseklækkeri, 2003/04.

Fish from groups Guldager I and Guldager IV (large fish) revealed similar growth patterns during the last part of the experiment. In both these groups the stocking density was extremely low (32 and 44 fish, respectively). From observation it is most probably the large fish that also survived to ongrowing in Guldager I group (the smaller individuals being subject to cannibalism). The fast growing individuals in these two groups exhibited growth rates of 3% bw d^{-1} through the monitoring period, reaching commercial size by 100 to 150 days after hatching (around 5 months). Growth rates in these two groups reduced when the mean bw of fish reached 120g to around 0.22-0.92 % bw d^{-1}.

Tange I and Guldager IV groups (stocking densities 210 and 1410 individuals, respectively) showed similar initial growth and comparable to Tange II and Guldager II groups before day 110 after hatching. Between 50 -60 g average size the growth rate started to subside from 2.6% to 2.0% bw d^{-1}. Total SGR (calculated using equation 1 page 19) reduced to 1.5% by 60 g average weight due to periods of low SGRs for the Tange I and Guldager IV groups (even after reducing the stocking density in the latter group). Therefore, under higher, more realistic stocking densities, the growth of perch to commercial size (80 to 100g in the Swiss market) takes from 200 to 215 days from hatching (80g fish) to just under 300 days post hatch for 100g fish. This means that one production cycle can be achieved in less than a year at a constant water temperature of 20 °C .

Food conversion ranged from 0.8 to 1.75 at beginning of ongrowing but rose to over 3.0 by 6. October 2003. The decrease in feed conversion efficiency followed the decrease in growth rate. There was no relationship found between food conversion ratio and stocking density of fish.

EFFECT OF STOCKING DENSITY ON GROWTH PERFORMANCE OF EURASIAN PERCH IN RECIRCULATED SYSTEMS.

In order to understand the effects of stocking density on the survival, mean growth, total production and variation in growth rates for Eurasian perch an experiment was conducted with three stocking densities.

Fourteen hundred 80-day old fish were graded (removing all fish over 10g i.e. fast growers and potentially cannibalistic individuals). Size range at stocking was from 1.6g to 9g. (Average bw 5g). The fish were transferred to 580l cylindroconical tanks at three stocking densities of 138, 245 and 357 fish per tank (refer to table 3 for details on stocking density and average weight etc.).

Table 3: Numbers of individuals, weights and stocking densities for three densities of perch reared in recirculated systems

Density	**Low**		**Medium**		**High**	
Number	138	138	245	249	357	357
Total weight (g)	946	826	1168	1064	1506	1523
Average bw (g)	6.86	5.99	4.78	4.27	4.22	4.27
Density (fish m^{-3})	276	276	490	496	714	714
Density (kg m^{-3})	1.89	1.65	2.34	2.13	3.01	3.01

Water temperature was held constant at 20 °C . Salinity was 0ppt and pH was between 7 and 8. Ammonia and nitrite concentrations were measured three times weekly. Maximum levels measured were of 0.1mg/l and 0.198mg/l, respectively.

The fish were fed 2mm Dan-EX 1344 starting at 5% bw d^{-1} reducing to 3% bw d^{-1} by the end of the experiment. Total length (cm) and bw (g) were measured on individual fish. Survival, growth rate, food conversion efficiency, median and variation in length and weight were assessed.

Due to skewness, the data set failed the test for normality. Thus comparisons between tanks for median length and weight were carried out using the non-parametric Kruskall-Wallis one way analysis of variance on ranks. A multiple pair wise comparison between tanks was carried out using Dunn's method.

Results and Discussion

High survival was obtained in all tanks (81.9-99.4%; table 4) regardless of stocking density (1.6 – 3kg m^{-3}). However, a trend of improved survival with increase in stocking density was observed, with the best overall performance observed in the highest stocking density. Feed conversion and specific growth rates were also better for fish stocked at higher densities. Improvement in survival, food conversion efficiency and growth rate with increased stocking density has also been recorded for perch reared in cages (Fontaine *et al*., 1996), in flowthough systems and recirculated systems (Melard *et al*., 1996). It has been suggested that this increased performance with higher stocking densities is due to reduced stress (young perch shoal in the wild as a survival strategy therefore high densities reduce stress levels in fish). Moreover, increased densities may suppress any aggressive or territorial behaviour; with more individuals close together it is harder for those with cannibalistic tendencies to single out individual fish to prey upon. However, it has also been shown that once perch are over 20g mean weight, higher densities have a negative influence on growth rates (Melard *et al*., 1996a).

Plots of frequency for total length (cm) and wet weight (g) are shown in figures 2a-c and 3a-c. The low density group revealed a larger standard deviation for both length and weight than in the middle and high density groups (table 5). However when calculated as the coefficient of variation (CV) , there is no obvious differences in CV for length and weight related to density, therefore stocking density at the levels chosen in this experiment does not have any role in the variation in growth of individuals in this instance.

Table 4: Results of final weight (g), survival (%), food conversion ratio (FCR) and specific growth rate (SGR) for three densities of perch juveniles reared in a recirculated system.

Density	**Low**		**Medium**		**High**	
Initial weight (g)	946	826	1168	1064	1506	1523
Final weight (g)	1763	2317	2827	3238	4470	4720
% Survival	81.9	99.3	91.4	96.4	99.4	95.5
FCR	2.46	1.42	1.60	1.16	1.07	1.03
SGR (% d^{-1})	1.36	2.27	1.94	2.45	2.39	2.49

Comparison of length revealed no significant difference between replicates, and therefore data was pooled and reanalyzed. Results showed that the larvae at the lowest stocking density (137 individuals starting density) were significantly larger ($P \leq 0.05$) than the medium and high stocking densities. There was no significant difference in length between medium and high stocking densities.

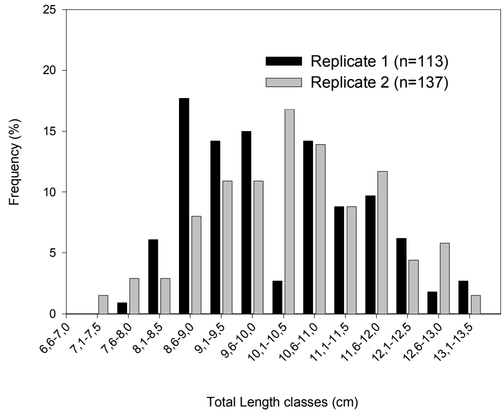
The analysis of mean fresh weight revealed significant differences between replicates of the highest density groups and thus data could not be pooled in this instance. There was no obvious trend related to density according to fresh weight (refer to table 5 for pairwise significant differences between tanks). This obscure result could be explained by the fish being composed of two sexes. Perch have an early sexual differention (Zelenkov, 1981) where females can grow up to 20% faster than males (Malison *et al*., 1988). Moreover, recirculation systems have been shown to promote sexual dimorphism (Fontaine *et al*.. 1996). High constant temperature inhibits the females' ability to put energy into gonadal development and instead transfers this energy to somatic growth and fatty deposits. Male perch however can continue their gonadal development even through constant temperature and light conditions. Thus if the percentage of males to females was in some way not equal in replicate tanks then this dimorphism might obscure the results. Another cause for the results obtained could be due to social interaction within the tanks. Research has shown that with grading out larger fish there is a sudden surge in growth of smaller fish (Melard *et al*., 1995) which suggest that a form of social interaction exists.

