Breeding selection in aquaculture fishes, with emphasis on the meagre *Argyrosomus regius*

Pierrick HAFFRAY

www.sysaaf.fr ; Mel : haffray@rennes.inra.fr

Syndicat des Sélectionneurs Avicoles et Aquacoles Français

-

SYSAAF

SYSAAF references in aquaculture

- Salmonids
- Marine and new fish species
- Shellfish and shrimp

Gènocéan

- Multi-year international genetic advising + audit

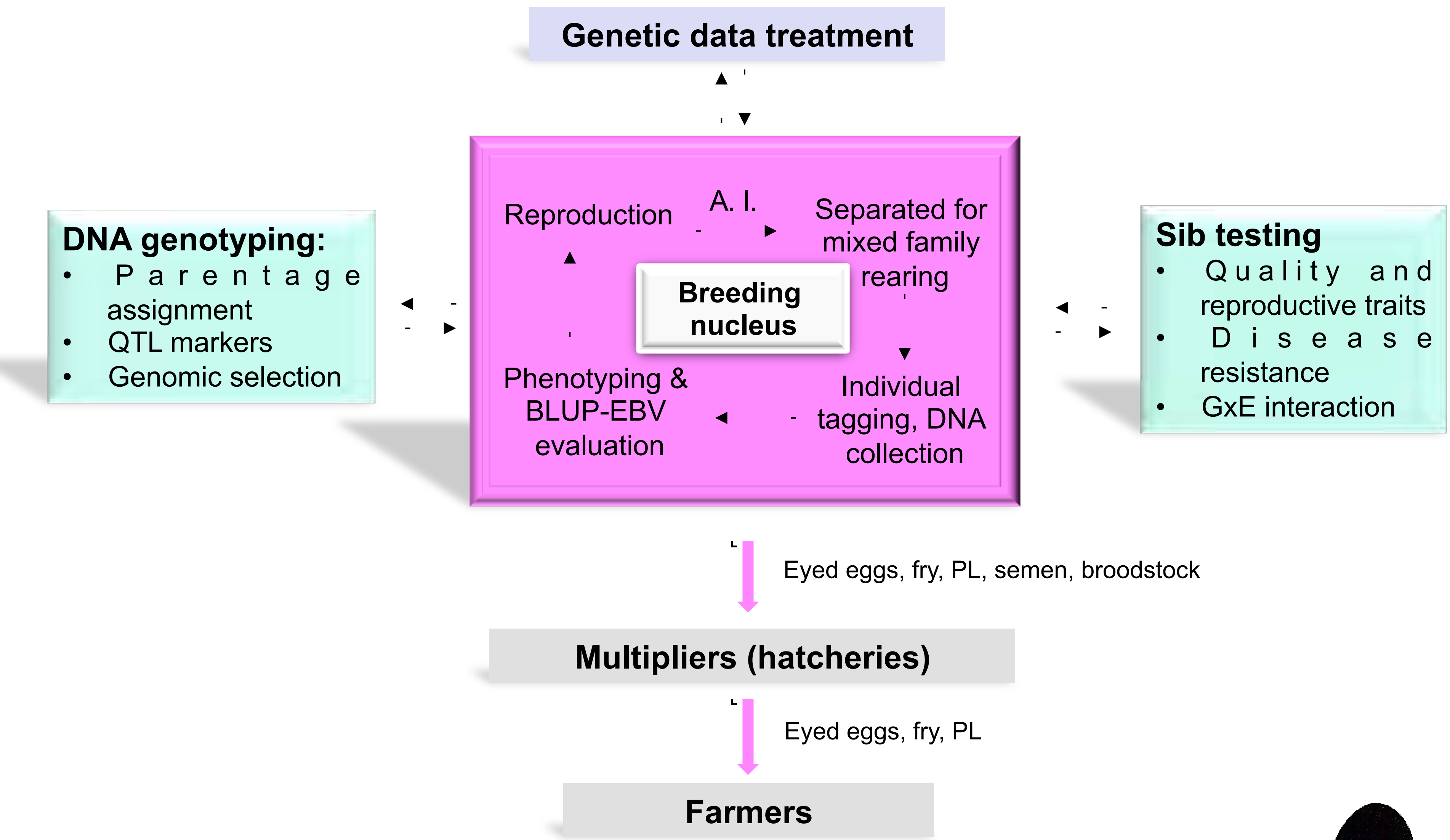
Syndicat des Sélectionneurs Avicoles et Aquacoles Français

SYSAAF

Genetic selection?

