Genetically modified fish

From Wikipedia, the free encyclopedia

Genetically modified fish (GM fish) are genetically modified organisms. The DNA of the fish has been modified using genetic engineering techniques. In most cases the aim is to introduce a new trait to the fish which does not occur naturally in the species. GM fish are used in scientific research, and while they are being developed for use in aquaculture food production, as of May 2012 no GM fish has been approved by the FDA for this purpose.[1] Some GM fish that have been created have promoters driving an over-production of "all fish" growth hormone. This resulted in dramatic growth enhancement in several species, including salmonids,[2] carps[3] and tilapias.[4][5]

Critics have objected to GM fish per se on several grounds, including ecological concerns, and with respect to whether using them as food is safe and whether GM fish are needed to address the world's food needs. See the genetically modified food controversies article for discussion of issues about GM food and Regulation of the release of genetic modified organisms for discussion of regulatory regimes around the world.

External video

Terry Bradley: Transgenic Fish (http://www.youtube.com /watch?v=fVx9m3ucGcY) *YouTube*

Contents

History and Process

Main article: Genetic engineering

The history and key methods of genetic engineering are discussed on that page in detail.

Generally, genetic modification entails manipulation of DNA. The process is known as cisgenesis when a gene is transferred between organisms that could be conventionally bred, or transgenesis when a gene from one species is added to a different species. Gene transfer into the genome of the desired organism, as for fish in this case, requires a vector like a lentivirus or mechanical/physical insertion of the altered genes into the nucleus of the host by means of a micro syringe or a gene gun.[6]

The first recorded instances of production of transgenics in aquatic species are those of Maclean and Talwar (1984)[7] in rainbow trout and Zhu et al. (1985)[8] in goldfish.[9] Since then over 35 species have been genetically engineered in research laboratories.[10]

Types

Salmon

Salmon belong to the Salmonidae family which also includes salmon and trout. Although the smallest species is just 13 centimetres (5.1 in) long as an adult, most are much larger, and the largest can reach 2 metres (6.6 ft).[11] All salmonids spawn in fresh water, but they spend most of their maturity in the sea. This life style is known as anadromous. They are considered to be predators, because they feed on small crustaceans, aquatic insects, and smaller fish.[11] A genetically modified Atlantic salmon known as the AquAdvantage salmon has an increased growth rate and size over the wild type Atlantic salmon from which it was derived, up to doubling its weight with a reduced time of growth to maturity.[12] Although materials have been submitted to obtain approval to grow and market the AquaAdvantage salmon, as of December 2012 the FDA had not granted approval.[1][13]

Tilapia

Nile tilapia

Tilapia is the common name for several species of cichlid fish from the tilapine cichlid tribe. Tilapia inhabit a wide range fresh water habitats, including lakes, streams, ponds and rivers. Anciently, tilapia hold great significance in artisan fishing in Africa, and are paramount lately in aquaculture. Tilapia are very vulnerable to cold temperatures, and thus survive well with temperatures above 60 °F (16 °C). (See tilapia as exotic species.)[14]

Tilapia is the fifth most important fish in fish farming, with production reaching 1,505,804 metric tons in 2000.[15] Because of their large size, rapid growth, and palatability, tilapiine cichlids are the focus of major farming efforts, specifically various species.

Zebrafish

Zebrafish are freshwater fish and are part of the Cyprinidae. They are a popular aquarium fish, commonly sold as zebra danio, and have been very vital as model organisms in research. They derive their name from the uniform horizontal stripes along the side of the body bilaterally. Males bear gold stripes within the blue stripes, while females bear silver stripes within the blue stripes. Zebrafish can mature up to 6.4 centimeters in the wild, but usually it is rare for them to mature beyond 4” in captivity.[16]

Uses - actual and potential

Research

Most genetically engineered fish are used in basic research in genetics and development. Two species of fish, zebrafish and medaka, are most commonly modified because they have optically clear chorions (shells), rapidly develop, and the 1-cell embryo is easy to see and microinject with transgenic DNA.[17] Also, zebrafish have the capability of regenerating their organ tissues, and GM zebrafish are being explored for benefits of unlocking human organ tissue diseases and failure mysteries. For instance zebrafish are used to understand heart tissue repair and regeneration in efforts to study and discover cures for cardiovascular diseases.[18]

