Agricultural Biotechnologyes in Developing Countries:

Options and opportunities in crops, forestry, livestock, fisheries and agro-industry to face the challenges of food insecurity and climate change (ABDC-10)

Current status and Options for:

Biotechnologies in Fisheries and Aquaculture in Developing Countries

M. Pourkazemi

International Sturgeon Research Institute, RASHT- IRAN

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World Capture Fishery & Aquaculture → 113 million ton

- **17.1 kg per Capita**
- **Aquaculture 44.3%**
- **90% of total fish production comes from developing countries; particularly China (70% global production)**

Biotechnology → Good quality Brood stocks → Good seeds

↓

High production

- **Disease/ Pathogen Control**
- **Feeds improvement (feeding and Nutrition)**
- **Improve Water quality**
- **Improve Environment Condition and minimize the aquaculture impacts**

- *230 species are in aquaculture*
- *Lack of knowledge of the Biology, reproduction physiology*

Penaeus monodon (Black tiger prawn):

Hatchery for Specific Pathogen Free (SPF) are available, BUT production still depend on Broodstock collection from the wild

↓

White Shrimp (*Vannamei*) replaced over last few years and provide 100% white shrimp and 60% all farmed *penaeid* shrimp

Role of Biotechnology in Biosecurity and disease control:

Disease is the most significant factor impact the intensive production of Salmon, Carp, Shrimp and tilapia→ (10-90% losses of total production)

Application:

- As sensors in the production environment
- For Waste management (by Microbial technology)
- Disease detection and control (PCR and Molecular Techniques..)

(Tradition: Only after mortality has been observed then disease control is often carried out)

Current status of Application of Biotechnology in Developing Countries:

A) Aquaculture

* Polyploidy, Triploidy→ Various application

❖Sterility (useful for conservation)
❖Prevent side effects (e.g. Deterioration of carcass)
❖High mortality in male at early maturation

*Developing countries→ Most research of the application are experimental and this techniques are not currently used for commercial purposes.

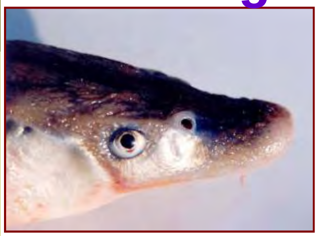
*Remaining a Gap between research finding and the particular implementation of triploidy

❖Uncertinity on 100% triploidy in some species
❖Lack of knowledge on effect of competition between 2N and 3N
❖Lack of robustness in 3N compare to 2N in Tilapia
❖Delay in reproduction and increase growth rate NOT sufficient beneficial in large scale
❖Need to test 3N status of each batch of embryos

Conclusion: This techniques has not been used extensively in developing countries for production purposes

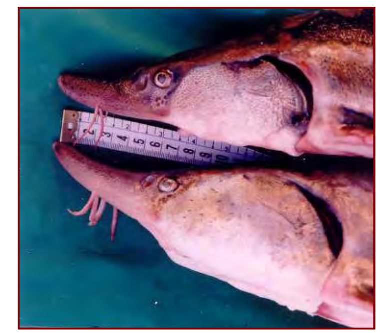
Crossing between tetraploids and diploids is a way to produce 100 % triploids, However, in most species 4N production is not straightforward

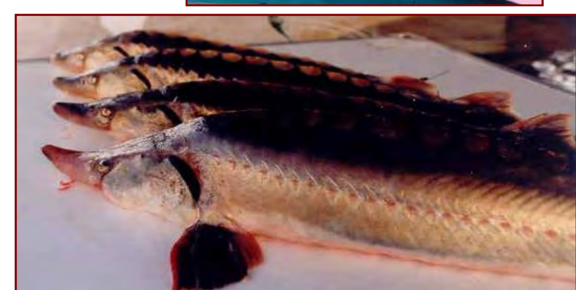
Reciprocal crosses between Persian Sturgeon (2N= 240) X Beluga (2N=120) Sterile 3N Hybrid (Pourkazemi et al. 2006)



