More resource and cost efficient production through selective breeding

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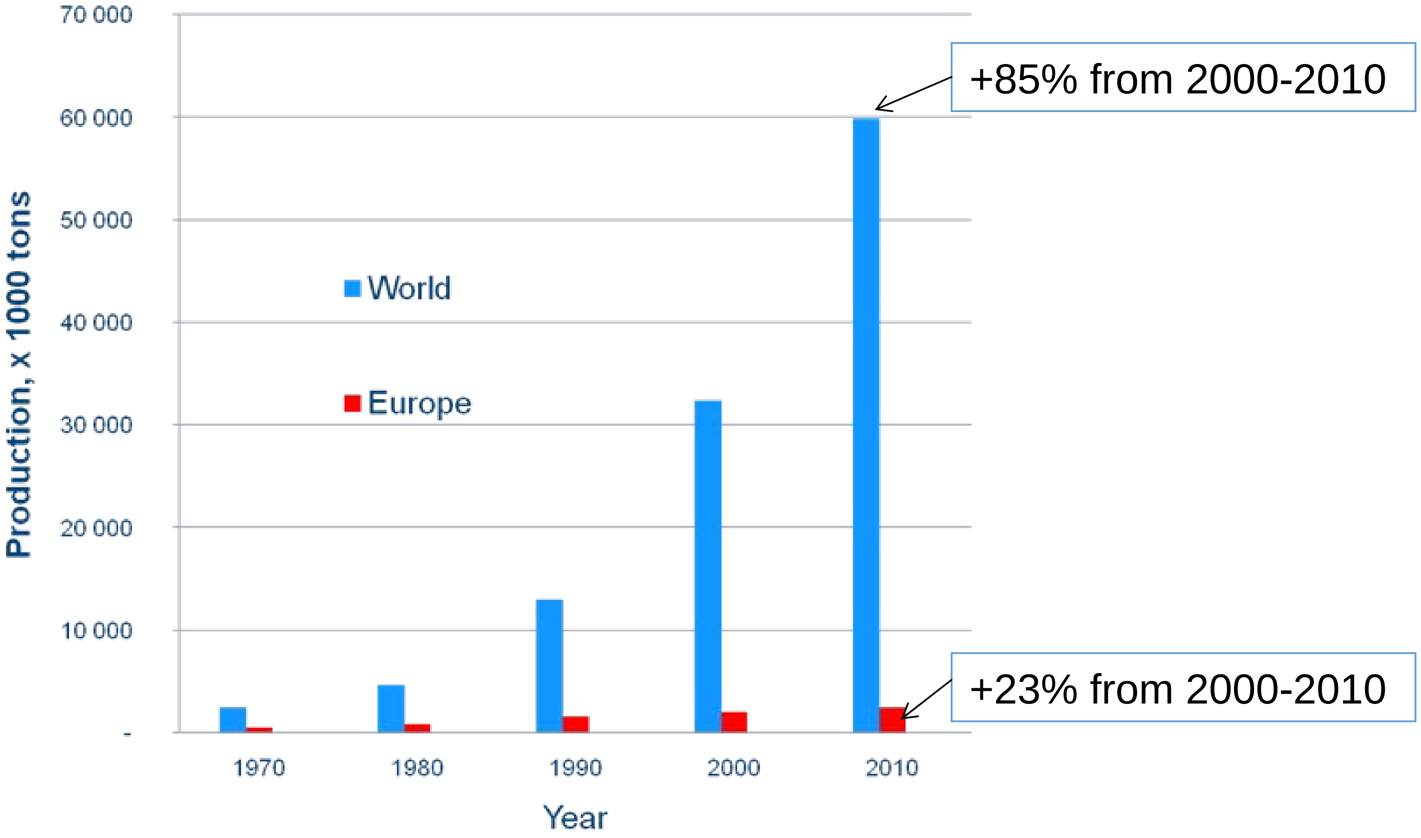
Introduction

- Aquaculture production the fastest growing food production with an increase of 7.5% per year