With the type of tanks used (cylindroconical tanks) the surface area for food dispersal is limited and thus any large fish will dominate the feeder, resulting in an inequality in muscle growth and fat deposition between fish. The effect of stocking density would be interesting to examine with monosex groups of perch and with a more restricted weight class.

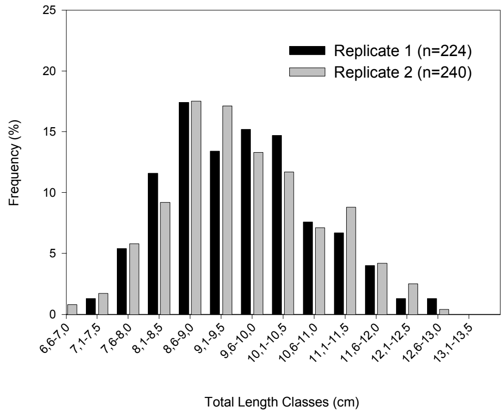
Table 5: Means, ranges, standard deviations (SD), coefficients of variation (CV) of total lengths (cm) and weight (g) for perch reared at three densities in a recirculated system.

Density	**Low**		**Medium**		**High**	
Mean length (cm)	10.181	10.445	9.642	9.641	9.532	9.768
Range: Min	7.9	7.4	7.2	6.9	6.9	7.1
Max	13.2	13.3	12.8	12.7	13.3	13.4
± S.D.	1.336	1.331	1.158	1.201	1.236	1.054
CV (%)	13.1	12.7	12.0	12.5	13.0	10.8
Mean weight (g)	15.603$^{e.f}$	16.913$^{a.b.c.d}$	12.622$^{b.f}$	13.490^{c}	12.590$^{a.e.g}$	13.870$^{d.g}$
Range: Min	6.7	4.9	4.6	4.1	4.4	5.7
Max	38.3	37.0	29.3	31.3	36.9	37.8
± S.D.	6.503	6.921	4.923	5.531	5.844	5.654
CV (%)	41.7	40.9	39.0	41.0	46.4	40.7

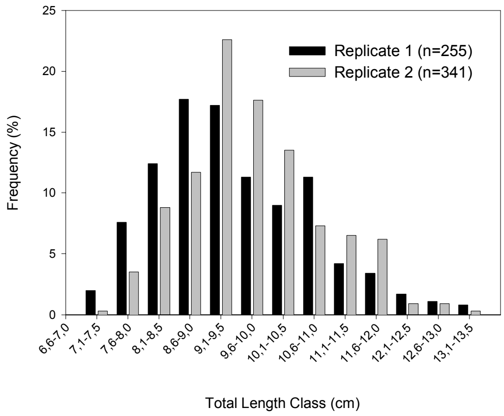
Pairs of superscript letters denote significant ($P \leq 0.05$) difference in weight between those groups.



a) Stocking density ca. 138 individuals

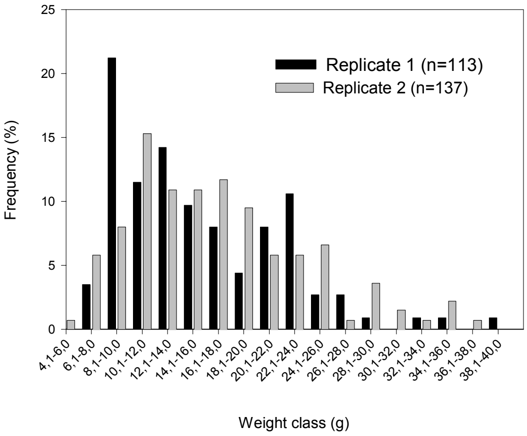


b) Stocking density ca. 245 individuals

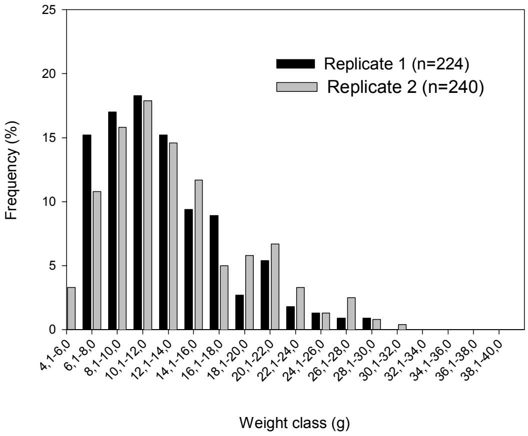


c) Stocking density ca. 357 individuals

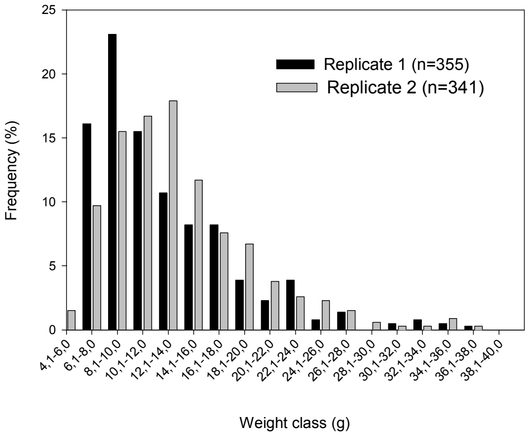
Figure 2: Frequency of final total length classes for Eurasion perch juveniles stocked at a) 137 b) 245 and c) 357 individuals per 500l, Bornholms Lakseklækkeri, Nexø, 2003.



a) Stocking density 138 individuals



b) Stocking density 245 individuals



c) Stocking density 357 individuals

Figure 3: Frequency of weight (g) classes for Eurasion perch juveniles stocked at a) 137 b) 245 and c) 357 individuals per 500l, Bornholms Lakseklækkeri, Nexø, 2003.

ONGROWING 2004:

Nursery phase.

After the larval rearing period (26 days post hatch) and weaning period (completed on 1st June 2004, i.e. 32 days post hatch), a nursery phase of 40 days commenced. Perch juveniles were fed 12% bw d^{-1} with a mixture of Nippai® Size 2 and 3 and Dan-Ex 1362 0.4mm granulate to accommodate the particle size requirement of the substantial size variation between individuals. Cannibalism was held to a minimum by feeding the larvae every 15 minutes using automated spinwheel feeders (Torp aquateknik. Denmark). The last signs of cannibalism were seen on 5. June 2004 i.e. 23 days after the first signs of cannibalism were observed.