"ParsBlu & BluPars"



Gynogenesis/ Androgenesis:

- Useful for genetic analysis in Carp, Tilapia, Rainbow trout breeding program
- For Capitalizing on non additive genetic effects
- To increase additive genetic variance and for product uniformity

Advantage of monosex:

- Superior in Growth
- Desirable meat quality
- Prevent reproduction during grow- out
- Appearance of sexual/territorial behavior
- High value products (Caviar in Sturgeon)
- Male mortality before harvest (Salmon)

Gynogenesis in Sturgeon:

Lack of sex marker

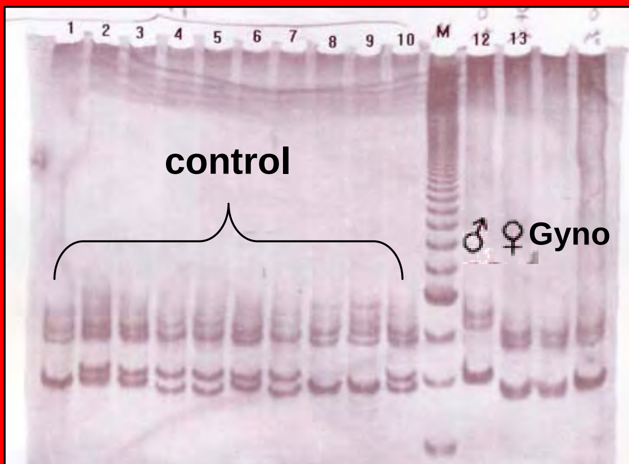
Difficulty of sex separation and need several techniques All methods are very stressful to fish