- In 2010 world production of fish and shellfish was 60 mill. tons
  - expected production in 2014 is 80 mill. tons
  - will pass the volume of capture fisheries (91 mill tons) in 2016

- Production of aquatic plants 19 mill. tons in 2010
  - expected production in 2014 26 mill. tons

World and European aquaculture production, 1000 tons (FAO)

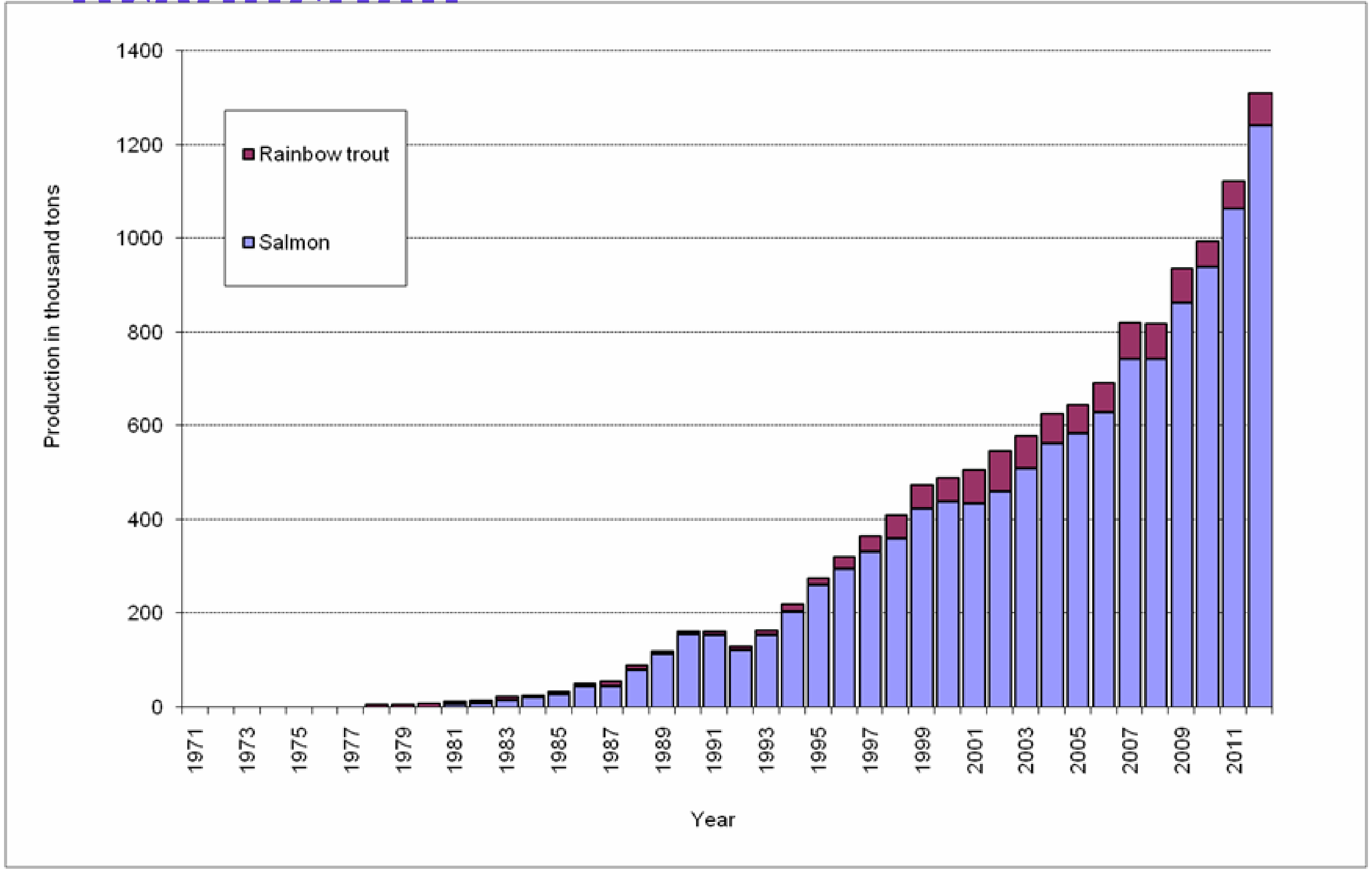


Aquaculture production in Europe, x1000 tons

Country	Prod. 2010	ΔP (%) 2001-2010	No. of species
Norway	1 008	98	11
Spain	252	-19	36
France	224	-11	28
UK	201	18	18
Italy	153	-30	38
Russia	120	34	19
Greece	113	16	15
Netherlands	67	17	12
Faroe Islands	48	-3	2
Ireland	46	-24	10
Germany	41	-22	13
Denmark	40	-4	8
Poland	31	10	10
Czech	24	-20	13
Ukraine	23	26	18
Hungary	14	8	12
Croatia	14	27	16
Finland	12	-20	4
Sweeden	11	83	5
Other	51	14	11
Total	2 493	20	

-5 % without Norway

Development of Norwegian production



Key success factors for the Norwegian industry

- Atlantic salmon an unique and well known product - exported to more than 100 countries

- Research and development from the very start in the 1970's
  - Selective breeding
  - Fish nutrition and feed manufacturing technology
  - Vaccines
  - Cooperation between Research and Industry

Benefit of genetic improvements

- Shorter production cycle (reduced risk)
- Increased resource efficiency
  - feed, land, water and labour per unit of product
- 'Tailor maid' products
- Full benefit of improvements in other factors
  (e.g feed, technology) - A better car is needed to get full benefits of
  a better road, and vice versa.
- Highly favourable Benefit/Cost ratios

History of selective breeding

- Science of animal and plant selective breeding - **1920-30’s**

- Selective breeding programs for farm animals and plant species – **1940-60’s**
  - Today all main animal and crop products from genetically improved breeds