It's the **cumulative** improvement of profitability by the **reproduction** of the best parents at each **new generation** according to the **market demand**

Organisation of a breeding program

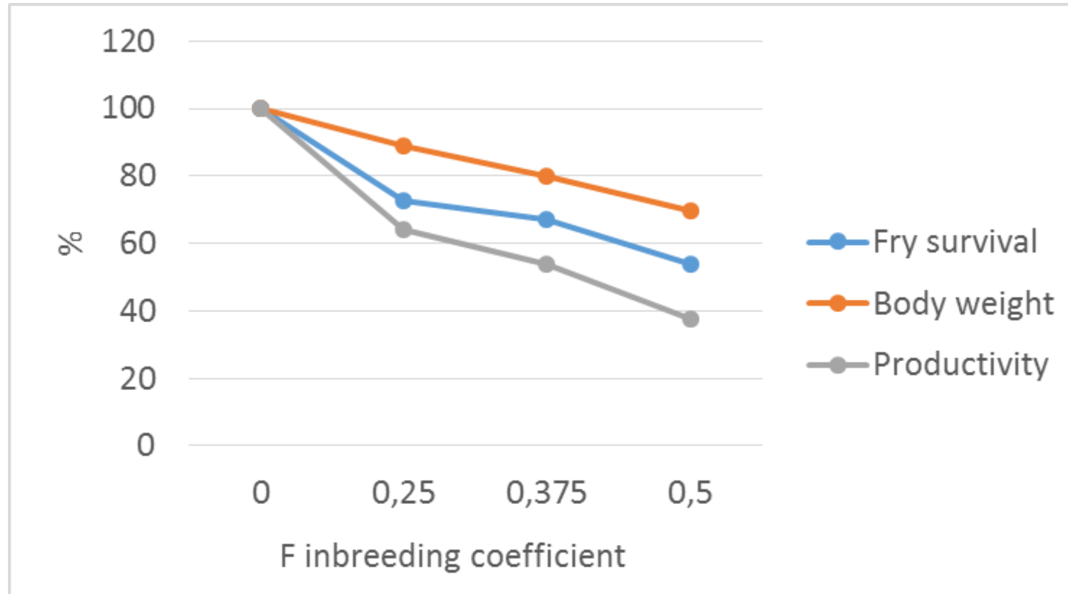


Syndicat des Sélectionneurs Avicoles et Aquacoles Français

SYSAAF

1st objective of a breeding program: not loose performance by inbreeding!

Effect of 3 generations of successive full-sib crossing in rainbow trout (Gjerde *et al.*, 1983)



- **Effective number of parents participating to the next generation:**

$$Ne = \frac{4 \times N_{Sires} * N_{Dams}}{N_{Sires} + N_{Dams}} \qquad F = - 1 / 2Ne$$

Ne > 100 ⇒ F < 0,5 % / generation

Technical requirements to invest in selection

- Have a broodstock with minimum genetic variability → Ne > 100
- Define traits to improve according to the market → ?
- Create at least 150-200 families per generation, more being better
- Limit initial non-genetic bias (maternal effects, tanks effects, mortality, cannibalism…)
- Apply a minimum of selection pressure (< 10 %)
- Manage inbreeding by optimized mating → pedigree and artificial fertilization
- Use adapted specialized genetic software (inbreeding, estimation of the breeding value)
- Transfer efficiently the genetic progress to the production

Which method of selection?