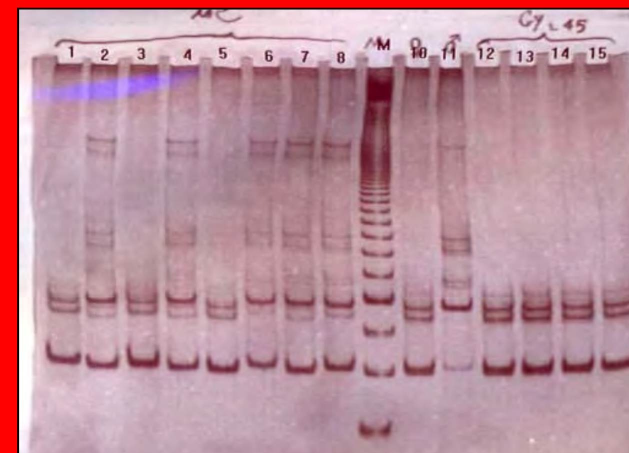
Ultrasonography

Biopsy

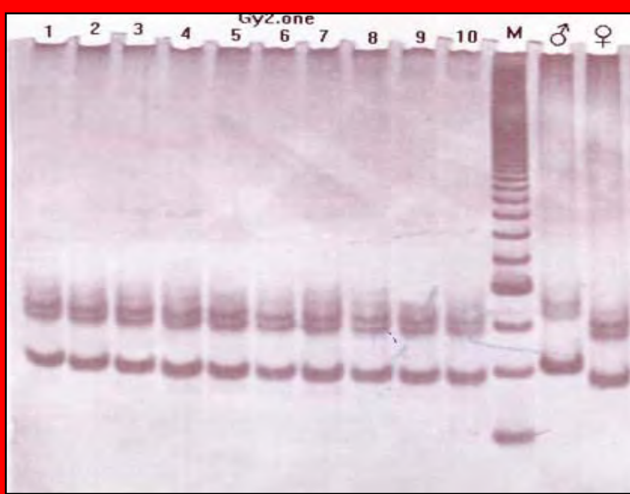
Laprascopy

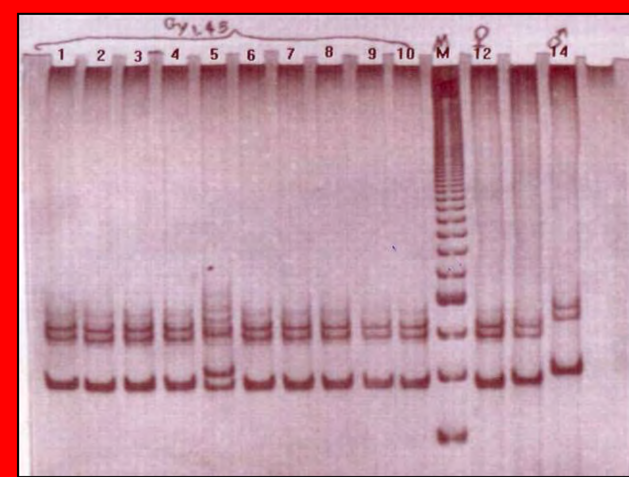
Production of all female fingerling will be great help for sturgeon farmers (Gynogenesis in Beluga Pourkazmi 2009)





DNA marker for Gynogenetic Beluga



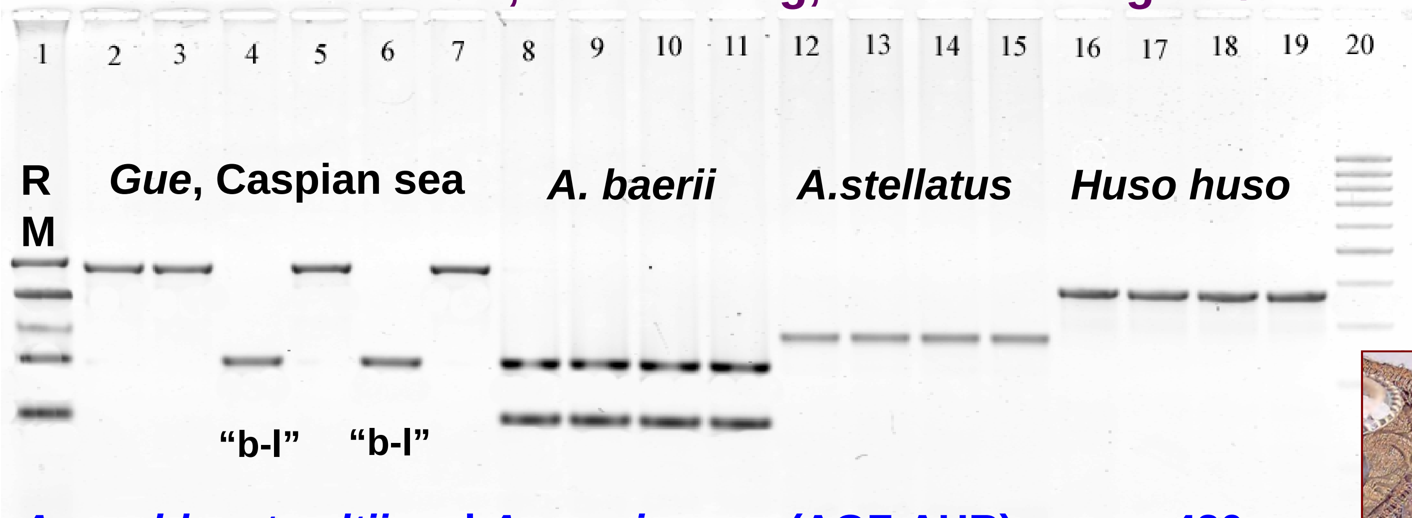


New methods of using heterolog sperm for Gynogenesis (Hassanzadeh 2009).