- Simple breeding programs for brook trout (**1920’s**), rainbow trout (**1930’s**), chinook salmon (**1940’s**) and common carp (**1960’s**)

- More advanced family based programs for rainbow trout and Atlantic salmon in Norway – **1970’s**

Improvements - Farm animals

- **Broilers – 1957 vs. 1991 broilers and feeds**

(Havenstein et al., 2003a,b)

> 68% reduction in days to harvest
~ 66% improvement in feed efficiency
10-15% improvement in carcass yield
~ 30% improvement in carcass fat

85-90% genetics

- **Pigs – 1980 vs. 2001 pigs and feeds**

(Fix et al., 2010)

~ 15% reduction in days to harvest
~ 45% improvement in lean feed efficiency

50% genetics

Status of selective breeding programs world wide

- 101 family based breeding programs
  Neira (2010) and Rye et al. (2010)

- Species with most programs:

Nile tilapia	20
Atlantic salmon	13
Rainbow trout	13
Common carp	8

- Only about 8 % of world aquaculture production was based on family breeding programs

- Only production of Atlantic salmon that is based 100 % on genetically improved stocks

Traits to be selected for

Growth – Feed efficiency
Age at sexual maturity
Disease resistance
- bacteria
- virus
- parasites

Carcass quality traits

Year-class	Trait(s)
1972	Growth (G)
1980	G + Age at sexual maturity (SM)
1989	G + SM + Furunculosis (F)
1990	G + SM + F + Filét Colour (FC)
1992	G + SM + F + FC + Infectious Salmon Anemia (ISA) + Deformity (D)
1993	G + SM + F + FC + ISA + D + Filét Fat (FF)
1997	G + SM + F + FC + ISA + D + FF + Infectious Pancreas Necrosis (IPN)
2001	G + SM + F + FC + ISA + D + FF + IPN + Carcass Yield (CY)

Farmed Atlantic salmon, Norway

Production time (months)

Rearing period	1975	2010
Freshwater	16	8
Seawater	24	12
Total	40	20

A large part of this improvement due to selective breeding

Realized genetic gain in feed efficiency

Selected (5. gen) vs. Wild Atlantic salmon (Thodesen et. al., 1999)