Breeding methods	Within-family selection	Family selection	Mass selection
Selection program	- **8 families / year** = 50 / generation - Separate family rearing = **8 tanks** - Tagging 100-200 fish / family → **1 cage** - Selection of 20 fish / family at 2 years	- **40 families / year** = 180-240 / generation - Separate family rearing = **40 tanks** - Tagging 100-200 fish / family → **1 cage** - Selection of 20 fish / family at 2 years of the 10 best families - BLUP-EBV	- **40 families / year** = 180-240 / generation - Mixed family rearing = **1 tank → 1 cage** - Selection of 300-1000 fish /year - **DNA parentage assignment**
Expected genetic gain for growth	+ 5-6 % / generation	+ 10-12 % / generation	+ 15-20 % / generation
+	**Simple, robust** Intermediate facility demanding **Good for inbreeding management**	- **Theoretically the more efficient** if > 400 families / generation - **Multitrait and mutigeneration** based on BLUP-EBV - **Disease resistance**	**Simple** Low facility demanding High selection pressure (3-5 %) **Cost efficient ratio / family selection : 1 : 10**
-	**Only 50 % of the expected progress of mass selection**	**Costly** **Initial tank effect** **Complex**	**Only traits measurable on the candidates (growth, morphology)**

Biological and economical factors to consider for the selective breeding of the meagre