From 38 days post hatch, (i.e. 10 days into the nursery phase) the weaned fish were transferred from section 4 to section 2b of the hatchery. Each group was transferred to 2m x2m (volume = $4m^3$) tank. Water quality was held at the same conditions as for 2003. Feeding was continued with Dan-Ex 1362 1mm at 12% bw gradually reducing to 6% over a period of two weeks.

Table 6: % survival, average weight, final density, food conversion ratio (FCR) and specific growth rate (SGR) for juvenile perch after the nursery period, Bornholms Lakseklækkeri, July 2004.

Larval rearing group	***Artemia* (d 1-23)**	***Artemia* + Nippai (d 1-23)**	***Artemia* (d 1-9) Nippai (d 10-23)**	***Artemia* *(d 1-9)* *Artemia* + Nippai (d 10-23)**
Number of individuals	8992	12 963	7 820	11 033
% Survival	94.8	92.3	94	96.3
Average weight (g)	1.7	1.3	1.4	1.4
Total weight (kg)	15.853	17.474	11.073	15.755
Density (nr. fish m^{-3})	3876	5587	3371	4756
Density (kg m^{-3})	6.8	7.5	7.8	6.8
Food conversion ratio	1.02	1.08	0.93	1.06
Specific growth rate (% d^{-1})	5.14	5.25	5.24	4.84

Table 6 shows that % survival for all groups was high (92.3 – 96.3). There was no relationship found between % survival and stocking density of fish per tank. Food conversion ratios were considered to be very good (0.93 to 1.08) and were inversely proportional to density and specific growth rate. Specific growth rates ranged from 4.84 - 5.25 % bw d^{-1}.

After the nursery period, all juvenile fish were graded into three sizes; large (3g), medium (2g) and small (1g) by pumping fish directly from the tanks into an automated grader (Giovanni Milanese s.n.c., Italy) to reduce handling with nets, which can cause abrasive damage to the fish. 13 500 medium size fish were retained at the hatchery for feeding experiments. The remaining fish were transported to commercial ongrowing facilities (large and medium size) and for research purposes (small size).

<u>FEEDING EXPERIMENT 2004</u>: The effect of commercially available diets on the growth and fatty deposition in juvenile perch reared at two temperatures.

<u>Introduction:</u>

Within Aquaculture, research into fish nutrition and in particular the development of diets to provide the best production at the most economical price has been of the utmost importance. Energy sparing, i.e. the use of lipid in fish diets to provide energy for metabolic energy needs thus sparing protein for conversion to muscle block, has been a useful tool to improve protein conversion efficiency and reduce costs of fish diets (Xu *et al*., 2001)(protein being one of the most costly ingredients in fish food, Fiogbe *et al*., 1996). Within Eurasian perch nutrition studies, some conflicting evidence has been observed with high lipid diets. Experimental diets with high lipid content have been shown to improve growth rate, food conversion and protein utilization and at the same time be responsible for impaired growth and unknown mortality in larger cultured perch (Kestemont *et al*., 2001). Moreover, unlike salmonids which store excess energy as lipid within the muscle block (Jobling and Johansen, 2003), perch store the excess energy as fat within the adipose tissue that surround the gut and within the liver. Moreover, perch have been shown to be particularly sensitive to oxidized fats causing pathological intracellular damage to the liver (Kestemont *et al*.2001). The increase in fat deposition in the body cavity also results in a reduced filleting yield although it is believed not to have any detrimental effect on flesh quality (Matthis *et al*., 2003).

As yet, there is no commercial diet produced for perch. Therefore, in order to find the best diet for perch that is currently available on the market, three commercially produced diets with varying lipid content were tested on perch in terms of survival, growth, food conversion and lipid storage.

As yet, there is not much information on the effect of water temperature on the level of fat deposition in perch fed commercial diets. Thus it was decided to test the effect of optimal temperature (20 °C) and suboptimal temperature (16 °C) both on growth performance and fat deposition in juvenile perch.

Materials and methods:

Ongrowing experiments took place in two recirculating systems (sections 1b and 4) at Bornholms Lakseklækkeri from July until December 2004. The ongrowing experiments were divided into two shorter experiments; the first stocking with 2-5g fish and feeding 1.2-1.3mm diet. the second with 14- 20g fish fed 1.8 -2.0mm diet.

Two water temperatures were examined. In section 4, water temperature was held at 20°C (i.e. the optimum temperature for rearing perch at Bornholms Lakseklækkeri). In section 1b the temperature was held constant at 16 °C (the optimum rearing temperature for cultured salmonids, Shepherd and Bromage, 1988).

During the first feeding experiment, 9000 juvenile perch (average size 2g) were divided into nine 1x1m^2 plastic tanks in section 1b (volume = 500l. Average stocking density = 4.4kg m^{-3}). In section 4, 4500 juvenile perch (average size 5g) were divided into nine 500l circular tanks (average stocking 4.5kg m^{-3}).

Due to size heterogeneity, at the end of the first experiment, the fish were graded. The remaining fish were mixed together for a further ongrowing experiment. Four thousand five hundred fish (average size 14g) were divided into nine tanks in section 1b with 500 fish in each tank (stocking density 14kg m^{-3}) and 2250 fish (19 g) were divided between nine tanks in section 4, with 250 fish per tank (stocking density = 8.5kg m^{-3}).

For both feeding experiments, the nine tanks were further divided into three treatments (three tanks per treatment). For the first experiment all treatments were fed a commercially available diet starting at 5% bw d^{-1} and reduced to 3% when food spillage was noted. In the second experiment, feeding commenced at 2.5% bw d^{-1}. Food was delivered to the fish using automated spin feeders that were calibrated to deliver the same amount of feed in each tank. Feeding took place every half an hour over an eight hour period.

For both experiments, three commercially produced diets were chosen for comparison. In the first experiment, all the diets had a similar % crude protein content and protein/energy ratio but varied in levels of crude lipid and carbohydrate (both lipid and carbohydrate combined made up 30 % of the diet). In the second experiment with larger fish, the diets varied in lipid percentage and also in protein to energy ratio. Dan-Ex 1352 was not available in a larger pellet size and therefore was replaced with Dan-Ex 1362. The following diets were chosen (refer to table 7 for more detailed information on diet contents).

Dan-Ex 1352 (Danafeed A/S): this diet is produced for cod and was used in 2003 perch experiments at Bornholms Lakseklækkeri, providing satisfactory growth results. This diet is produced in granulate form and contains 13% crude lipid i.e. lower lipid levels than in standard trout diets, and 52% protein.

Dan-Ex 1362 (Danafeed A/S). This diet has the same lipid content as for Dan-Ex 1352, but contains 62% protein.

Dan-Ex 1051 (Danafeed A/S): A low fat, high carbohydrate diet formulated for carps and tilapia. The diet contains 10% crude lipid and 51% protein and is produced in a granulate form.

Bio-Optimal C80 (Biomar A/S): A diet primarily used for early rearing of salmonids. It has also been tested as a diet for Pike perch (*Stizostedion lucioperca*). This diet contains 20% crude lipid at 1.3mm pellet. At 2mm pellet size protein levels are lower (52 % crude protein) and lipid content is higher (26% crude lipid) resulting in the lowest protein/energy ratio of all the diets tested.

