



## How to reduce growth limiting social interactions in Arctic charr farming

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Intensive fish farming means rearing the fish in tanks and/or net-pens at high densities and achieving as high growth rate as possible. To rear fish in land based tank systems until slaughter is much more expensive than rearing them in net pens. The most common rearing routine is to rear the young more sensitive stages in tanks and then move the fish into net-pens at sizes between 20-100 g. The speed of production is high a marked sized charr (800g) can be achieved in 2 years from start feeding with a feed conversion factor close to 1. An increased awareness of fish behaviour resulting in an increased farming skill together with selection programs has made the good results possible.

### Social groupings in Arctic charr

Most studies on the behaviour of fish when confined in higher densities are done in experimental set-ups due to the difficulty of studying fish in full rearing conditions. This is especially true when it comes to separate individual behaviour among thousands of other fish in net-pens or tanks. Most of these laboratory experiments are aimed to scale the situations down from farming condition. When groups of fish are observed in aquarium, they typically develop dominance hierarchies.

Individual fish that are successful competitors have higher feed intakes and consequently higher growth rates than less competitive ones. This is particularly pronounced in small scale experimental conditions where less competitive fish (subordinates) often are excluded from the feeding area or physically loose feed to more aggressive and dominant individuals. The subordinates suffer from stress and have increased levels of stress hormones. These fish often keep a very low profile and cease eating even with excess feeding.

However, groups of fish that are kept in aquarium without refuges and not giving subordinate individuals a possibility to hide or escape from dominant fish, is indeed an artificial condition.

In full scaling condition with thousands of fish reared in high densities in net-pens and tanks individual variation in growth is probably more related to a high level of aggression rather than by dominance hierarchies, where high ranked fish are more aggressive or competitive during food release. For fish in general, it has been shown that the significance of social dominance is reduced when group sizes increase. The reason is that neither repeated attacks nor defence of a favourable area or food resource can be sustained by dominant individuals under such conditions.

## Behaviour Problems when farming Arctic charr

In fish farms, no matter how skilful the farmer is, there will always be size discrepancies between individuals. The reason for this may be both genetically determined and/or an effect of competition between individuals governed by their social status. Evidence for this is found in more or less all fish farms today, where a varying proportion of the fish exhibits higher growth rates.

Several problems related to the behaviour of fish can be identified in culture conditions. The causes for these problems are often linked to undesirable social behaviour caused by aggression between individuals. Visible signs of behavioural problems are often a reduced or skewed growth rate, stress, fin damages, mortality and abnormal behaviour. Some of these problems are fairly easy to detect early and therefore possible to solve, whereas others are more difficult.

It is important that fish farmers are aware of the behaviour problems aggression can cause and have some form of tool to detect it. Malcolm Jobling (Feeding of charr in relation to aquaculture. *Nordic Journal of Freshwater Research* 71, 102-112, 1995) suggested that the social environment could be assessed by observations of weight gain, size variation and feed conversion ratios. Three scenarios were given:

- A high growth rate and little variation in body size (i.e. low coefficient of variation for growth rate), indicates good rearing conditions in which there is little or no depression of growth due to aggressive behaviour.
- Sub-optimal and disparate growth coupled to poor feed conversion ratios reflects a poor social environment, which may be the result of competition due to underfeeding or because of bad temporal or spatial distribution of feed.
- Poor growth with little variation indicates a general growth depression resulting from a poor environment, and a poor feed conversion ratio would reflect feed waste.

Thus, a fish farmer can, by keeping precise track of fish growth and feed consumption, easily evaluate the social situation in his rearing environment and thereby avoid behavioural problems that may lead to severe growth variation.

## Health and welfare

Fish in all environments, including culture and in the wild, sometimes suffers from stressful conditions. One of the first signs of stress that is related to behavioural problems in farmed fish is the occurrence of fin damages. These are to a large extent a cause of social interactions and commonly considered a sign of unsuitable rearing conditions. Stress is likely to have negative effects on the immunocompetence of fish, even if very few studies have been done in this area. Fish may seem healthy before, during and immediately after a period of stress, but disease problems may occur later on. They may be asymptomatic carriers of pathogens that under normal conditions are held back by the immune system. When that system is impaired or suppressed by stress, the disease-causing agent may start to grow, gain control and kill the fish. In addition, stress may suppress the immune system and increase the vulnerability of the fish to invading pathogens.

Surface activity is an important behaviour of fish held in culture, and situations with over activity may indicate that something is wrong in the rearing environment. Leaping (fish jumping with their whole body breaking the water surface) and rolling (the dorsal part of the body breaking the surface) are well-known behaviours in salmonids. The cause for leaping seems to be related to infections of ectoparasites (e.g. louse), exposure to acute stress and the presence of predators. No seasonal variation in rolling has been observed, and high rolling activity may be explained by buoyancy compensation (gas bladder filling) as an effect of stress exposure. Fish often lose air from the swimbladder during stress exposure and it is important that the neutral buoyancy is restored within a relative short period of time.

Measuring stress on fish health in culture is difficult as described above but there are, however, signs of stress and bad environment that are possible to detect in culture conditions:

- Abnormal swimming behaviour (e.g. leaping, rolling).
- Low locomotor activity
- Low and variable growth
- Fin damages, wounds and scale loss
- High number of external parasites

Since many immune assays are becoming available in kits, farmers can perform quick and sensitive tests directly at their farm. Many of these tests do not require the fish to be killed but a blood sample is enough.