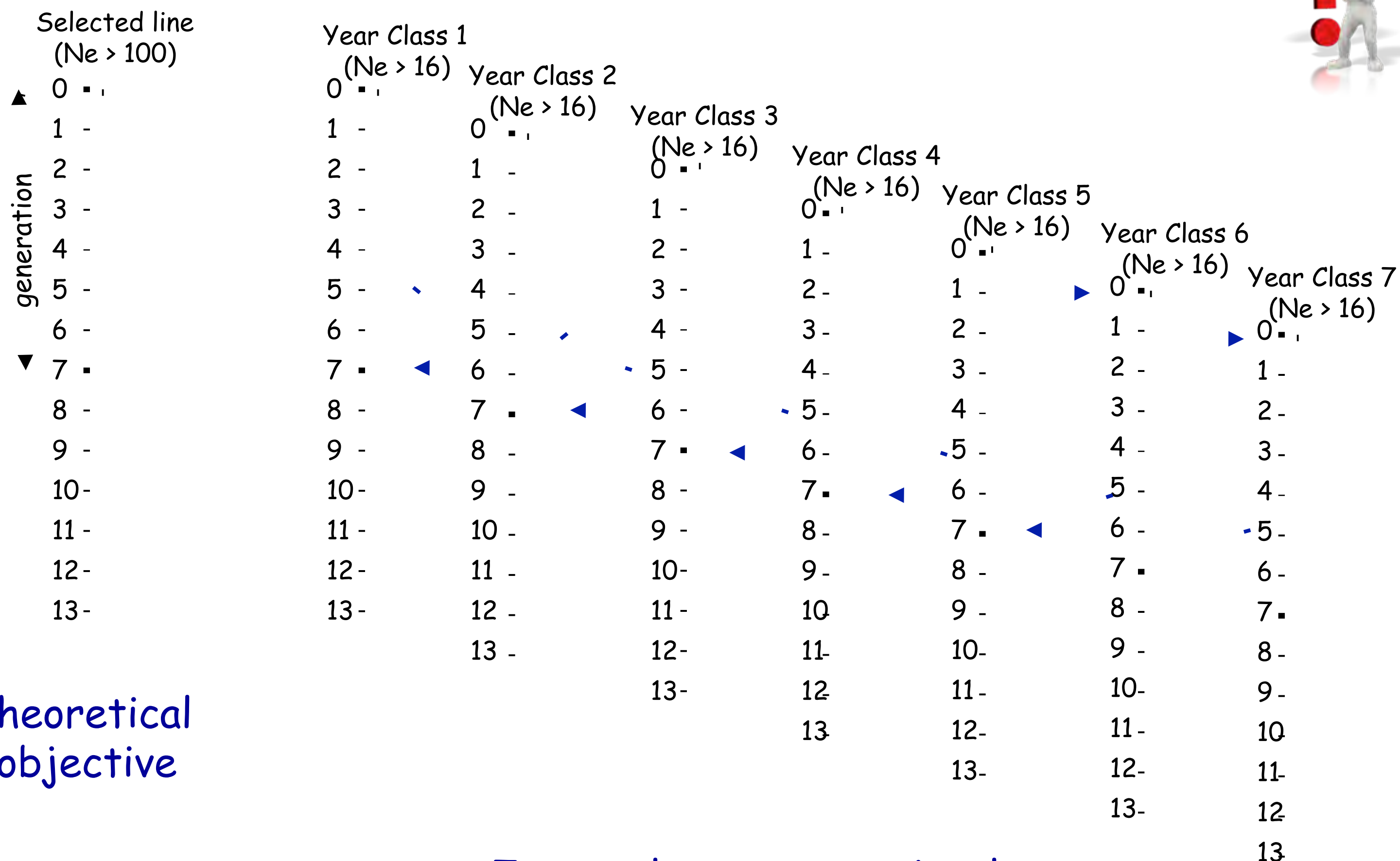
Unfavorable factors

- Limited and variable production (3900 T in 2010 and 560 T in 2013 in EU (FEAP); 2,8 M€ at 5 €/kg) → 3% of the turn-over for genetics = 84 K€ investment / year !
- Long generation interval (5-7 years) ⇒ Limited genetic gain / year (+2-3 %) ≈ + 20-25 % in 10 years
- Need of female hormonal stimulation and only 10 % ready to spawn in a tank → 10x the female number
- High body weight of the broodstock (> 8-10 kg) → Difficulty for manipulation and high rearing cost to meet adequate Ne

Favorable factors

- Artificial fertilization → Factorial mating design and high number of families
- DNA parentage assignment available (Soula et al., 2012; Duncan et al., 2012; Bestin et al., 2014)
- Genetic variation of broodstocks? → DIVERSIFY
- Heritability of growth?

How to split the families production per generation?



Theoretical objective

7 year classes + rotational mating by males

Genetic variation of the wild populations of the meagre ?

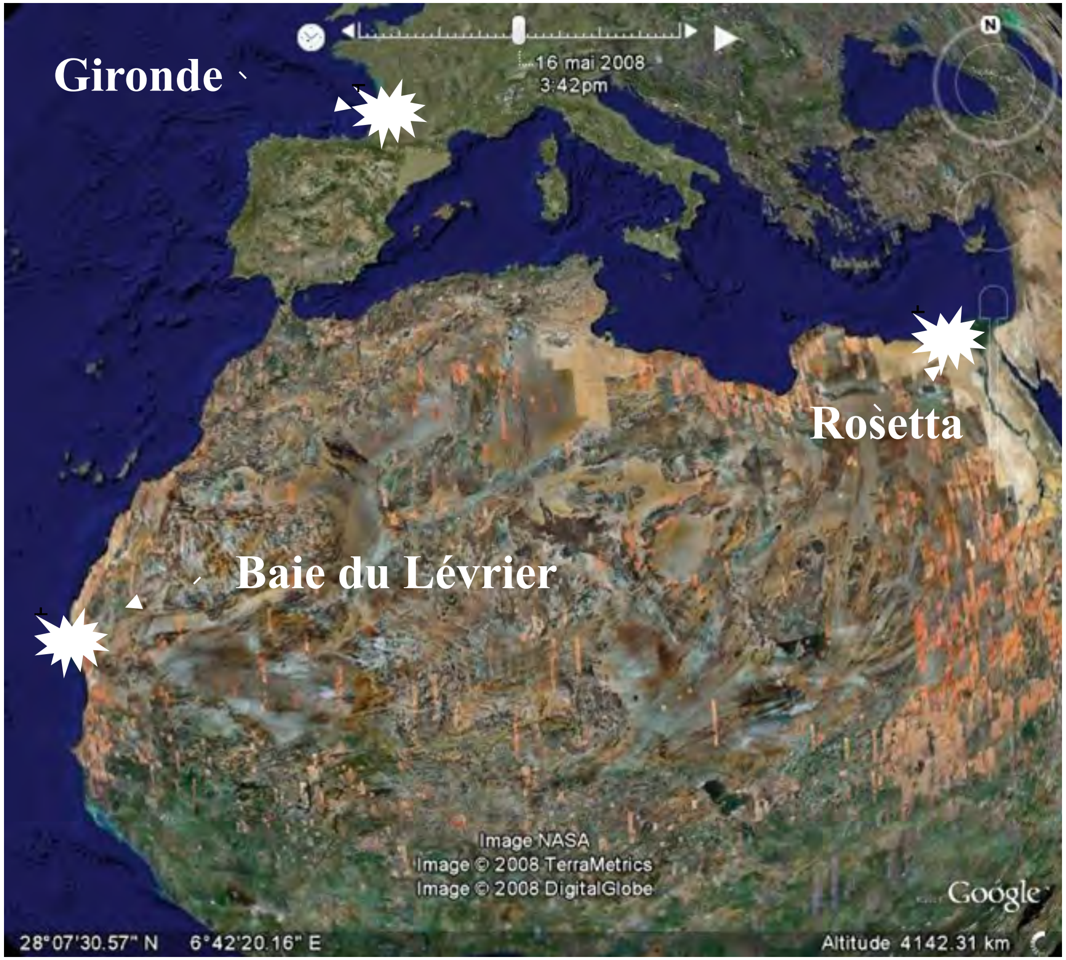
Haffray et al., 2012, Aquat. Living Resour., 25, 173-183

