Advancing the Understanding of Biosafety

Latest scientific findings,

policy responses and public participation

Lecture

Transgenic Fish - How to Assess Contained Use Applications

Antonietta Guitiérrez Rosati

Session

Risk Assessment

An Appraisal of Current Approaches

Nagoya

7. - 9. October 2010

Prof. Antonietta Guitiérrez Rosati
Universidad Nacional Agraria La Molina – Lima, Peru

Introduction

Several public and private research groups are following the aim of developing and finally marketing GE fish. The commonly used methodology is the microinjection of the recombinant DNA fragment into fertilized fish eggs or early embryos. Inducing transgenesis in fish is a relatively inefficient process. Only about 1% of the treated eggs will stably incorporate the recombinant DNA into its genome and subsequently transmit the transgene to its progeny. The use of growth hormone (GH) genes has been most popular. At least 14 species of fish have been genetically modified with GH genes, and although they mostly grow faster than controls, they do not necessarily grow to a larger mature size. The economic aim of this research is a reduction of costs of feed stuff and raising time. Up to now no GE fish has been approved for commercial production. There are many concerns about the use of modern biotechnology in aquaculture in developing countries, in relation to the environment and human health but also in relation to socioeconomic considerations and intellectual property rights (IPR) and also whether or not good biosafety regulations are in place.

Impacts of Transgenes

A fish which expresses the target gene at an acceptable level may not be able to transmit the gene to progeny due that many GE fish are genetically mosaic individuals and unless the gonads possess the transgenes, the trait may not be hereditable. Pleiotropic effects also need to be considered when assessing the properties and impacts of GE fish. When GE coho salmon was compared to a control group, it was found that the genetic engineering process had affected the activity of a number of naturally existing genes. These changes included an increased amount of the protein parvalbumin-b, a protein that has been identified as a major food allergen in fish.

Because transgenes are patentable and developing countries are forced to allow for their patenting when joining the WTO, IPR issues are of spezial concern. Developing countries are frequently disadvantaged in the use of, and access to, IPR because of increasingly protective attitudes taken by owners of IPR (CIPR 2002). A further area of debates are issues of animal welfare with regard to accelerating industrial meat production through GE applications.

Contained Use

When considering adverse effects on biodiversity, it is very important to consider that the escapes of GE farmed fish are unpredictable in terms of damages, primarily due to the poor knowledge we have about aquatic biodiversity. The major focus of the relevant literature is on the effects of escaped GE fish on populations of their natural counterparts, but it is important also to bear in mind possible impacts on aquatic ecosystems as a whole. Risks might arise from the transmission of transgenes to wild fish or the establishment of the GMO itself as permanent inhabitant of an aquatic ecosystem.

To adress these concerns, a number of research efforts to develop systems for sterile fish production are being made. The techniques include triploidisation, antisense transgenics, ribozymes and gene targeting (Maclean & Laight 2000). According to the authors, adopting a precautionary approach should be a general rule, but still each individual case needs studies, appraisals and the establishment of best possible containment measures before ap-

proval for commercial production should be given. Scientists of the Swedish Gothenburg University recognized that GE fish has a great potential to revolutionise commercial aquiculture, but advised the EU to take precautions and to avoid their culture in open systems.

GE fish risk assessment depends on a number of factors (Aleströ & de la Fuente 1999): (i) the species released and the biotope it is released into, (ii) the character of the transgene and the new phenotype, (iii) the general fitness of the GMOs versus wild populations, and finally, (iv) the number of released GE fish, which is an important factor. Many authors consider GE fish as an „exotic“ species which behaviour is hard to predict. "Case by case & step by step" risk research and risk assessment, starting with physically contained testing, moving to confined field tests via small scale and intermediate scale to large scale are necessary to decide about moving forword from research to development and finally commercialisation.

Triploidization

The creation of triploid genomes is a measure to suppress the appearance of ecological risks arising from the mating between GE and non-GE fish, considering that triploids are sterile. Triploids would also be economically beneficial for the developers because it hinders unauthorised breeding of the transgenes. In practice, it is possible to develop tests triploidy, but not on sterility. In some species a certain percentage of triploid individuals could be in fact fecund. Additionally, it would be very useful to induce the reversion of sex in GE fish, so that only females grow up (Maclean & Laight 2000). However, neither of these approaches is 100% effective, nor can the genetic changes induced by triploidy be accurately assessed, monitored or controlled.