Pets

The GloFish is a patented[19] brand of genetically modified (GM) fluorescent zebrafish with bright red, green, and orange fluorescent color. Although not originally developed for the ornamental fish trade, it became the first genetically modified animal to become publicly available as a pet when it was introduced for sale in 2003.[20] They were quickly banned for sale in California.[21]

Food (potential)

Genetically modified fish have been developed with promoters driving an over-production of "all fish" growth hormone for use in the aquaculture industry to increase the speed of development and potentially reduce fishing pressure on wild stocks. This has resulted in dramatic growth enhancement in several species, including salmon,[22] trout[23] and tilapia.[24]

AquaBounty, the leading company in GM fish for the food industry, claims that their GM AquAdvantage salmon can mature in half the time it takes non-GM salmon and achieves twice the size.[25] AquaBounty has applied for regulatory approval to market their GM salmon in the US. As of May 2012 the application was still pending.[1]

Detecting aquatic pollution (potential)

Several academic groups have been developing GM zebrafish to detect aquatic pollution. The lab that originated the GloFish discussed above originally developed them to change color in the presence of pollutants, to be used as environmental sensors.[26][27] A lab at University of Cincinnati has been developing GM zebrafish for the same purpose,[28][29] as has a lab at Tulane University.[30]

Regulation

Main article: Regulation of the release of genetic modified organisms

The regulation of genetic engineering concerns the approaches taken by governments to assess and manage the risks associated with the development and release of genetically modified crops. There are differences in the regulation of GMOs between countries, with some of the most marked differences occurring between the USA and Europe. Regulation varies in a given country depending on the intended use of the products of the genetic engineering. For example, a fish not intended for food use is generally not reviewed by authorities responsible for food safety.

Controversy

Main articles: Genetically modified food controversies and Human genetic engineering

Critics have objected to use of genetic engineering per se on several grounds, including ethical concerns, ecological concerns (especially about gene flow), and economic concerns raised by the fact GM techniques and GM organisms are subject to intellectual property law. GMOs also are involved in controversies over GM food with respect to whether using GM fish as safe is safe, whether it would exacerbate or cause fish allergies, whether it should be labeled, and whether GM fish and crops are needed to address the world's food needs. These controversies have led to litigation, international trade disputes, and protests, and to restrictive regulation of commercial products in most countries. See the genetically modified food controversies article for discussion of issues about GM fish and GM food.

With respect to concerns about GM AquAdvantage Salmon interbreeding with wild fish, the company indicates that their GM salmon are not capable of reproducing, as the GM fish are sterile.[12] AquaBounty also emphasizes that their GM fish would not survive wild conditions due to the geographical locations where their research is being done, as well as the locations of their farms.[12]

An article in Slate Magazine in December 2012 by Jon Entine, Director of the Genetic Literacy Project, criticized the Obama Administration for preventing the publication of the environmental assessment (EA) of the AquAdvantage Salmon, which was completed in April 2012 and which concluded that "the salmon is safe to eat and poses no serious environmental hazards."[31] The Slate article said that the publication of the report was stopped "after meetings with the White House, which was debating the political implications of approving the GM salmon, a move likely to infuriate a portion of its base".[31] Within days of the article's publication and less than two months after the election, the FDA released the draft EA and opened the comment period.[32]