Trait	Selected - Wild, %
Growth	+113
Daily feed intake, kg feed/kg growth	+40
Protein utilization	+9
Energy utilization	+14
FCR, kg feed/kg growth	-20

G10: -30% lower FCR (1.2 vs. 1.7), Prod. 1 000 000 tons

Saved feed: 500 000 tons, or

420 000 tons increased production with the same amount of feed

Atlantic salmon (fish species) are resource efficient animals

Retention of energy and protein (%)

Species	Energy	Protein
Pigs	20	13
Poultry	17	18
Wild Atlantic salmon	34	30
Selected farmed salmon	60	55

Further improvement through selective breeding

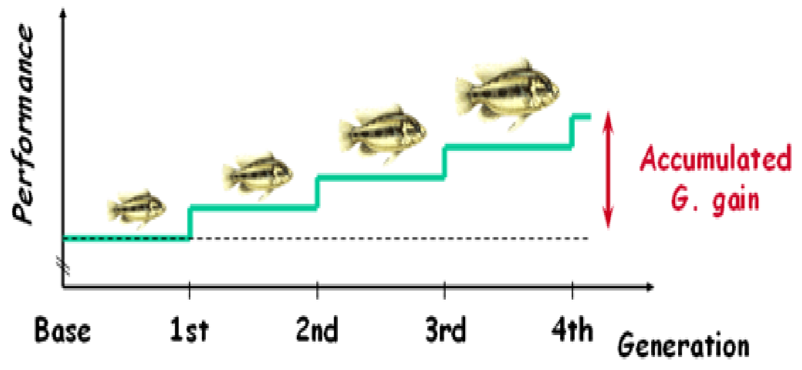
Different improvement strategies

1. Crossbreeding – for non-additive genetic effects (heterosis) and/or complementarities of breeds

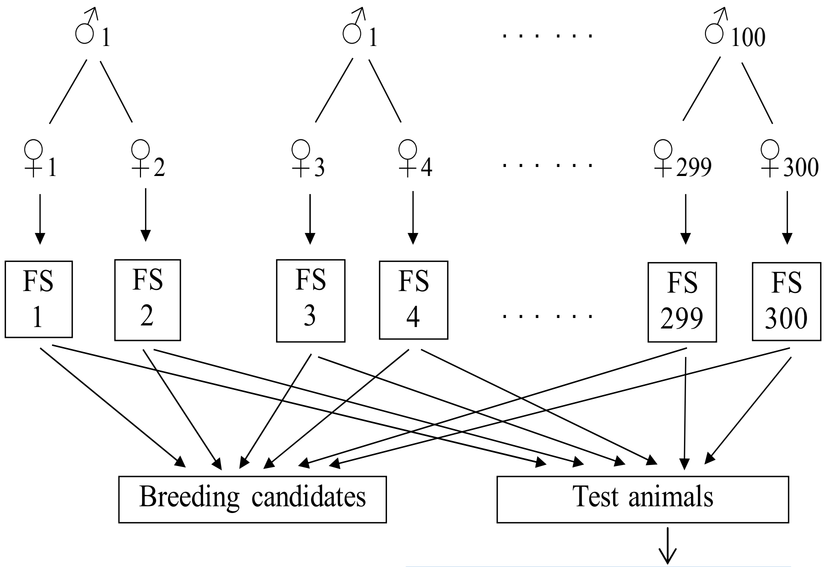
2. Pure-breeding – for additive gene effects
   - Individual (mass, phenotypic) selection – **Low cost**
   - Sib or combined (own+sib) selection – **High cost**