Water quality parameters were measured three times weekly. Salinity was at 0ppt, pH was maintained between 7 and 8 and oxygen was constantly above 6mg/l.

Water in sections 1b and 4 was recirculated, with less than 3% water exchange a week. Dissolved waste products (Ammonia, nitrite and nitrate) were similar between both systems and were below any critical levels (ammonia < 0.01mg l^{-1}, nitrite: <0.1mg l^{-1} and nitrate <125mg l^{-1}). Day length was held at constant summertime conditions of 16L: 8D as suggested by Huh *et al*., (1976).

A total weight of the fish (to the nearest gram) was taken every two weeks. Mortalities were noted on a daily basis.

Percent survival, specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and coefficient of variation (CV) were calculated using the following equations;

$$\% \text{ survival} = \frac{N_f}{N_i} * 100$$

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

$$\text{FCR} = \frac{F}{W_f - W_i} \qquad (2)$$

$$\text{PER} = \frac{W_f - W_i}{P_f} \qquad (3)$$

CV= 100* SD/Mean

Where N_i represents initial numbers of individuals, N_f the final number of individuals, W_f the final biomass of fish, W_i the initial biomass, D the number of days, F the amount of food given and P_f the amount of protein given.

Table 7: Contents, according to producers specifications, of three commercial diets used in feeding experiments during ongrowing of perch juveniles at 16 and 20 °C . Bornholms Lakseklækkeri. 2004.

	Dan Ex 1352	Dan Ex 1051	Bio-Optimal C80	Dan Ex 1362	Dan Ex 1051	Bio-Optimal C80
Pellet size (mm)	1.2	1.3	1.3	1.8	1.8	2.0
Crude protein (%)	52	51	56	62	51	52
Crude lipid (%)	13	10	20	13	10	26
Carbohydrates (%)	17	19	9.5	7	19	10
Fibre (%)	1.4	1.5	0.6	0.8	1.5	0.2
Ash (%)	10.3	11	7	11.6	11.0	6.0
Totalt phosphorus (%)	1.4	1.4	1.2	1.6	1.4	0.9
Gross energy (kcal)	4921	4667	5473	5051	4667	5818
Digestible energy (kcal)	3921	3622	4428	3979	3622	4801
Protein:Energy ratio (mg kj^{-1})	25	26	25	29	25	22

For each feeding experiment, cumulative mortality (numbers of fish) was plotted against days after hatching in order to illustrate any pattern of mortality over the rearing period.

Significance in differences observed in final weight and specific growth rates according to feed type was tested using one way analysis of variance. Pairwise multiple comparison procedures were performed using the Holm-Sidak method. Differences were considered significant when $P \leq 0.05$.

At the end of the feeding experiment all fish were weighed and counted. Thirty fish were sampled from each tank and frozen prior to transportation to North Sea Centre, Hirtshals for further processing. This is still under way and results are therefore not included in this report. Sex, total length (cm), wet weight (g), gutted weight (g) and weight of fat deposited in the abdominal cavity (g) will be measured. Condition factor (K) (the relation between wet weight and total length) will be calculated.

Results and discussion:

Tables' 8a-b and 9a-b summarize the survival and growth performance for the two experiments during the ongrowing period carried out at 16 and 20 °C with three selected commercially produced feedtypes.

a) Survival

At 16°C, survival over the rearing period was high (92-99.2 %) in both experiments.. There appeared to be no difference in survival according to feed type. Plots of cumulative mortality over the rearing period (figures 4a and b) revealed that mortality was consistent over the rearing period for most tanks and that any increase in mortality was tank related and not feed related. The mortality observed in Tanks 1051-r1 and 1352-r2 in the first experiment and tank 1051-r1 during rearing of 14g fish was most likely due to their close proximity to the entrance of the rearing unit. Sudden disturbance particularly during routine morning activities in the hatchery may have stressed the fish resulting in increased mortality observed in these particular tanks.

At 20°C , higher mortality was observed than at 16°C particularly during the first experiment with stocking of small (5g) fish (71-90.2% survival). The initial mortality could be due to stress from the transferal process (figure 4c). It is observed that after sorting and starting the second feeding experiment the mortality is reduced and remains minimal during the rearing process (figure 4d). This mortality has no relation to stocking density. The mortality observed in the first rearing period (stocking 5g fish) is therefore most likely due to cannibalism due to heterogeneous growth which could be ascerbated at warm water temperatures. Moreover, the tank design in this section favours vertical structuring of fish in the tank and possibly encourages social hierarchy through a restricted surface access to feeding. Unknown mortality (i.e. fish missing from the tanks during final counting) was also recorded in tanks with the highest overall mortality at 20°C, which supports the cannibalism theory due to type II cannibalism involving complete consumption of smaller individuals.

Table 8: Results of ongrowing of perch juveniles at 16 °C using three feed types. Bornholms Lakseklækkeri (2004)

a) Stocking 2g individuals

Feed type	**Dan-Ex 1352**			**Dan-Ex 1051**			**Bio Optimal C80**		
Replicate	R1	R2	R3	R1	R2	R3	R1	R2	R3
Stocking density (kg m^{-3})	4.100	3.872	4.256	4.468	3.848	4.664	4.424	4.104	4.436
Survival (%)	94.6	96.8	99.3	92.4	96.2	96.4	95.7	97.9	99.3
Start average individual weight (g)	2.050	1.936	2.128	2.234	1.924	2.332	2.212	2.052	2.205
Final average individual weight (g)	11.442	11.885	12.393	10.500	9.978	10.790	13.162	12.919	13.535
Specific growth rate (% d^{-1})	2.09	2.21	2.12	1.88	2.00	1.84	2.17	2.21	2.18
Feed conversion ratio	1.75	1.57	1.72	2.05	1.90	1.45	1.68	1.68	1.60
Protein efficiency ratio	1.10	1.22	1.12	0.96	1.03	1.35	1.06	1.06	1.11

b) Stocking 14 g individuals

Feed type	**Dan-Ex 1362**			**Dan-Ex 1051**			**Bio Optimal C80**		
Replicate	R1	R2	R3	R1	R2	R3	R1	R2	R3
Stocking density (kg m^{-3})	14.832	13.064	13.700	15.120	13.180	15.252	14.700	14.402	14.184
Survival (%)	99.2	96.2	96.6	94.2	97.6	97.0	99.0	98.8	99.2
Start average individual weight (g)	14.832	13.064	13.700	15.120	13.180	15.252	14.700	14.402	14.184
Final average individual weight (g)	36.373	33.040	31.901	33.361	32.148	39.913	39.986	37.879	37.177
Specific growth rate (% d^{-1})	1.28	1.28	1.16	1.05	1.25	1.34	1.43	1.37	1.31
Feed conversion ratio	1.35	1.41	1.43	1.61	1.26	1.30	1.22	1.23	1.32
Protein efficiency ratio	1.20	1.14	1.13	1.22	1.44	1.51	1.58	1.56	1.46

