POSSIBILITIES TO INCLUDE DISEASE RESISTANCE IN THE NORWEGIAN BREEDING PROGRAMME FOR SALMONIDS

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SUMMARY

Disease resistance is an important breeding goal in a selection programme for fish, and genetic variation in resistance is reported. However, disease resistance is difficult to measure. Today, survival rate is recorded, but too many irrelevant factors influence survival. Consequently, survival is not included in the selection criteria. Using family selection it is possible to infect parallels of each progeny groups with diseases and record mortality, but this is costly. The most promising approach seems to be an indirect selection based on parameters in the immune system or stress response parameters when these are correlated to disease resistance.

INTRODUCTION

In aquaculture, efficient breeding and selection programmes are rarely practiced even though the traditions of fish farming go back thousands of years in some regions. In Norway, a breeding programme for salmonids was worked out during the early 1970's. Compared with other farmed animals, fish have the advantage of a high reproductive capacity and this allows for high selection intensities. The high fecundity makes it possible to produce progeny groups with a high number of individuals in each group. The possibility to test different traits in parallels of full or half sib groups is better in fish than in other species.

The increase in fish farming has led to an increase in the variety and incidence of diseases. Culture densities and frequent deterioration of environmental quality are among factors that increase the occurence and seriousness of diseases. We probably have not yet met all problems concerning diseases in fish farming. Because of this we want to include disease resistance in the breeding goal.

However, before a trait can be included in a breeding goal it must fulfil some conditions:

- The trait has to show genetic variation
- The trait has to be easily determinded

In addition, the trait has to be of economical importance.

NORWEGIAN SELECTION PROGRAMME

The selection is based on a combination of family and within family selection. The two breeding centers have the possibilities of testing a total of 670 progeny groups equally divided on Atlantic salmon and rainbow trout. All records of production traits in freshwater are collected at the breeding center.

The marking system presently used is a combination of fin-clipping and freeze-branding and has some limitations. Only 120 different progeny group codes are available for each species at each of the breeding centers. Therefore, an initial family selection based on growth in the freshwater phase is practiced.
For the remaining groups, a sample of fish from each of the progeny groups is marked and commercially stocked for furher rearing in floating net cages at the breeding centers. Another sample from each progeny groups is marked and divided between 10 test stations which are commercial fish farms along the coast.
Records from the test stations combined with the records from the breeding centers are used to produce the breeding values for the progeny groups. Survival rates in different periods are recorded both during the freshwater phase and the seawater phase, but survival rate is not included in the selection programme. The traits selected for are growth rate and age at maturation.
(For more detailed information see Refstie 1990)

GENETIC VARIATION OF DISEASE RESISTANCE

1) Survival rate

Survival rate is presently recorded as the relative number of survivors in the different progeny groups. Today, percentage survival for each progeny groups is the only measure that can be included in the selection programme.
Rye et al (1990) studied survival rates in early life of eight year-classes of Atlantic salmon and nine year-classes of rainbow trout. The survival rates in the observed periods during incubation and early freshwater phase ranged from 48 to 98% in both species, the lowest in the period prior to the eyed-egg stage and during first feeding. Losses in these two periods accounted for more than 75% and 95% of the total losses for Atlantic salmon and rainbow trout, respectively. In both species, heritabilities for survival derived from the sire components of variance were low (0.04-0.09).

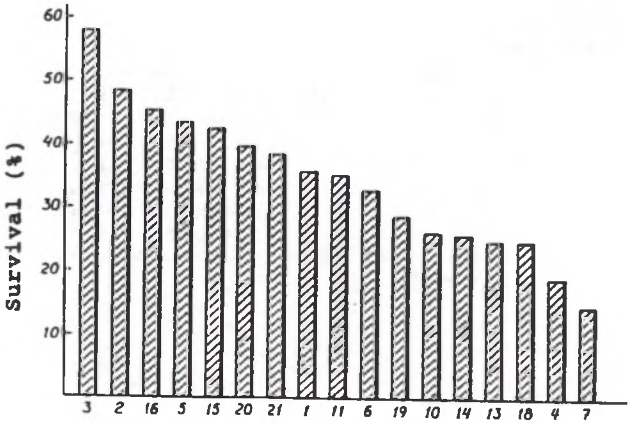
2) Survival after specific infections/diseases