3. Combination of 1 and 2.

- Selection response cumulative over generations

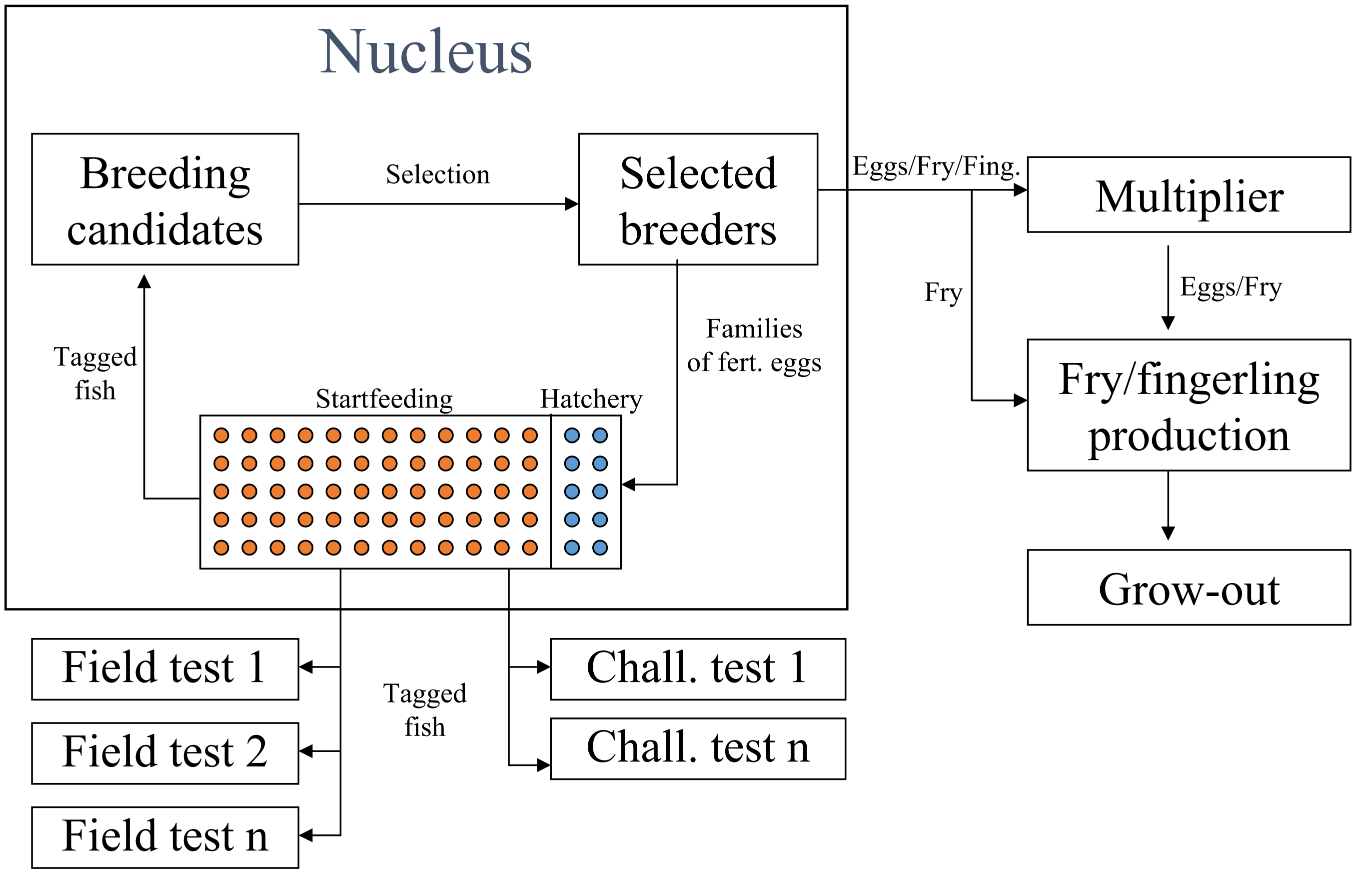


Production of family groups