Table 9: Results of ongrowing of perch juveniles at 20 °C using three feed types. Bornholms Lakseklækkeri (2004)

a) Stocking 5g individuals

Feed type	**Dan-Ex 1352**			**Dan-Ex 1051**			**Bio Optimal C80**		
Replicate	R1	R2	R3	R1	R2	R3	R1	R2	R3
Stocking density (kg m^{-3})	4.71	4.63	4.65	4.76	4.32	3.63	4.35	4.56	4.57
Survival (%)	71.0	83.2	80.6	79.0	75.4	90.2	83.6	78.6	84.0
Start average individual weight (g)	5.460	5.370	5.398	5.516	5.012	4.216	5.046	5.288	5.306
Final average individual weight (g)	19.794	18.858	17.146	15.711	15.265	11.951	19.268	19.280	17.736
Specific growth rate (% d^{-1})	3.36	3.37	3.01	2.72	2.90	2.71	3.50	3.37	3.14
Feed conversion ratio	1.60	1.32	1.30	0.98	1.78	1.44	1.24	1.13	1.20
Protein efficiency ratio	1.20	1.46	1.48	2.00	1.10	1.36	1.44	1.58	1.48

b) Stocking 19g individuals

Feed type	**Dan-Ex 1362**			**Dan-Ex 1051**			**Bio Optimal C80**		
Replicate	R1	R2	R3	R1	R2	R3	R1	R2	R3
Stocking density (kg m^{-3})	8.55	8.58	8.51	8.54	8.38	8.02	8.86	8.74	8.38
Survival (%)	94.4	94.0	92.4	91.6	95.2	89.2	91.6	94.0	95.6
Start average individual weight (g)	19.840	19.908	19.736	19.812	19.440	18.608	20.556	20.276	19.448
Final average individual weight (g)	59.305	59.932	62.277	55.380	51.479	49.919	58.865	59.847	56.887
Specific growth rate (% d^{-1})	1.36	1.36	1.40	1.23	1.21	1.14	1.26	1.33	1.34
Feed conversion ratio	1.27	1.26	1.21	1.44	1.47	1.49	1.29	1.30	1.28
Protein efficiency ratio	1.27	1.28	1.33	1.36	1.31	1.36	1.49	1.48	1.50

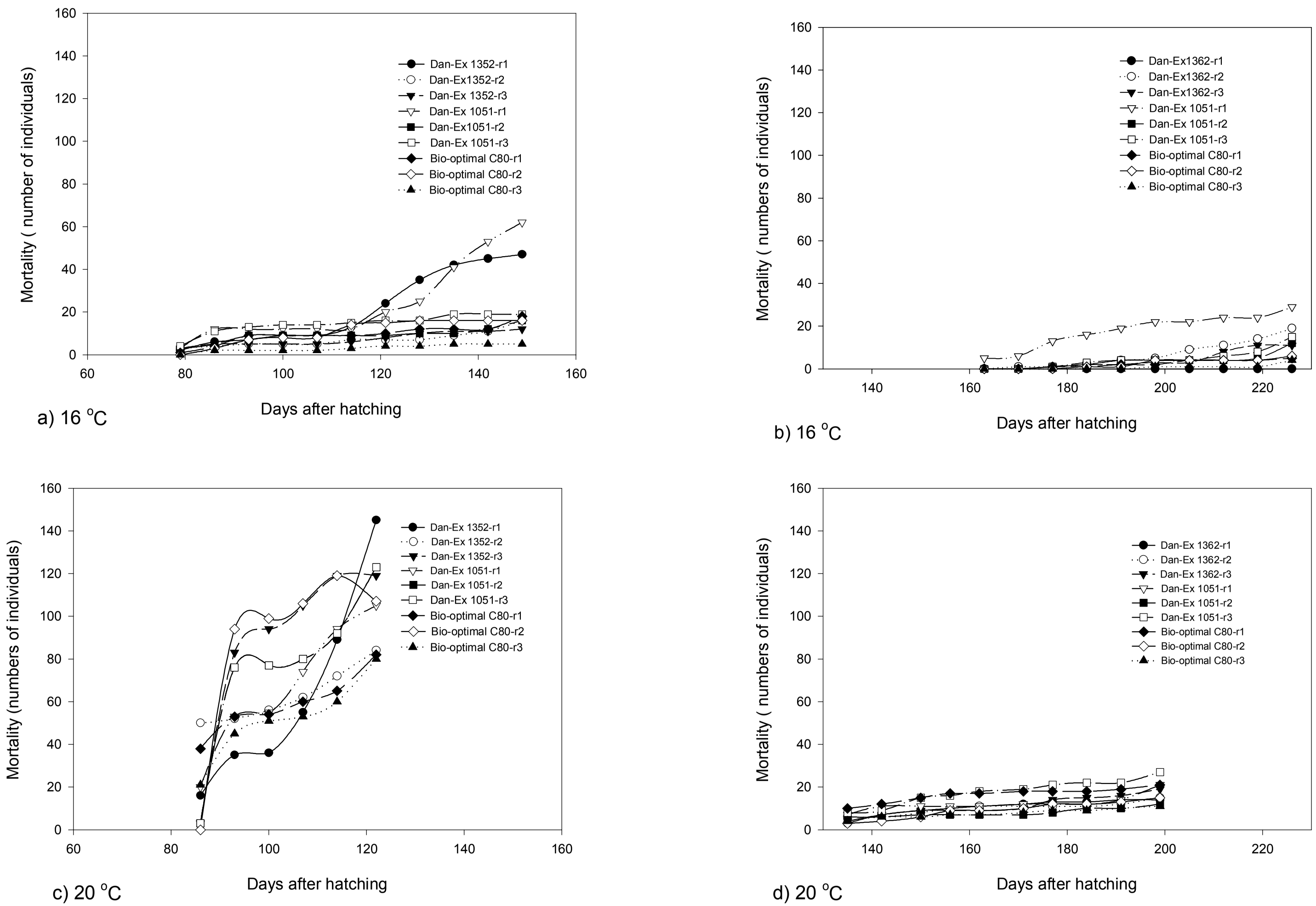


Figure 4: Cumulative mortality of perch during rearing experiments using three commercial feedtypes at 16 °C (a,b) and 20 °C (c,d). Each tank stocked with 1000 fish. Bornholms Lakseklækkeri, Nexø, 2004.

b) Growth

Section 1b and section 4 are separate systems with different tank and system designs. Therefore results from these two systems should be compared with caution due to unknown variables between them. However, it was evident that at the fish raised at 20°C performed better than those reared at 16 °C ; with larger final bw, higher specific growth rates and better food conversion ratios, as was expected. Perch is a thermophilic species with optimal rearing temperature of 23 °C (Melard *et al*., 1995)

Figure 5 illustrates the increase in average weight during the rearing period. At 16 °C (Fig 5a) there was a significant difference in the final average weight according to feedtypes during the first rearing period stocking 2g fish. The average weight of fish produced was significantly larger for fish fed Bio optimal C80 than for Dan-Ex 1352 and Dan-Ex 1051. The diet with least lipid and protein content (Dan-Ex 1051) resulting in the smallest fish being produced. Further ongrowing revealed the production of larger fish with diet Bio-Optimal C80 although this was not significant.

