BREEDING SALMON FOR RESISTANCE TO INFECTIOUS PANCREATIC NECROSIS

The viral disease infectious pancreatic necrosis (IPN) has been a major constraint on salmon aquaculture. Research funded by the Biotechnology and Biological Sciences Research Council, led by Professors Stephen Bishop, John Woolliams and Chris Haley at the University of Edinburgh's Roslin Institute, demonstrated that host resistance is a heritable trait and that observed genetic differences are almost entirely due to variation in a single quantitative trait locus (QTL) of the salmon genome. The large effect of the QTL on resistance was consistent in seawater cages and in controlled freshwater experiments. Fish inheriting two copies of the resistant variant of the QTL have negligible mortality, whereas those receiving the susceptible variant from both parents have mortality levels higher than 50 per cent during epidemics.

Dr Ross Houston has continued the research using high-throughput sequencing technology to study differences in DNA and RNA sequence between salmon carrying resistant variants and those carrying susceptible variants. This has enabled detection of more closely linked single nucleotide polymorphism (SNP) markers that show association with resistance to the IPN virus at the population level.

Incorporation of these improved markers into selective breeding programmes has further improved the accuracy and simplicity of genetic tests that enable the identification of IPN-resistant fish at an early stage.

GLOBAL IMPACT ON FISH FARMING

Infectious pancreatic necrosis (IPN) outbreaks can affect salmon farms in Scotland, Norway, Chile and other salmon-producing countries. Typical mortality levels in an epidemic are around 25 per cent, and severe outbreaks are known to kill as many as 90 per cent of farmed fish. No vaccine is effective in very young fish.

As a result of the University of Edinburgh's research, genetic markers have been identified that enable selection of salmon lines with improved IPN virus resistance.

This is estimated to have produced an additional £26 million in gross value added for the UK ecnomy annually. In addition, the main commercial supplier involved in the research has a substantial share of the international market in eggs and young fish, meaning the impact of the research has wide global impact.

ECONOMIC BENEFITS

In 2008 the salmon-breeding company Landcatch Natural Selection (LNS) implemented marker-assisted selection (MAS) for IPN resistance when selecting its elite and commercial salmon populations. This is one of the first successful documented examples of MAS in any aquaculture species. A licence agreement between the Roslin Institute and LNS enabled a molecular genetic test for IPN resistance incorporating the QTL resistance markers to be sold internationally to aquaculture companies.

IPN resistance, using MAS, can reduce IPN mortality from an average of 25 per cent to virtually zero. Taking account of the market share of LNS for the eggs and smolts required by the UK salmon industry, this equates to an economic impact of £26 million gross value added, through reduced costs and losses, as well as greater output of marketable salmon, supporting between 360 and 450 jobs across the UK. As LNS also supplies 15-20 per cent of the eggs and smolts required by the global salmon farming industry, there is also a substantial international economic impact.

The UK's salmon farming is heavily concentrated in the Scottish Highlands and Islands, and therefore provides employment in some of the remotest communities where alternative opportunities are limited. Severe outbreaks of IPN are potentially devastating for such communities.

Implementation of the findings also reduces the ecological impact of salmon farming, as IPN is an endemic infectious disease that affects both wild and farmed salmon.

JUST ADD CHIPS

The research translation process has served as a paradigm for other economically important diseases. Landcatch Natural Selection (LNS) received funding from the Technology Strategy Board and BBSRC through their Genomes UK competition to develop a high-density salmon SNP chip, which will be a key tool for improving the competitiveness and sustainability of the UK salmon farming industry. These SNP chips are now being used to select salmon for increased resistance to sea louse infestations.

The SNP chip and the IPN resistance research have involved collaborations between the University of Edinburgh and partners including Edinburgh Genomics, the Universities of Stirling and Glasgow, and commercial operators LNS and Affymetrix.

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