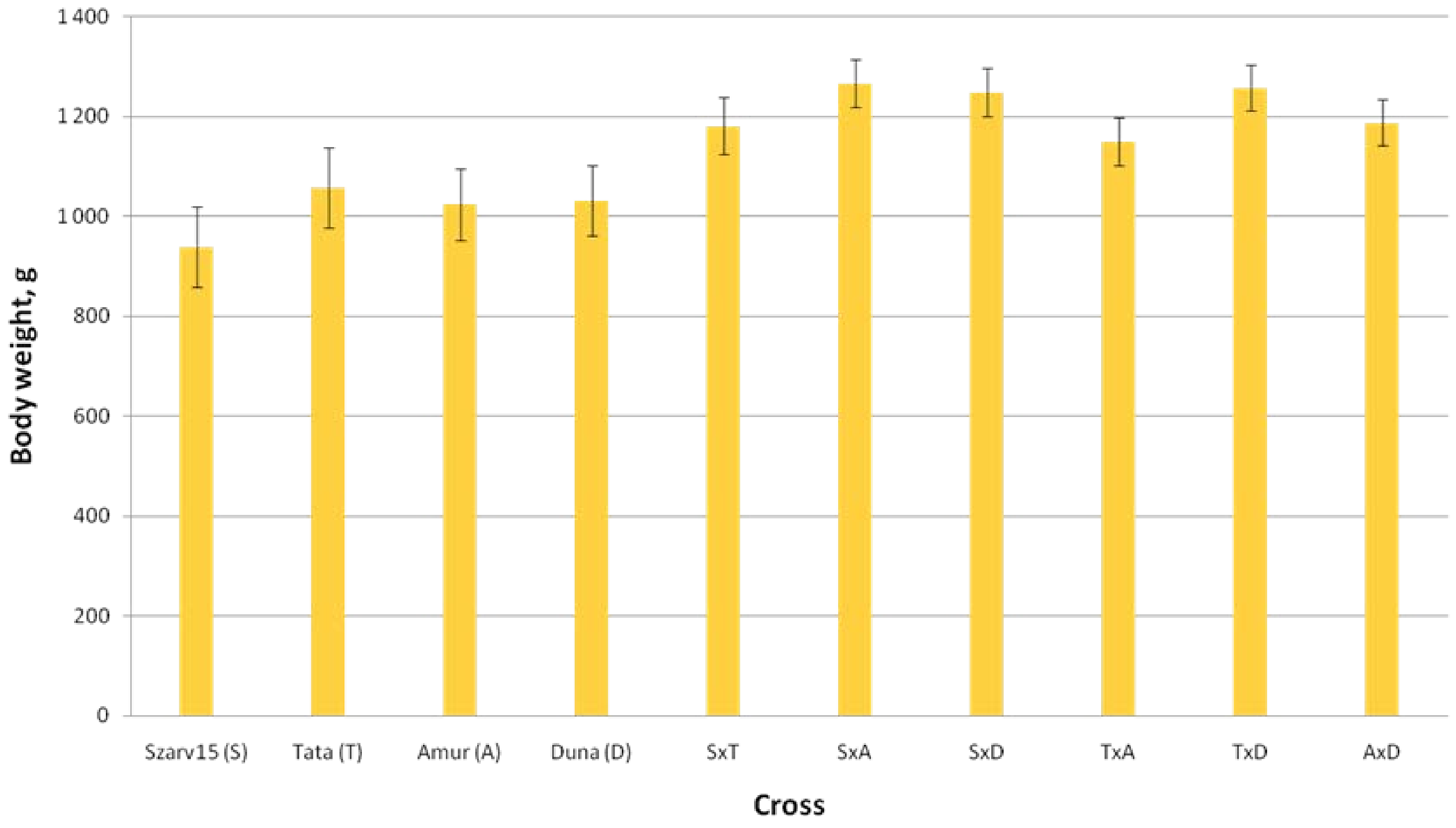
Recording of traits
- Growth
- Sexual maturity
- Disease resistance
- Carcass quality