At 20 °C, (Fig 5b) both Dan-ex 1352 and 1362 produced comparable results to Bio Optimal C80. There was no significant difference between fish produced using Bio Optimal C80 and Dan Ex 1362 and 1352. These diets produced fish that were significantly larger that those fed Dan-Ex 1051.

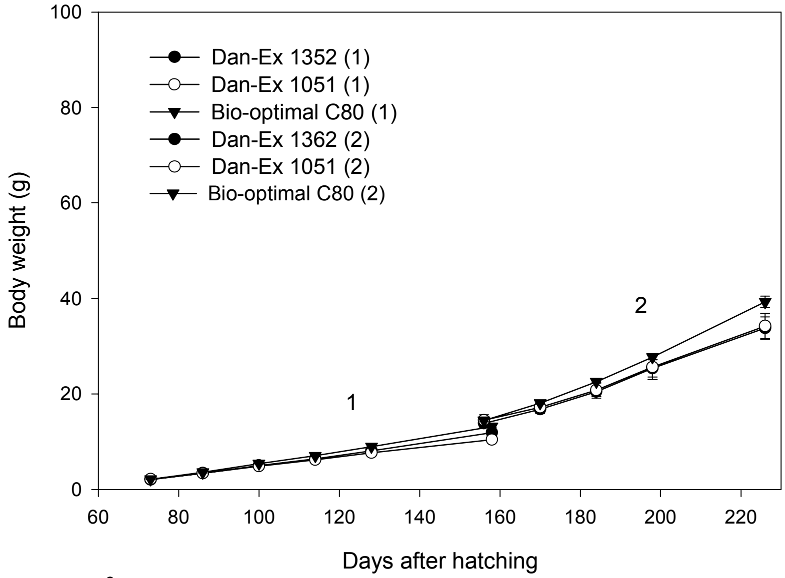
Specific growth rates were also significantly slower for fish fed Dan-Ex 1051 than the other feed types for fish reared at 20 and 16 °C. This is with the exception of 14g stocking at 16 °C where fish fed Dan-Ex 1051 were smaller that the other treatments although the difference was found not to be significant ($P>0.05$). In all rearing experiments, specific growth rates decreased as the fish became larger as would be expected.

In figure 5b, thee growth curve from 2003 was included. In 2004, the growth of perch juveniles at 20°C was slower than in 2003. This was most likely due to a combination of selection of medium size fish for the experiment (i.e. the removal of faster growing fish at the start of the ongrowing experiments which would have artificially enhanced the average size of fish in the tank) and the increased stocking density in 2004 compared to 2003. Once fish reach 20g, Melard *et al*. (1996a) recorded a reduction in growth with increased density. However, the growth data in 2004 support 2003 data that production of 80 g and 100 g size fish is possible within one year from hatching. At 16 °C however, suboptimal growth was obtained. Under 16°C it would take around 450 days to reach 100 gram fish. However, often in outdoor fishfarms in shallow ponds, summer water temperature can rise to over 22 °C. This temperature is lethal to salmonids but is close to optimal growth temperature for perch. Therefore, under warm summers even in outdoor facilities it may be possible to shorten production time of perch to close to one year, particularly if juveniles are produced indoors out of season.

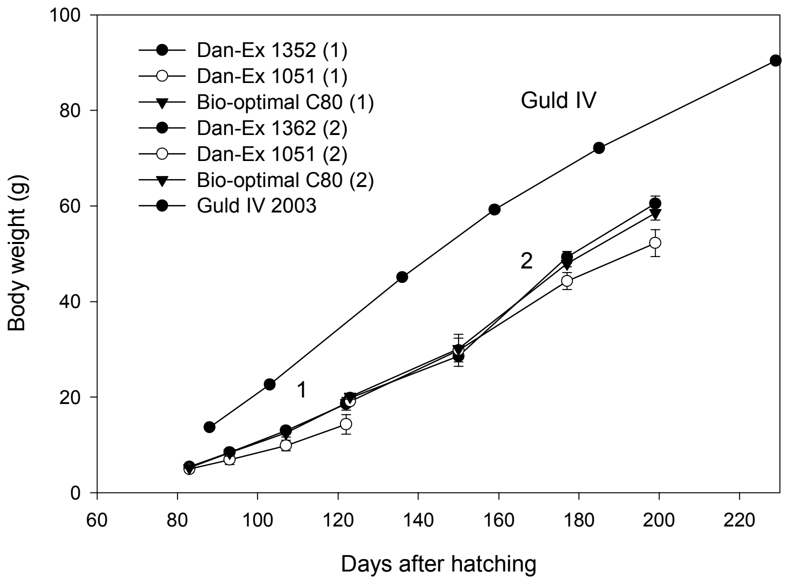
Food conversion ratios and protein efficiency ratios

Feed conversion varied between tanks, feed types and rearing temperature, with FCR's of between 0.98 and 2.05 observed (see table 8 and 9). At 16 °C the most consistent and best feed conversion was observed in fish fed Bio-Optimal C80 both at 1.3mm and 2mm pellet size. At 20°C during the feeding experiment with 4g fish Bio-Optimal C80 also proved to give the overall best food conversion, but this was not the case when fed the 2mm diet. With higher lipid and less protein than the 1.3mm pellet, the performance of Bio-Optimal C80 at 20 °C was not as good, with Dan-Ex 1362 providing better overall food conversion.

The efficiency to convert protein in the body (Protein efficiency ratio) was inversely related to protein/energy ratio i.e. the higher the protein to energy ratio in diet fed the poorer the conversion to live body mass. This observation is complies with results obtained using experimental diets with varying protein to energy ratio in relation to flesh quality (Mathis *et al*. 2003). From first impressions it seems that lipids in the diet are having a sparing effect. However, analysis of nitrogenous compounds in the waste water conducted during a similar experiment has shown that the sparing effect of lipid in perch is limited (Mathis *et al*. 2003). It could be that the diets with higher protein to energy levels exceed the amount of protein necessary for optimal growth, the remaining protein.



a) 16 °C



b) 20 °C

Figure 5: Mean and standard deviations of body weight (g) of perch juveniles raised at a) 16 °C and b) 20 °C, stocking at (1) 2-5g and (2)14-19g individual weight. Mean values for fish raised at 20 °C in 2003 added for comparison with 2004 growth data.

being used as an energy source or excreted. The best result in terms of protein efficiency ratio was observed with Bio-Optimal C80 (Protein/Energy ratio = 22 mg kj $^{-1}$) both in 16 and 20 °C. 22 mg kj $^{-1}$ was also observed to result in the best growth for Eurasian perch stocked at 36g (Mathis *et al*., 2003). Protein is one of the most expensive ingredients in fish feeds and a cause of nitrogen effluents to the environment. Optimization of protein conversion into fish muscle is therefore desirable and in development of perch feeds, the protein to lipid ratio will be an important factor to include.

