Selection potential for feed efficiency in farmed salmonids

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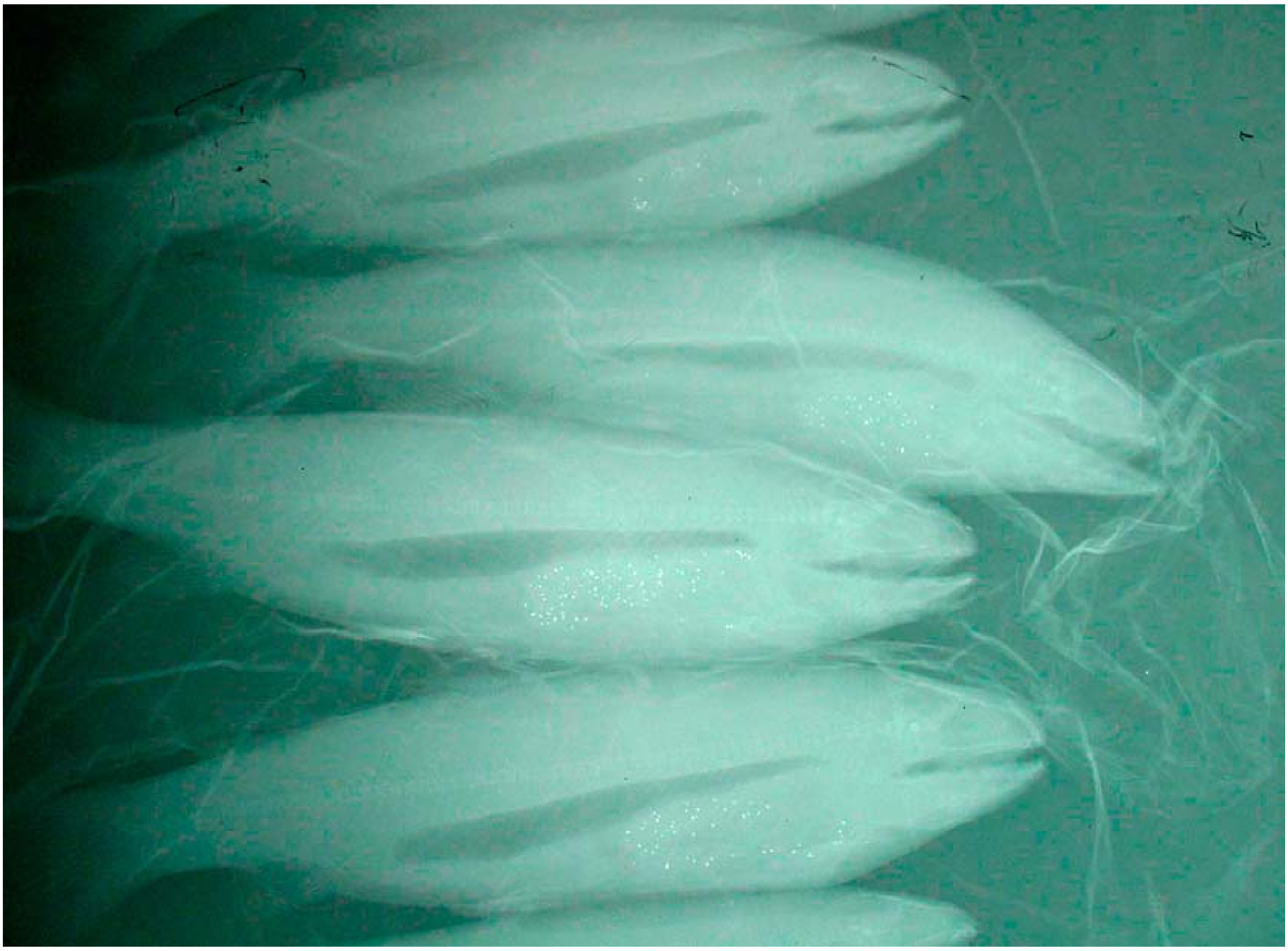
Feed is the major cost in farmed fish production. Improving feed efficiency, a ratio of wet weight gain to feed intake, would have the effect of reducing feed costs and minimising nutrient effluent to the environment. Selective breeding is a potential tool for improving feed efficiency, and improved feed efficiency is one of the major goals in aquaculture breeding programmes. Selective breeding programmes exist for many major aquaculture species, including several salmonid species.

Recording feed intake

To be able to select directly for feed efficiency, feed intake of individual fish should be recorded. Until recently, difficulties in measuring individual feed intake on a large scale have prevented accurate genetic evaluation of feed utilization traits in farmed fish. To solve the recording challenges, we have applied the X-ray method to measure feed intake and feed efficiency of thousands of individuals in pedigreed populations of farmed rainbow trout (*Oncorhynchus mykiss*)[1,2] and European whitefish (*Coregonus lavaretus*)[3,4].

To measure feed intake of individual fish using the X-ray method, all fish held in a tank are first fed with feed containing small radio-opaque glass beads. Thereafter, the fish are X-rayed. The number of glass beads consumed can be counted from the X-ray films. Because the glass bead content of the feed is known, it is possible to calculate the quantity of feed that each fish consumed on a specific meal[1].

Figure 1. Small radio-opaque glass beads added into a feed can be used to record feed intake.



Genetic variation in feed efficiency

The studies on rainbow trout[2] and European whitefish[3] show that direct selection for feed efficiency is possible in farmed fish. Yet, genetic improvement of feed efficiency is expected to be about three (rainbow trout) to eight-fold (European Whitefish) slower compared to the improvement of growth rate. This results because feed efficiency seems to display modest amount of genetic variation for selection. For instance, in European whitefish, only 6 percent of the phenotypic variation in feed efficiency was explained by genetic effects. Simultaneously, feed intake and weight gain, the two component traits of feed efficiency, exhibited moderate genetic variation (23-26% of variation explained by genetics).

Our studies have been conducted during three week to three month long trial periods at an exponential growth phase of the fish. During this time, most feed consumed is directed to growth, and there is only little variation in nutrient diversion to other body functions. It is possible that if feed efficiency could be recorded during longer time periods (e.g. across the whole fish life), more genetic variation for feed efficiency would be revealed.

Indirect selection for feed efficiency

Recording of individual feed intake from thousands of fish is challenging. Thus, it is of interest to assess whether more easily recorded traits that are genetically related to feed efficiency could be used to indirectly select for feed efficiency.

Our study showed that feed efficiency can be indirectly improved by selecting on growth rate[2,3]. Rapid growth is genetically related to improved feed efficiency. This is good news because all fish breeding programmes select for rapid growth anyway.

Moreover, selection against body lipid percentage can be used to indirectly select for lower feed intake, and thus to improve feed efficiency[4]. This is logical because extensive feed intake is related to excess lipid deposition, and lipid deposition is energetically more expensive than deposition of muscle[4]. Fish breeding programmes often control lipid deposition by selection to maintain high product quality. This has an additional benefit of maintaining high feed efficiency.

Figure 2. Rainbow trout.

Implications for selective breeding

Feed efficiency is economically a fundamental trait, and thus even small improvements are economically important. As breeding proceeds, the small genetic changes in feed efficiency accumulate from generation to generation. This leads to moderate feed efficiency changes in a longer term. For instance, during the last four generations of selection in the Finnish national rainbow trout breeding programme, growth rate has increased by ~28%[5]. Feed efficiency is expected to have increased simultaneously by 8% as a correlated genetic response. When majority of fish farmers use the improved fish material, the practical impact of the selection work is extensive. Accordingly, all efforts to increase feed efficiency will be of fundamental importance.

References

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