Competence building for designing and running selective breeding programs for aquaculture species

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Selective breeding = Genetic improvement

- Genetic variation among individuals for important economic traits
- Identify and select the best as parents for the next generation
- Genetic gain = Increase in performance from one gen. to the next
- Genetic gain is cumulative – Like walking in a stair – High Benefit/Cost ratio
- Outcome
  - reduced production costs
  - improved product quality
  - increased resource efficiency

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Selective breeding programs for aquaculture species (Neira, 2010; Rye et al., 2010)

Questionnaire to professionals, institutions, breeding companies

Year started	No. programs using sib information		
	Developed countries	Developing countries	Total
1970 – 1979	4	0	4
1980 – 1989	5	1	5
1990 – 1999	22	11	30
2000 – 2008	31	29	60
Total	**62**	**41**	**101**

Asia (except Japan)
Africa
South-America (except Chile)
Central America
Caribbean

Asia: 28
Africa: 6
Latin America: 7

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Breeding programs that use sib information (Gjedrem et al., 2012)

Table 12
Impact of selective breeding programs on the production of different aquaculture species (modified from Neira, 2010 and Rye et al., 2010).

Species	No. of programs[a]	No. of families per program	Average no. of traits selected	World prod. in 2005, (1000 tonnes)
Common carp	8	76	2.0	3044
Rohu carp	1	60–70	2	1196
Silver barb	1	–	1	97
Tilapia Nile	20	229	3.6	1703
Tilapia blue	2	90	2.0	2
Tilapia red	4	125	4.0	–
Tilapia *O. shiranus*	1	51	1.0	–
Channel catfish	1	200	4	380
African catfish	1	70	1	29
Striped catfish	1	182	3	436
Atlantic salmon	13	280	5.4	1236
Chinook salmon	2	100	1.5	24
Coho salmon	4	133	2.7	117
Rainbow trout	13	206	5.2	487
European whitefish	1	70	2.0	1
Turbot	2	60	1.0	7
Atlantic cod	3	110	4.0	8
European seabass	3	100	5	58
Sea bream	4	100	6	111
Freshwater prawn	2	82	1	205
Shrimp, *P. monodon*	3	212	–	723
Shrimp, *P. vannamei*	4	197	2.0	1599
Abalone	3	210	1.7	334
Oysters	3	48	4.3	4615
Mussel	1	60	3.0	1410
Total listed species	101	–	–	17,822
Total all species	–	–	–	48,150[b]

8 % of production based on improved species

Close to 100 % for the most important farm animals and plant crop species

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Food and Agriculture Organization of the United Nations

COMMISSION ON GENETIC RESOURCES FOR FOOD AND AGRICULTURE

Contrasting AqGR with Terrestrial GR

Sector Genetic Resources	Number of species farmed	Number of major farmed species	Number of strains/breeds/varieties
Plant	6000	9	~7,400,000
Livestock	37	5	~9000
Forests	7900	2400	~700
Aquatic Genetic Resources	554	17	??????

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Contribution (%) to world aquaculture production

Continent	Volume	Value
Asia	90.8	77.4
Europe	4.2	9.3
Latin America	4.0	11.4
Africa	0.8	1.0
Oceania	0.2	0.9
	100.0	100.0

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Limiting factors for increased impact of genetic improvement programs (Neira , 2010)

- Lack of knowledge in the industry on what a breeding program is and what to expect from it (*have to solve other problems first*)
- Lack of trained professionals in quantitative genetics
- Lack of financial resources
- Lack of a market paying a higher price for improved stock
  - to cover the running cost of the program

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Required competence in selective breeding programs

- Quantitative genetics
- Genomics
- Statistics – multitrait mixed linear models
- Production biology and production of the actual species
- Economy – relative weighting of traits

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Competence building

Basic knowledge
Undergraduate, Bachelor/Master degree - 5 years

Post graduate, PhD – 4 years
- Theoretical courses
- Thesis on (preferably own) experimental data
- Work in a scientific environment – to mature as scientist

Project and job related competence and experience
(becoming a skilful scientist requires time)

Experience from
GIFT, the Philippines
Rohu carp, India

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GIFT – Genetic Improvement of Farmed Tilapia

1988: 130 000 tons
1998: 725 000 tons
2016: 2 200 000 tons

ADB (RETA 5279) + UNDP/DGIP, INT/88/019), 1988-1998

WorldFish and AKVAFORSK

- Several short 1-2 weeks training workshops in the Philippines during the project period
- Two workshops in Norway
- No funds for Master and PhD studies
- Large world-wide impact

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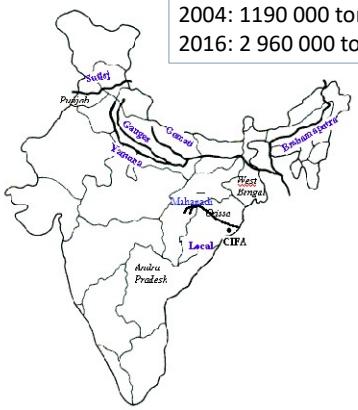
Genetic improvement of rohu carp in India

NORAD (Ind-040) + ICAR/CIFA + AKVAFORSK, 1992-2002

- Several short 1-2 weeks training workshops during the project period (2 in Norway)
- Two persons in 6 months in Norway
- No fund for Master and PhD studies
- Lack of upscaling to a commercial sustainable selective breeding program

Rohu
1992: 330 000 tons
2004: 1 380 000 tons
2016: 1 850 000 tons

Catla
1992: 300 000 tons
2004: 1190 000 tons
2016: 2 960 000 tons



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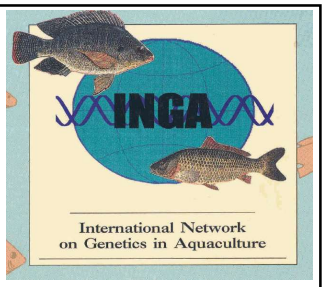
INGA – ICLARM/WorldFish International Network on Genetics in Aquaculture

http://pubs.iclarm.net/resource_centre/WF_180.pdf



- Three 14 days training courses – Philippines, Indonesia, India
- Developed 9 selective breeding programs for 8 different species in Asia
- Important for the establishment of selective breeding programs in several countries

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Lesson from Norway in the 1960s

- Start of scientific animal selective breeding in Norway
  - dairy cows, pigs, sheep, poultry, fur animals (and Atlantic salmon and rainbow trout in the 1970s)
- Several young persons with permanent positions at Dep. of Animal Science got scholarships (e.g. Kellog Foundation) for 1 year training abroad (USA, Scotland)
- Short term courses in Norway/Nordic countries with invited teachers from abroad
- Large impact of animal husbandry in Norway

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How to get the trained persons back home?

Build strong scientific groups in the home country

- Establish a breeding program in the home country
  – with technical scientific support from abroad
- Employ 3-4 skilful persons with bachelor/master degree
  - at a University/Institute in the home country,
    and with close cooperation with the Industry
- Give scholarship for PhD study in Norway
  – using data from the breeding program back home
- At least two years in Norway – every second year

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Conclusions

- Establish (long term) selective breeding program
- Build strong scientific groups to make it attractive to return and work back home
- Establish strong relationships between University/Institutes and the Industry for the benefits of both
- Give (some) scholarship to persons with permanent positions back home - conditions on returning back home
- Funding of short term training courses for Post Docs
- On line training in specific topics (e.g. FAO-Iran)

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