As yet, the results of lipid storage in the abdominal cavity are not available for comment.

Economics (cost of diet)

Table 10 summarises the cost of production of perch in terms of food used during the rearing experiments. Although none of the perch were reared to commercial size (due to restricted time frame in project period) a comparison was made of costs to the end of the respective experiments.

Table 10: Cost of production of Eurasian perch as dkk per kg fish produced (feed only) reared at 16 °C and 20 °C using three commercial feed types at 1.3mm and 2.0mm pellet size (2004).

	1.2-1.3mm			**1.8-2.0mm**		
	Dan Ex 1352	**Dan Ex 1051**	**Bio-Optimal C80**	**Dan Ex 1362**	**Dan Ex 1051**	**Bio-Optimal C80**
20 °C (DKK/kg)	13.00	25.00	18.50	19.50	26.40	13.00
16 °C (DKK/kg)	16.62	32.21	28.54	18.70	23.85	11.40

For small perch both at 20 °C and 16 °C , Dan-Ex 1352 proved to be the most economical diet costing 13.00 and 16.62 dkk/ kg fish produced for 11g and 18 g fish respectively. For 2mm diets, Bio-optimal C80 proved to be the most economical

13dkk/kg and 11.4dkk/ kg at 20 and 16 °C, respectively. Moreover at 20 °C, the cost of production was cheaper according to food. However, the cost of heating water may out way the costs of feed dramatically and therefore cost effectiveness is lost.

CONCLUSIONS:

1. At 20 °C, perch can be reared to marketable size within one year (Swiss market: 215 days = 80g, 300 days = 100g).
2. Grading is important to a) reduce cannibalism (with takes place mainly over 23days during weaning) and b) to reduce the effects of growth heterogeneity and dominance over food.
3. Tank design may affect performance. In particular, restricted feeding surface may enhance social hierarchy in perch. This needs to be examined further.
4. In small fish (under 20 g) increased stocking density improved survival, feed conversion and growth rate. However, there was no significant improvement in average weight of fish produced by increased or decreased stocking density although length was significantly larger in the lowest stocking density compared to middle and high densities.
5. Heterogeneity in growth potential between males and female perch is well documented. Improved systems may involve the use of monosex production of fish (all female populations).
6. The nursery phase of 44 days prior to ongrowing proved successful with high survival and optimal food conversion.
7. Bio-optimal C80 provided the best growth rates and food conversion in juvenile perch both a 20 °C and 16 °C , although Dan Ex- 1362 was superior in larger perch at 20°C .
8. The low fat diet (Dan-Ex1051) resulted in the poorest growth performance and food conversion efficiency.
9. Optimal protein to energy ratio for perch using commercial diets was shown to be 22mg kj^{-1} supporting the result in the literature using experimental diets.

10. The most cost effective diets were Dan-Ex 1352 at 1,3mm pellet and Bio-optimal C80 at 2mm pellet size for small and larger juveniles, respectively, both for rearing temperatures of 16 and 20 °C.
11. Although it was more cost effective at 20 °C than at 16 °C in terms of food utilization and perch production, the cost to heat the water from 16 to 20 °C could be enough to decrease the cost effectiveness of the diet at the higher temperature. This needs to be further investigated.

REFERENCES

Fiogbe, E.D., Kestemont, P., Mélard, C., and Micha, J.C., 1996. The effects of dietary crude protein on growth of the Eurasian perch *Perca fluviatilis*. Aquaculture 144:239-249.

Fontaine, P., Tamazouzt, L., and Capdeville, B., 1996. Growth of the Eurasian perch (*Perca fluviatilis* L.) reared in floating cages and in water recirculated system: first results. Journal of Applied Ichthyology, 12: 181-184.

Fontaine, P., Gardeur, J.N., Kestemont, P., and Georges, A., 1997. Influence of feeding level on growth, intraspecific weight variability and sexual growth dimorphism of Eurasian perch *Perca fluviatilis* L. reared in a recirculation system. Aquaculture, 157:1-9.

Huh, H.T., Calbert, H.E., and Stuider, D.A., 1976. Effects of temperature and light on growth of yellow perch and walleye using formulated food. Transcripts of American Fisheries Society, 105:254-258.

Jobling, M. and Johansen, S.J.S., 2003. Fat distribution in Atlantic salmon, *Salmo salar* L., in relation to body size and feeding regime. Aquaculture Research 34:311-316.

Kestemont, P., Vandeloise, E., Mélard, C., Fontaine, P. and Bronw, P.B., 2001. Growth and nutritional status of Eurasian perch *Perca fluviatilis* fed graded levels of dietary lipids with or without added ethoxyquin. Aquaculture 203:85-99.

Malison, J., Kestemont, P. and Sommerfelt, R., 2003. Percid Aquaculture: Current status and future research needs. In: T.P. Barry and J.A. Malison (Editors) Proceeding of PERCIS III: The third international percid fish symposium. University of Wisconsin, Madison, Wisconsin, U.S:A. July 20-24, 2003. University of Wisconsin Sea Grant Institute. P1.

Malison, J.A., Kayes, T.B., Wentworth, B.C. and Amundson, C.H., 1988. Growth and feeding responses of male versus female yellow perch (*Perca flavescens*) treated with estrodiol-17ß. Canadian Journal of Fisheries and Aquatic Sciences 45: 1942-1948.

Matthis, N., Feidt, C. and Brun-Bellut, J., 2003. Influence of protein/energy ratio on carcass quality during the growing period of Eurasian perch (*Perca fluviatilis*). Aquaculture 217:453-464.

Mélard, C., Baras, E., Desprez, D., Philippart, J.C. and Kestemont, P., 1994. Intensive culture of perch (*Perca fluviatilis*). First results of stocking density on growth and survival of larvae and juveniles. In: J. Muir and F. Sevilla (Editors) Measures for success, EAS special publ. no. 21, 206-207.

Mélard, C., Kestemont, P. and Grignard, J.C., 1996a. Intensive culture of juvenile and adult Eurasian perch (*P. fluviatilis*): effect of major biotic and abiotic factors on growth. Journal of Applied Ichthyology, 12: 175-180.

Melard, C., Baras, W., Mary, L. and Kestemont, P., 1996. Relationships between stocking density, growth, cannibalism, and survival rate in intensively cultured larvae and juveniles of perch (*Perca fluviatilis*). Annales Zoologici Fennici, 9:3-4.

Shepherd, J. and Bromage, N., 1988. Intensive Fish farming. BSP Professional Books, London. 404pp.