(Argyrosat research project, 2008-2010)

Syndicat des Sélectionneurs Avicoles et Aquacoles Français

Only 3 reproductive areas previously described

Quéro and Vayne 1987



Reproduction areas

Other spawning areas (Turkey? Morocco?, Guadalquivir? Portugal. Croatia?...)

Same species ?

If yes, how many populations?

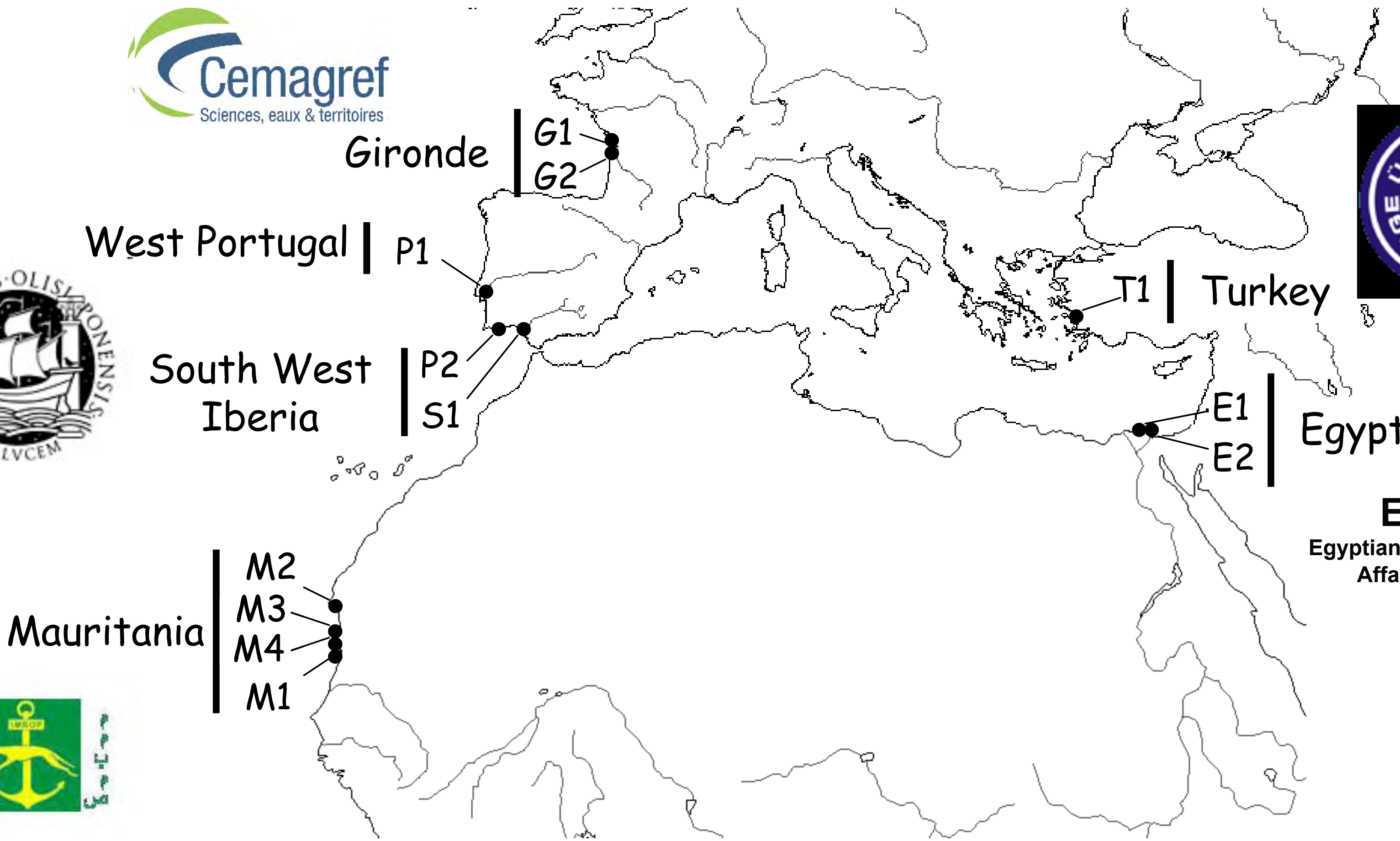
Genetic distances ?