A fish breeding program



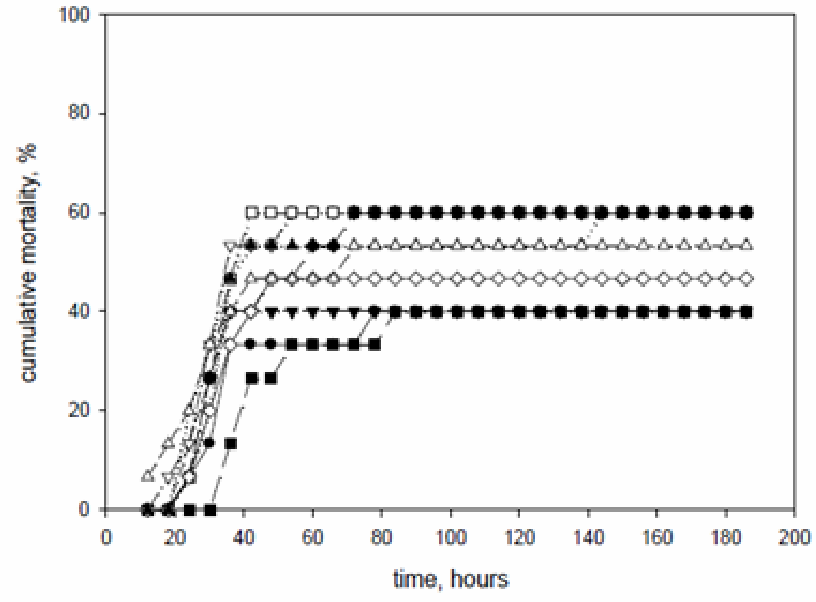
Some results from the EUROCARP project
EU-funded, 2006-2008