Notes

1. ^ *a b c* Andrew Pollack for the New York Times. "An Entrepreneur Bankrolls a Genetically Engineered Salmon" (http://www.nytimes.com/2012/05/22/business/kakha-bendukidze-holds-fate-of-gene-engineered-salmon.html?pagewanted=all) Published: May 21, 2012. Accessed September 3, 2012 [1] (http://www.nytimes.com/2012/05/22/business/kakha-bendukidze-holds-fate-of-gene-engineered-salmon.html?pagewanted=all)
2. ^ Jun Du, Shao; Zhiyuan Gong, Garth L. Fletcher, Margaret A. Shears, Madonna J. King, David R. Idler & Choy L. Hew (1992). "Growth Enhancement in Transgenic Atlantic Salmon by the Use of an "All Fish" Chimeric Growth Hormone Gene Construct" (http://www.nature.com/nbt/journal/v10/n2/abs/nbt0292-176.html). *Bio/Technology* **10** (2): 176–181. doi:10.1038/nbt0292-176 (http://dx.doi.org/10.1038%2Fnbt0292-176). Retrieved 28 May 2009.
3. ^ Devlin, Robert; Carlo A. Biagi, Timothy Y. Yesaki, Duane E. Smailus & John C. Byatt (15 February 2001). "Growth of domesticated transgenic fish" (http://www.nature.com/nature/journal/v409/n6822/full/409781a0.html). *Nature* **409** (6822): 781–782. doi:10.1038/35057314 (http://dx.doi.org/10.1038%2F35057314). PMID 11236982 (//www.ncbi.nlm.nih.gov/pubmed/11236982). Retrieved 28 May 2009.
4. ^ Rahman, M. A.; A. Ronyai, B. Z. Engidaw, K.Jauncey, G-L. Hwang, A. Smith, E. Roderick, D.Penman, L.Varadi, N. Maclean (19 Apr 2005). "Growth and nutritional trials on transgenic Nile tilapia containing an exogenous fish growth hormone gene" (http://www3.interscience.wiley.com/journal/118974519/abstract?CRETRY=1&SRETRY=0). *Journal of Fish Biology* **59** (1): 62–78. doi:10.1111/j.1095-8649.2001.tb02338.x (http://dx.doi.org/10.1111%2Fj.1095-8649.2001.tb02338.x). Retrieved 28 May 2009.
5. ^ Hackett, P.B. and Alvarez, M.C. (2000) The molecular genetics of transgenic fish. Recent Adv. Mar. Biotech., 4, 77-145.
6. ^ Csiro. Genetic modification (http://www.csiro.au/resources/WhatIsGM)
7. ^ Maclean, N. & Talwar, S. 1984. Injection of cloned genes with rainbow trout eggs. *Journ. Embryol and Exp. Morphol.* 82 (Supp) 187.[2] (http://dev.biologists.org/content/82/Supplement/186.full.pdf+html) (note: Journal name is now "Development" [3] (http://dev.biologists.org/content/by/year))
8. ^ Zhu, Z.Y., Li, G., He, L. & Chen, S. 1985. Novel gene transfer into the fertilised eggs of the goldfish (Carassius auratus L. 1758). *Journ. Appl. Ichthyol.* 1: 31-34. doi:10.1111/j.1439-0426.1985.tb00408.x (http://dx.doi.org