Xu, X.L., Fontaine P. Mélard, C. and Kestemont, P., 2001. Effects of dietary fat levels on growth, feed efficiency and biochemical compositions of Eurasian perch *Perca fluviatilis*. Aquaculture International 9:437-449.

Zelenkov, V.M., 1981. Early gametogenesis and sex differentiation in the perch, *Perca fluviatilis*. Journal of Ichthyology 21:124-130.

DFU-rapporter – index

Denne liste dækker rapporter udgivet i indeværende år samt de foregående to kalenderår. Hele listen kan ses på DFU's hjemmeside www.dfu.min.dk, hvor de fleste nyere rapporter også findes som PDF-filer.

Nr. 120-03	Danmarks Fiskeriundersøgelser. Ramme- og aktivitetsplan 2003-2006
Nr. 121-03	Genudlagte blåmuslinger (*Mytilus edulis* L.) på vækstbanker i Limfjorden 2002. Per Sand Kristensen og Nina Holm
Nr. 122-03	Blåmuslingebestanden i det danske Vadehav efteråret 2002. Per Sand Kristensen og Niels Jørgen Pihl
Nr. 123-03	Blåmuslinger (*Mytilus edulis* L.) i Århus Bugt 2002. Forekomster og fiskeri. (fiskerizonerne 24, 25, 26, 30, 31 og 34). Per Sand Kristensen
Nr. 124-03	Forebyggelse af YDS (yngeldødelighedssyndrom) og begrænsning af medicinforbrug i æg- og yngelopdræt i danske dambrug. Per Aarup Jensen, Niels Henrik Henriksen, Kaare Michelsen, Dansk Dambrugerforening og Lone Madsen, Inger Dalsgaard, Danmarks Fiskeriundersøgelser, Fiskepatologisk Laboratorium
Nr. 125-03	Laksens gydevandring i Varde Å-systemet. Radiotelemetri-undersøgelse. Niels Jepsen, Michael Deacon og Mads Ejby Ernst
Nr. 126-03	DFU's standardtrawl: Konstruktion og sammenlignende fiskeri. Ole Ritzau Eigaard, Josianne Støttrup, Erik Hoffmann, Holger Hovgård og Søren Poulsen
Nr. 127-03	Status and Plans. DIFRES November 2003. Tine Kjær Hassager (Ed.)
Nr. 128-03	Udsætninger af pighvar ved Nordsjællands kyst fra 1991-1997. Claus R. Sparrevohn og Josianne Støttrup
Nr. 129-03	Fiskebestande og fiskeri i 2004. Sten Munch-Petersen
Nr. 130-04	Bestanden af blåmuslinger i Limfjorden 1993 til 2003. Per Sand Kristensen og Erik Hoffmann.
Nr. 131-04	Udsætningsforsøg med ørred (*Salmo trutta*) i Gudenåen og Randers Fjord, gennemført i 1982-83, 1987-89 og 1994-96. Stig Pedersen og Gorm Rasmussen
Nr. 132-04	En undersøgelse af muligheder for etablering af måleprogram på såkaldte modeldambrug. Lars M. Svendsen og Per Bovbjerg Pedersen
Nr. 133-04	Udnyttelse af strandkrabber. Knud Fischer, Ole S. Rasmussen, Ulrik Cold og Erling P. Larsen
Nr. 134-04	Skjern Å's lampretter. Nicolaj Ørskov Olsen og Anders Koed

Nr. 135-04 Undersøgelse af biologiske halveringstider, sedimentation og omdannelse af hjælpestoffer og medicin i dam- og havbrug, samt parameterfastsættelse og verifikation af udviklet dambrugsmodel. Lars-Flemming Pedersen, Ole Sortkjær, Morten Sichlau Bruun, Inger Dalsgaard & Per Bovbjerg Pedersen

Nr. 135a-04 Supplerende teknisk rapport (Anneks 1 – 8) til DFU-rapport nr. 135-04. Undersøgelse af biologiske halveringstider, sedimentation og omdannelse af hjælpestoffer og medicin i dam- og havbrug, samt parameterfastsættelse og verifikation af udviklet dambrugsmodel. Lars-Flemming Pedersen, Ole Sortkjær, Morten Sichlau Bruun, Inger Dalsgaard og Per Bovbjerg Pedersen

Nr. 136-04 Østersfiskeri i Limfjorden – sammenligning af redskaber. Per Dolmer og Erik Hoffmann

Nr. 137-04 Hjertemuslinger (*Cerastoderma edule*) på fiskebankerne omkring Grådyb i Vadehavet, 2004. Per Sand Kristensen og Niels Jørgen Pihl

Nr. 138-04 Blåmuslinger (*Mytilus edulis* L.) og molboøsters (*Arctica islandica* L.) i det nordlige Lillebælt i 2004 (fiskerizone 37 og 39). Forekomster og fiskeri. Per Sand Kristensen

Nr. 139-05 Smoltdødeligheder i Årslev Engsø, en nydannet Vandmiljøplan II-sø, og Brabrand Sø i foråret 2004. Kasper Rasmussen og Anders Koed

Nr. 140-05 Omplantede blåmuslinger fra Horns Rev på bankerne i Jørgens Lo og Ribe Strøm 2002-2004. Per Sand Kristensen og Niels Jørgen Pihl

Nr. 141-05 Blåmuslingebestanden i det danske Vadehav efteråret 2004. Per Sand Kristensen, Niels Jørgen Pihl og Rasmus Borgstrøm

Nr. 142-05 Fiskebestande og fiskeri i 2005. Sten Munch-Petersen

Nr. 143-05 Opdræt af torskeyngel til udsætning i Østersøen (forprojekt). Josianne G. Støttrup, Julia L. Overton, Christian Möllmann, Helge Paulsen, Per Bovbjerg Pedersen og Peter Lauesen

Nr. 144-05 Skrubbeundersøgelser i Limfjorden 1993-2004. Hanne Nicolajsen

Nr. 145-05 Overlevelsen af laksesmolt i Karlsgårde Sø i foråret 2004. Anders Koed, Michael Deacon, Kim Aarestrup og Gorm Rasmussen

Nr. 146-05 Introduktion af økologi og kvalitetsmærkning på danske pionerdambrug. Lars-Flemming Pedersen, Villy J. Larsen og Niels Henrik Henriksen

Nr. 147-05 Fisk, Fiskeri og Epifauna. Limfjorden 1984 – 2004. Erik Hoffmann

Nr. 148-05 Rødspætter og Isinger i Århus Bugt. Christian A. Jensen, Else Nielsen og Anne Margrethe Wegeberg

Nr. 149-05 Udvikling af opdræt af aborre (*Perca fluviatilis*), en mulig alternativ art i ferskvandsopdræt. Helge Paulsen, Julia L. Overton og Lars Brünner

Nr. 150-05 First feeding of Perch (*Perca fluviatilis*) larvae. Julia L. Overton og Helge Paulsen

Nr. 151-05 Ongrowing of Perch (*Perca fluviatilis*) juveniles. Julia L. Overton og Helge Paulsen