Body weight of common carp strains and their crosses after two growing seasons

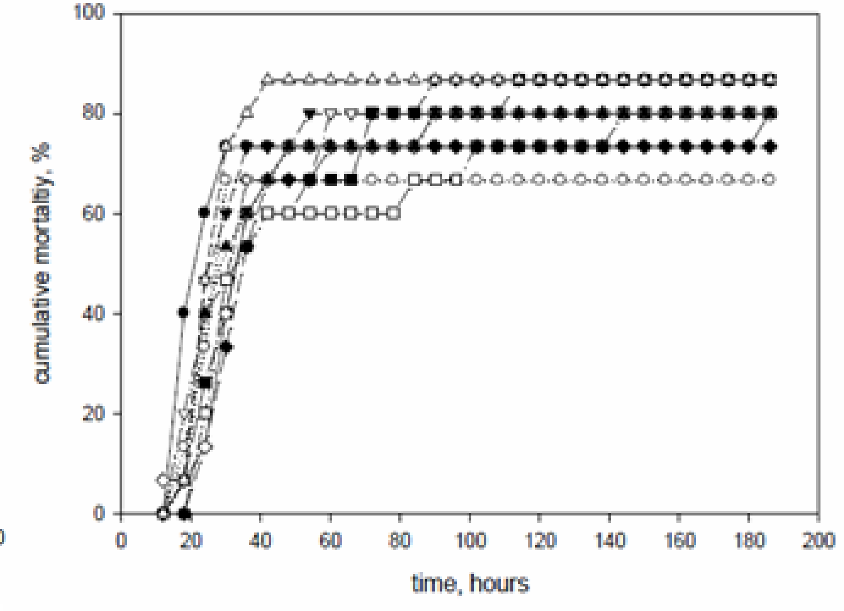


Aeromonas hydrophila infection

10 families with lowest mortality

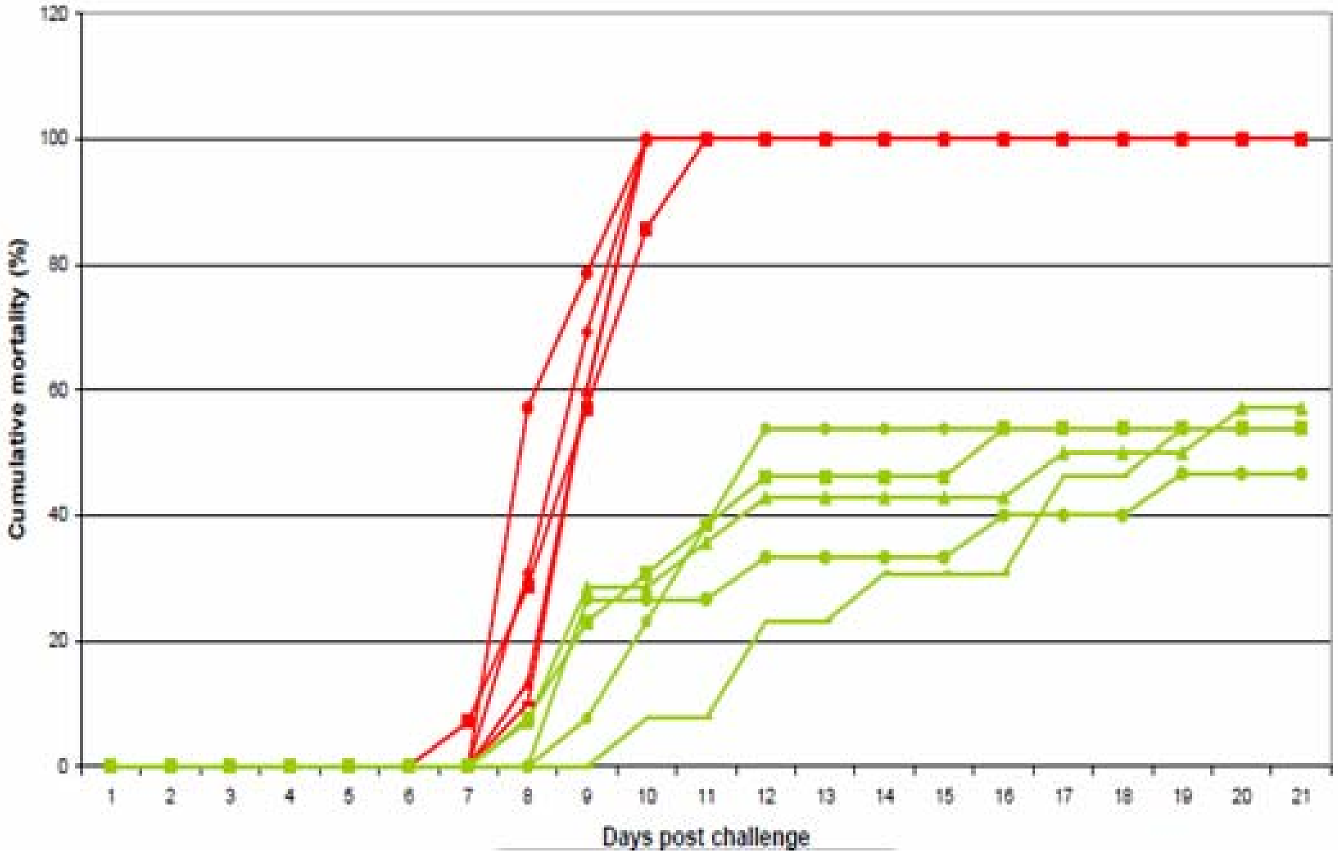


10 families with highest mortality



KHV infection

Mortality of the 10 families with highest and lowest mortality



Production of common carp in European countries in 2011

Country	Tons
Russia	56 000
Ukraina	20 000
Czech	18 000
Poland	14 000
Hungary	11 000
Serbia	6 000
Germany	5 000
France	4 000
Moldova	3 200
Lithunia	3 100
Croatia	2 900
Romania	2 800
Other	14 000
Total	**150 000**

At least 30-40 000 tons to run a family based breeding program (Morten Rye, AFGC)

Only Russia meets this requirement

The production in Ukraina, Czech, Poland and Hungary add to 63 000 tons

A breeding program for the common carp

- The breeding station (nucleus) should test at least 100 families each year.
- Each country could have a multiplier station.
- Fry/fingerlings should be sent from nucleus to multiplier stations each year.
- Multiplier stations should produce eggs and fry/fingerlings to the grow-out farmers

Take home message

The powerful technology of selective breeding is a must to be competitive with respect to both cost and product quality in the present and future food market

A cost any primary food industry must take to stay in business