Genome Sequencing:

Species specific marker for Species (and or Products) identification in International Trade (5000 Animals and 25000 plants species listed in CITES Appendixes)

- **Caviar identification, Mislabelling, Russian sturgeon/ baerii like sturgeon**



A. gueldenstaedtii **and** ***A. persicus***	**(AGF-AHR) -**	**420 п.н.**
Huso huso	**(AHF-AHR)**	**377 п.н.**
A. stellatus	**(ASF–AHR)**	**274 п.н.**
A. baerii **and "*baerii*-like" haplotype of**		
A. gueldenstaedtii	**(ABF-AHR)**	**214 п.н.**
A. baerii	**(ABF-ABRM)**	**180 п.н.**

GMO (Genetically Modified Organism)

*** GM (Carp / Tilapia, Salmon)**

*** Not commercial release for food and agricultural purpose (Developed & Developing country) ⟹ Remain at experimental phase**

Because:

*** Environmental impact (Possible interbreeding with native population)**

*** Need grater amount of feed**

•Consumer acceptance

This Document doesn't provides any plan for Future (eg. Stop, Improve, Extend, Pubic awareness,…..)

Using sex hormone

- Risk of presence of residues in final product

- Super male production YY

  * Need more than one generation to obtain all male try

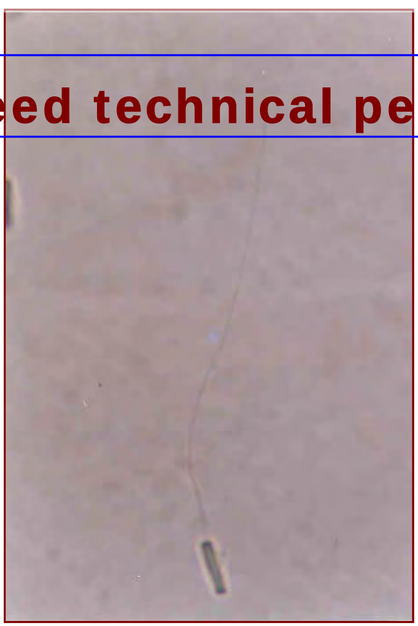
  * Need extensive progeny testing

Still not commercially being used in Tilapia farming ⇒ **still mixed-sex Tilapia culture in Asia**

Cryopreservation

- Application for conservation of rare species or population
- In restocking program in sturgeon hatcheries this technique store extra sperm of stripped male for future reproduction
- Provide the adequate sperm, when hatcheries face shortage of relevant broodstock

Expensive, need technical personnel and not commonly used.



Molecular Markers

- **Fisheries**
  - **Stock enhancement**
  - **Fishery management**
- **Aquaculture**
  - **Parentage Analysis**
  - **Genetic Selection (QTL)**

MAS (Markers Assisted Selection) / QTL (Quantitative Trait Locus)

- Need enough replication
- Powerful experiences → In order to detect real QTL
- Need physical maps to characterize the actual gene explaining the genetic variation
- Need high level of financial resources

(genome sequencing & implement MAS program)

RAPD dominant marker → very difficult to replicates in different laboratory

<u>In short & medium term</u>:

Conventional breeding programs may be more profitable in developing countries. No example of QTL application in breeding program, in developed or developing countries

Biosecurity and Diseases Control

Importing new species

Pathogen screening & disease diagnostics

Molecular method (DNA / RNA based) ⇒ to detect and indentify pathogen

⇒ each pathogen carries unique DNA or RNA sequence

(PCR primer or kits)

FAO: diagnostic process levels

Level I	**Field observations & necropsy**
Level II	**laboratory observation, bacteriology and histopathology**
Level II	**Electron microscopy, molecular biology and immunology**

Very good progress in molecular, immunological diagnosis procedures in various viral & bacterial parasites & fungal disease

-**IPNV, WSSW, YHV, IHHNV, TSV**

Very good document on review of DNA based techniques on pathogen detection, routine diagnostic tests (Developing countries) monitoring, treatment

Still need more validation for molecular techniques as acceptable screening method

Vaccines:

Wide range of antibacterial (10) Viral (5) pathogens are available and many new vaccines are under development

Pathogen →

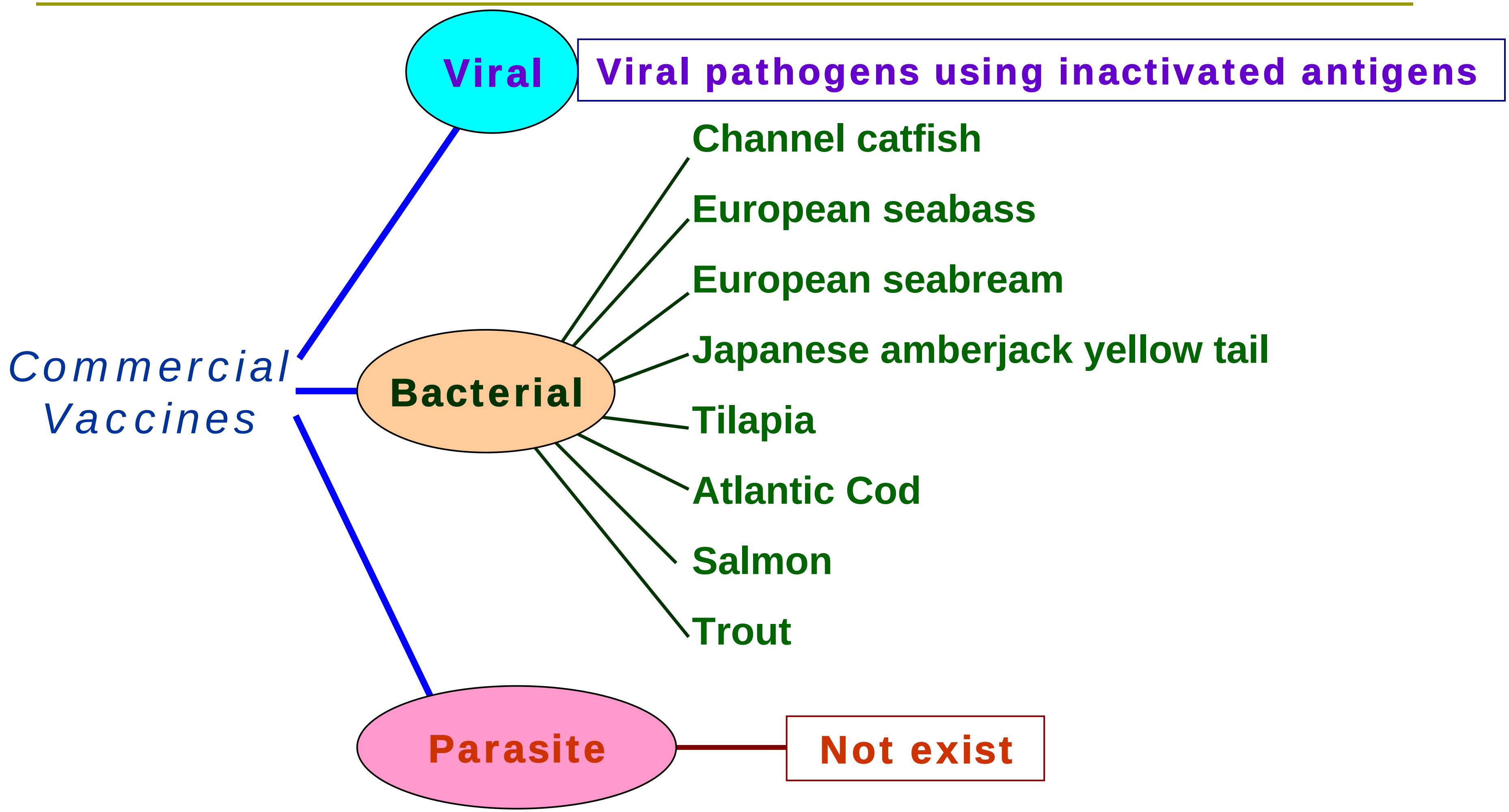
- **Inactivated (live vaccins)**
- **Weakened using chemical or genetically (limited survival in the host)**