Atlantic GE Salmon

The most advanced project is conducted by AquaBounty Technologies Inc, with headquarters in Massachusetts (USA), that has produced and patented Atlantic GE Salmon (Salmo salar) with the gene construct pOnMTGH1. In patent application PCT/CA92/00109 (Hew & Fletcher 1992) gene sequences derived from ocean pout anti-freeze gene promoter and other fish gene sequences including chinook salmon GH gene are described. Some evidence is presented for increased growth rate and earlier smelting. Transgenic individuals were on average more than 11-fold heavier than controls. In contrast to mammals, salmonids continue to grow throughout their entire life cycle, and even small differences in specific growth rate quickly translate into very large increases in size. Since 1996, AquaBounty works on receiving the approval of the U.S. authorities to become the first producer of a GE animal for human consumption. The U.S. FDA recently announced that the risk assessment has been concluded and that neither health nor environmental risks are to be expected based on the data provided by the company[1]. Anticipating a large public interest in this issue, the FDA will hold public expert meetings in September 2010 to discuss the biosafety data and conclusions, but also issues on labelling food from GE fish. The expert meeting was not able to come to recommendations, because many experts regarded AquaBounty’s data as too weak and premature (Heavey 2010, Voosen 2010).

1 U.S. FDA: Public Meetings on Genetically Engineered Atlantic Salmon, http://www.fda.gov/NewsEvents/PublicHealthFocus/ucm224089.htm

REFERENCES

Aleströ, P., de la Fuente J. 1999. Genetically Modified Fish in Aquaculture: Technical, Environmental and Management Considerations. Biotecnología Aplicada 16:127-130. http://elfosscientiae.cigb.edu.cu/PDFs/BA/1999/16/2/127-130.pdf

CIPR. 2002. Integrating Intellectual Property Rights and Development Policy. Commission on Intellectual Property Rights, UK. http://www.iprcommission.org/graphic/documents/final_report.htm

Heavey, S. 2010. Salmon leaves many questions. Thomson Reuter, 20.09.2010 http://www.reuters.com/article/idUSTRE68J0EZ20100921

Hew C. L., Fletcher, G.L. 1992. Gene construct for production of transgenic fish. Patent WO/1992/016618 http://www.wipo.int/pctdb/en/wo.jsp?WO=1992016618

Maclean, N. & Laight, R.J. 2000. Transgenic fish: an evaluation of benefits and risks. Fish and Fisheries, 1:146-172. http://onlinelibrary.wiley.com/doi/10.1046/j.1467-2979.2000.00014.x/abstract

Voosen, P. 2010. Panel advises more aggressive FDA analysis of engineered salmon. The New York Times, 21.09.2010. http://www.nytimes.com/gwire/2010/09/21/21greenwire-panel-advises-more-aggressive-fda-analysis-of-71171.html

BIBLIOGRAPHY

Bartley, D.M., Hallerman, E.M. 1995. A global perspective on utilisation of genetically modified organisms in aquaculture and fisheries. Aquaculture 137: 1-7.

Beardmore, J.A.; Porter, J.S. Genetically modified organisms and aquaculture. FAO Fisheries Circular. No. 989. Rome, FAO. 2003. 35p. ftp://ftp.fao.org/docrep/fao/006/y4955e/Y4955E00.pdf

Beardmore, J.A.B., Mair, G.C. & Lewis, R.I. 1997. Biodiversity in aquatic systems in relation to aquaculture. Aquaculture Research 28: 829-839. http://onlinelibrary.wiley.com/doi/10.1046/j.1365-2109.1997.00947.x/abstract

Donaldson, E.M. 1997. The role of biotechnology in sustainable aquaculture. In Sustainable Aquaculture ed. J.E. Basdad, Wiley, pp.101-126. http://www.cabdirect.org/abstracts/19981408756.html

Anderson, L. 2004. Genetically engineered fish - New threats to the environment. ed. Greenpeace International http://www.greenpeace.org/usa/en/media-center/reports/genetically-engineered-fish/

Hallerman, E.M., Kapuscinski, A.R. 1995. Incorporating risk assessment and risk management into public policies on genetically modified finfish and shellfish. Aquaculture, 137: 9-17. http://tinyurl.com/3xfectl

Hew, C.L. & Fletcher, G.L. 2001. The role of aquatic biotechnology in aquaculture. Aquaculture, 1: 191-204. http://tinyurl.com/342bs77

OECD, 1995. Proceedings of Workshop on Environmental Impacts of Aquatic Biotechnology (1992 Trondheim Norway), OECD, Paris. http://www.oecdbookshop.org/oecd/display.asp?lang=EN&sf1=identifiers&st1=971995141p1

Zhu, Z.Y. & Yong, H.S. 2000. Embryonic and genetic manipulation in fish. Cell Research,10: 17-27. http://www.nature.com/cr/journal/v10/n1/full/7290032a.html