### How to reduce behavioural problems and stress

Successful rearing methods in intensive systems really deal with making the fish apply a schooling behaviour. A schooling behaviour is achieved by taking advantage of the plasticity the fish have in their behaviour repertoire and rearing them in conditions where it doesn't pay to be territorial but where it is more advantageous to swim in groups.

### Stocking density

Net-pens can physically hold much higher densities without forcing the fish closer together. As opposed to farmed animals on land, fish are reared in a three-dimensional space and voluntarily form tight schools. However, the schools of fish need space so they can alter their swimming depth depending on hunger level or strong sunlight and high temperatures. Stocking density may influence the behaviour of fish in various ways. On one hand, problems with social hierarchies may be reduced as the density increases. On the other hand, increasing problems with stress, fin damages and health may occur when the stocking density increases. Different species seem to react differently to stocking density, and it is therefore important to find out the optimal stocking density for the particular species being cultured.

Growth rates in Arctic charr seem to be positively correlated to stocking density when feed supplies are adequate. Even at densities well over  $100 \text{ kg m}^{-3}$  in tanks, growth rates don't seem to be suppressed. In Swedish fishfarms where they rear fish in net-pens, charr are generally kept at densities between  $50\text{-}60 \text{ kg m}^{-3}$  and rainbow trout at  $30\text{-}40 \text{ kg m}^{-3}$ .

### Water current

Several studies have shown that sustained exercise (i.e. swimming against a low current) improves growth rates in several species of salmonid fish including Arctic charr.

The reason for this growth improvement is debated. One hypothesis is that active swimming increases protein synthesis on the expense of fat deposition, which results in increased weight gain. A second possibility is that the increased growth is the result of a decrease in aggressive behaviour. Several studies on Arctic char have shown the fish are less aggressive when forced to swim for prolonged periods at moderate speeds of about 1-2 body lengths (BL) per second. One very obvious change in behaviour at low water velocities is the change from irregular swimming activity (passivity to bursts) to pronounced schooling behaviour at exercise conditions. Some studies suggest that the dominants are less aggressive when they are forced to exercise due to an increased energetic cost of aggression and fighting in a current. Then the subordinates increase their growth rate either by an increase in their feed intake and/or by a decrease in their stress-related metabolic costs.

Whatever mechanisms are involved, it is very clear that exercise at moderate speeds (e.g. 1-2 BL/s) reduces the level of social interactions and improves growth in salmonid fish. The effect on other important species in culture is unknown, but it is likely that the effects are similar in those species showing aggressive behaviour.

In net-pen rearing, it is not possible to create a circular current but the fish generally form schools anyway. The shape of the cages is however important for the willingness of the fish to form tight schools. It is easy for fish to swim around in circular cages whereas square cages tends to disrupt the group structure when the school hit the corner.

#### Feeding regime and feed distribution

Fish-farmers feed the fish to satiation or near satiation and therefore a behavioural problem like aggression that is related to the feed ration is of minor importance. More important is the spatial and temporal distribution of the feed. If feed is delivered to a single location in the rearing unit, dominant fish will likely defend and hold position close to that area, giving them greater opportunities than lower ranked fish. Aggression is less frequent if the feed is dispersed rather than concentrated in a restricted area.

A fish farmer have to carefully balance between the size of the feed portion and the number of pellets the fish is able to catch before the feed pass out of the rearing system. To avoid feed waste, the best strategy would be to deliver very small portions, which ensures that the fish are able to catch all pellets. Repeated feeding at short intervals during the whole day seems to induce stress and energy losses in some species like Rainbow trout.

There are however differences between species in how they react to the feeding regime. Arctic charr are much slower at catching pellets in the water column than trout, and doesn't create as much boiling appearance as rainbow trout when the pellets hit the water surface. Studies have shown if the daily meal are given in few portions rainbow trout are favoured whereas Arctic charr grow better and with less size differences between individuals with frequent daily meals.

#### Size grading

Even if most factors reducing the competition for feed are optimised, fish will grow at different rates, and considerable size differences will occur with time. Thus, the fish are generally size sorted and split into different size groups with the purpose of avoiding escalated behavioural problems. However, if size-grading does result in a total growth gain is debated. Most studies show that size grading doesn't result in a net weight gain but is merely convenient for fish farmers to keep group with a low size variation at slaughter.

#### Breeding

In most farmed animals, domestication has a considerable effect on the behaviour and an increase or decrease in aggression level between individuals may be an undesired or desired, respectively, goal in breeding programs. To select for a friendlier fish that are more willing to school should of course be a desire for the aquaculture industry, although no breeding with this in mind exists today due to the difficulty of assigning such behavioural trait. In fish, there is a lack of knowledge on how aggression and correlated behaviours are effected by domestication. Aggression and schooling are alternative behaviours that fish apply depending on the situation. It is therefore likely that a selection for lower aggression, i.e. an increase in the threshold that induces an aggressive behaviour, will increase the tendency to school.

The scarce studies on social behaviour in fish at full scale rearing condition reveal that most fish species that are reared in net cages gather in schools as ring structures with few fish near the centre or close to the cage wall rather than dispersing within the entire cage volume. Atlantic salmon and rainbow trout form circular polarised schools during daytime. At night the schooling groups have been observed (by IR cameras!) to disperse. It is likely that Arctic charr show the same response.

This is a summary from a book chapter: Brännäs, E., Alanärä, A., & Magnhagen, C. 2001. Social behaviour in fish. In *Social behaviour in farmed animals*, eds. L. Keeling & H. Gonyou. Bab International, Wallington, UK.