Several studies on the variation of disease resistance between and whithin species have been reported (reviewed by Chevassus and Dorson, 1990).
Gjedrem and Aulstad (1974) studied variation in mortality due to vibriosis in 14 wild populations of Norwegian salmon and one Swedish population tested in the same farming environment. The mortality in the Norwegian populations varied from 0.87% to 8.9% whereas it reached 29.7 % in the Swedish population. The heritability for resistance to vibrio disease of this salmon parr was estimated to 0.12 and 0.07 based on the sire and dam components, respectively.

In a study done by Refstie (1982) the survival rate after an induced outbreak of vibriosis varied from 39 to 99% between offspring groups after 13 sires. The difference between progeny groups was significant, but heritability was not calculated.

Standal and Gjerde (1987) studied genetic variation in survival in three year-classes of Atlantic salmon during the sea rearing period. Mortality was high throughout this period, and cold-water vibriosis ("Hitra-disease") was the main cause of death. There was a significant variation in survival between progeny groups (fig 1) The heritability for survival calculated on the observed scale was estimated to 0.21 from the sire component for this year-class (1980) with a total survival rate of 31.8%.

Fig. 1 The sire least square means for survival when the main cause of death was cold-water vibriosis (year-class 1980).



MEASUREMENTS OF DISEASE RESISTANCE

1) Survival rate

The main problem working with this trait in a selection programme is to develop good methods for measuring the trait. Survival is easy to record when the breeding programme is based on family selection, but survival rate is a very complex trait and a rather difficult trait to work with. Many irrelevant factors to disease resistance, like accidents and management problems, influence survival. The factors will differ between farms and between years within farm. Consequently, survival alone is not a good parameter for measuring disease resistance.

Another problem is the identification of the dead fish. With the marking system used today, it is impossible to read the freeze brands when the fish are dead. With a better marking system and individual records of the cause of mortality, survival rate would be a better selection criterion.

2) Exposing fish to specific infection agents

Another possible way of measuring resistance is to expose parallels of the progeny group to specific disease agents.

This has to be done without risks of infecting the breeding stock, other fish farms or wild population. So this is a rather expensive method to practice.
Another way to do this without the risk of spreading diseases, is to expose parallels of each progeny group to standardized, high levels of stress and observe survival rates as the selection criterion for disease resistance. High stress levels seem to increase the incidence of diseases caused by environmental micro-organisms.

3) Indirect selection

The advantage of indirect selection is that the records can be collected from healthy fish and serve as a marker of their resistance to diseases. Such parameters could be stress response or parameters in the immune system. The possible relationship between the susceptibility to stress and disease resistance has often been pointed out. Refstie (1982) studied the level of cortisol induced by standardized stress in rainbow trout. A significant variation for cortisol level was noted between the progeny groups, but there was no significant correlation between cortisol levels and mortality after an induced infection with vibriosis. In addition to cortisol level, several immunological parameters are under investigation:

Lysozyme
Total-hemolytic activity (complement)
Transferrin
Total antibody production (Total IgM)
Antibody production against specific agents

Røed et al (1990) studied the genetic influence on serum haemolytic activity in rainbow trout. Both the antibody-dependent and the non-specific haemolytic activity showed statistically significant variation between families. The magnitude of the estimated heritabilities ranged from medium to relatively high. Even though indirect selection for disease resistance seems promising, the correlation between parameters showing genetic variation and realized disease resistance has not yet been determinded.
Another problem for the incorporation of disease resistance in a selection programme is the genetic correlation between traits. Unfortunate correlations may occur either between resistance parameters or with other performance traits.

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