/10.1111%2Fj.1439-0426.1985.tb00408.x)
9. ^ FAO History page (http://www.fao.org/docrep/006/y4955e/y4955e05.htm#TopOfPage)
10. ^ Van Eenennaam, AL. University of California, Davis Extension Service. Genetic Engineering and Fish Fact Sheet. 2003.[4] (http://anrcatalog.ucdavis.edu/pdf/8185.pdf)
11. ^ *a* *b* Salmonidae
12. ^ *a* *b* *c* Environmental Assessment for AquAdvantage Salmon (http://www.fda.gov/downloads/AdvisoryCommittees/CommitteesMeetingMaterials/VeterinaryMedicineAdvisoryCommittee/UCM224760.pdf)
13. ^ Staff (26 December 2012) Draft Environmental Assessment and Preliminary Finding of No Significant Impact Concerning a Genetically Engineered Atlantic Salmon; Availability (http://www.gpo.gov/fdsys/pkg/FR-2012-12-26/pdf/2012-31118.pdf) Federal Register / Vol. 77, No. 247 / Wednesday, December 26, 2012 / Notices, Retrieved 2 January 2013
14. ^ Chapman, Frank. "Culture of Hybrid Tilapia: A Reference Profile" (http://edis.ifas.ufl.edu/FA012). *Stanford Magazine* (Institute of Food and Agricultural Sciences) (Circular 1051.). Retrieved 2012-03-10.
15. ^ Fessehaye, Yonas (2006). *Natural mating in Nile tilapia (Oreochromis niloticus L.) Implications for reproductive success, inbreeding, and cannibalism* (http://edepot.wur.nl/22920) (PDF). Wageningen: Wageningen UR. p. 150. ISBN 90-8504-540-1.
16. ^ Smith C. "The behaviour and ecology of the zebrafish, Danio rerio". *Biological Reviews* **83** (February 2008): 13–34. doi:10.1111/j.1469-185X.2007.00030.x (http://dx.doi.org/10.1111%2Fj.1469-185X.2007.00030.x). PMID 18093234 (//www.ncbi.nlm.nih.gov/pubmed/18093234). More than one of `|last1=` and `|last=` specified (help); `|accessdate=` requires `|url=` (help)
17. ^ Hackett, P.B., Ekker, S.E. and Essner, J.J. (2004) Applications of transposable elements in fish for transgenesis and functional genomics. Fish Development and Genetics (Z. Gong and V. Korzh, eds.) World Scientific, Inc., Chapter 16, 532-580.
18. ^ Major R and Poss K. (2007) Zebrafish Heart Regeneration as a Model for Cardiac Tissue Repair. Drug Discov Today Dis Models. 4(4): 219–225 [5] (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2597874/pdf/nihms58902.pdf)
19. ^ Published PCT Application WO2000049150 "Chimeric Gene Constructs for Generation of Fluorescent Transgenic Ornamental Fish." National University of Singapore [6] (http://patentscope.wipo.int/search/en/detail.jsf?docId=WO2000049150)
20. ^ Eric Hallerman Glofish, The First GM Animal Commercialized: Profits amid Controversy. June, 2004. Accessed September 3, 2012.[7] (http://www.isb.vt.edu/articles/jun0405.htm)
21. ^ Schuchat S. (2003) Why GloFish won't glow in California. San Francisco Chronicle.[8] (http://sfgate.com/cgi-bin/article.cgi?f=/c/a/2003/12/17/EDGQV3KOLB1.DTL)
22. ^ Shao Jun Du et al. (1992) Growth Enhancement in Transgenic Atlantic Salmon by the Use of an "All Fish" Chimeric Growth Hormone Gene Construct. Nature Biotechnology 10, 176 - 181 [9] (http://www.nature.com/nbt/journal/v10/n2/abs/nbt0292-176.html)
23. ^ Devlin RF et al (2001) Growth of domesticated transgenic fish. Nature 409, 781-782 [10] (http://www.nature.com/nature/journal/v409/n6822/full/409781a0.html)
24. ^ Rahman MA et al. (2001) Growth and nutritional trials on transgenic Nile tilapia containing an exogenous fish growth hormone gene. Journal of Fish Biology 59(1):62–78 [11] (http://onlinelibrary.wiley.com/doi/10.1111/j.1095-8649.2001.tb02338.x/abstract)
25. ^ {AquAdvantage salmon}[12] (http://www.aquabounty.com/products/aquadvantage-295.aspx)
26. ^ National University of Singapore Enterprise webpage (http://r2m.nus.edu.sg/cos/o.x?c=/r2m/pagetree&func=view&rid=5858)
27. ^ Zebra Fish as Pollution Indicators (http://web.archive.org/web/20011109034604/http://nus.edu.sg/corporate/research/gallery/research12.htm) Page last modified on 31 July 2001. Accessed October 2012
28. ^ Carvan MJ et al (2000) Transgenic zebrafish as sentinels for aquatic pollution. Ann N Y Acad Sci. 2000;919:133-47 [13] (http://www.ncbi.nlm.nih.gov/pubmed/11083105)
29. ^ Nebert DW et al (2002) Use of Reporter Genes and Vertebrate DNA Motifs in Transgenic Zebrafish as Sentinels for Assessing Aquatic Pollution. Environmental Health Perspectives 110(1):A15 | January 2002 [14] (http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1240712/pdf/ehp0110-a0012d.pdf)
30. ^ Mattingly CJ et al (2001) Green fluorescent protein (GFP) as a marker of aryl hydrocarbon receptor (AhR) function in developing zebrafish (Danio rerio). Environ Health Perspect. 2001 Aug;109(8):845-9 [15] (http://www.ncbi.nlm.nih.gov/pubmed/11564622)
31. ^ *a* *b* Jon Entine for Slate Magazine. Wednesday, Dec. 19, 2012 Is the White House Interfering With a Scientific Review? (http://www.slate.com/articles/health_and_science/science/2012/12/genetically_modified_salmon_aquadvantage_fda_assessment_is_delayed_possibly.html)
32. ^ Brady Dennis for the Washington Post. December 21, 2012. Genetically altered salmon are safe, FDA says (http://www.washingtonpost.com/national/health-science/genetically-altered-salmon-are-safe-fda-says/2012/12/21/36a20512-4b90-11e2-b709-667035ff9029_story.html) accessdate=2012-12-22

References

- Greenberg, Paul (2011). *Four Fish: The Future of the Last Wild Food*. Penguin. ISBN 0-14-311946-X.