Developed country

Salmon farming in Norway: negligible 1 gram per ton

→ **Due to vaccines availability for furunculosis**

(Norway): Antibiotic use decreased annually from 47 tons to approxi. 1 ton


Commercial Vaccines
Viral
Viral pathogens using inactivated antigens
Bacterial
Channel catfish
European seabass
European seabream
Japanese amberjack yellow tail
Tilapia
Atlantic Cod
Salmon
Trout
Parasite
Not exist

Use of Probiotics

- Still relatively new but increasing in many species

- Red tide and toxic algae bloom

- Early detection of toxin using PCR and Expressed Sequence Tag (EST)

Biodiversity conservation and fishery management

* Document nicely address the negative impact of restocking on genetic variability, lack of adaptation & genetic loss in medium and long term experiments.

However example are not quite relevant to recent advanced techniques:

1) RAPD techniques in most population studies are NOT being consider as a reliable reproducible molecular methods.
2) Most references are relatively old 1997, 1999 →there are many recent publication 2007, 2008, 2009 on population structure of commercial species (shrimp, salmon, sturgeon, cyprinids and percidae)
3) Not adequately address the use of molecular marker for species, sex and product identification.

Conclusion Remarkers

Biotechnology

Fishery management

Limited application

- Restocking
- Stock identification
- Species specific marker
- Biology, Migration, …

1- National & Regional structure and organization

2- Training & Extension

Aquaculture

- **Genetic manipolation**
- **Genetic Improvement**
- **Health management**

Success Depend on

- **market**
- **Investment**

Better organization

→ **Set up PCR laboratories for shrimp**

- **90 India**
- **40 Vietnam**

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Biotechnology Activities	Developing Countries
Pathogen Screening, Vaccine and Probiotic	Good progress in Shrimp, Trout and Salmon/ Need more extension
Polypolidy (3N, 4N)	NOT extensively for production purposes
Gyno & Androgenesis	Problem in production GY line, Risky in most cases
Controlling Reproduction & Sex Reversal	Good progress in Many Species but Not related to Biotechnology Also no interest from Fish farmer to buy YY male
Cryopreservation	Useful tool But very limited in commercial scale
Genome Sequencing	Costs need National and Regional interest
GMO	Remain at Experimental phase, No Clear for Future Policy

Despite High Technical Progress in Biotechnology, NOT success in Implementation and Extension in Aquaculture and Fisheries

Future:

***Environmental sustainability key ➡ Responsible production through sustainable practice**

⬇

Only focused on disease control and vaccines <u>NOT</u> in other area: genetic manipulation Transgenetic

*** <u>Climate Change:</u>**

Mostly emphasize on management and less concentration on application of biotechnology as adaptive technologies

Options for Developing Countries

- Option very well addressed

1- Few biotechnology in use in small scale aquaculture Need information collection, analyzed advise to policy markers
2- Too technical and costly efforts to develop low cost & simple
3- Need more research to develop new vaccines, National priority to develop molecular diagnostics, vaccines & probiotic
4- Lack of priority at national level
5- Funding, Investment, capacity building
6- Efficient institutional structure
7- Strengthening Research & Extention
8- Establish National committee data base, exchange information regional web-site
* Package training, Extension is most appropriate

- Priorities:

* Biotechnology can contribute to sustainable aquaculture
1- Promoting & strengthening aquatic biotechnology
2- Adequate Institutional Capacity building / Develop National Research System
3- Biotechnology policy development and long term planning
4- Data collection / analysis and develop program

Short term training (Package)
Exchange experience, lesson learned, simplifying extension

Thank You for your Attention