Syndicat des Sélectionneurs Avicoles et Aquacoles Français

SYSAAF

Sample collection

Cemagref
Sciences, eaux & territoires



EEAA
Egyptian Environmental Affairs Agency

Syndicat des Sélectionneurs Avicoles et Aquacoles Français

SYSAAF

Genetic distances between populations

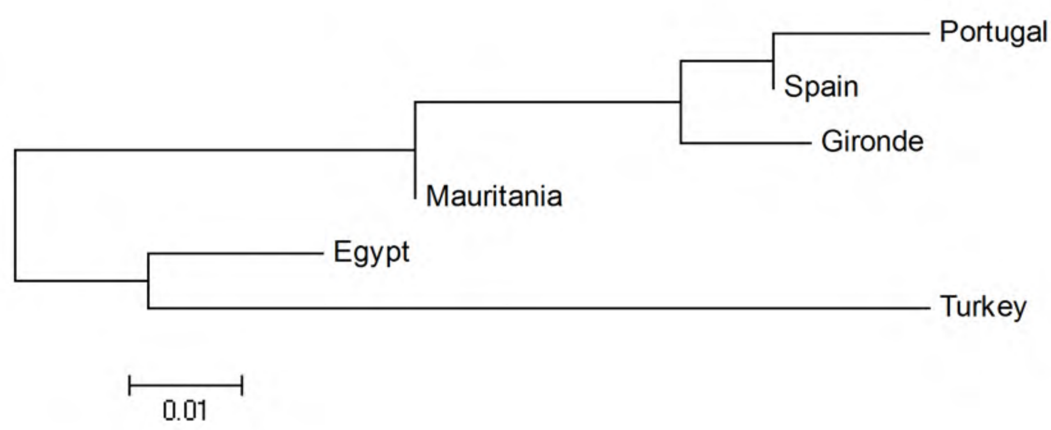
	Gironde	West Portugal	Mauritania	South Spain	Egypte	Turkey
Gironde		0,026***	0,026***	0,025***	0,099***	0,140***
West Portugal	**0,026**		0,041***	0,012***	0,107***	0,168***
Mauritaniea	**0,026**	**0,041**		0,024***	0,061***	0,098***
South Iberia	**0,026**	**0,012**	**0,024**		0,073***	0,126***
Egypt	**0,104**	**0,113**	**0,063**	**0,076**		0,081***
Turkey	**0,151**	**0,184**	**0,104**	**0,134**	**0,085**	

Genetic distance (Reynolds et al., 1983) in bold and F_{ST} (Weir et Cockerham, 1984)

- **Very high genetic fragmentation rarely reported in marine fishes (≈ intercontinental level!)**

Evolutionary relationship between the 6 populations

Genetic distances between the 6 populations based on the neighbor-joining algorithm (MEGA 4; Tamura et al., 2007)



- Subdivision of the meagre in at least 2 different genetic units:
    - Atlantic unit
    - Mediterranean unit
- Glaciation? Relictual population in Eastern Mediterranean Sea ? Physical barriers? Fonder effect? Reproductive homing migration?
- Limited suitable areas and environments for reproduction and nursery and growing?

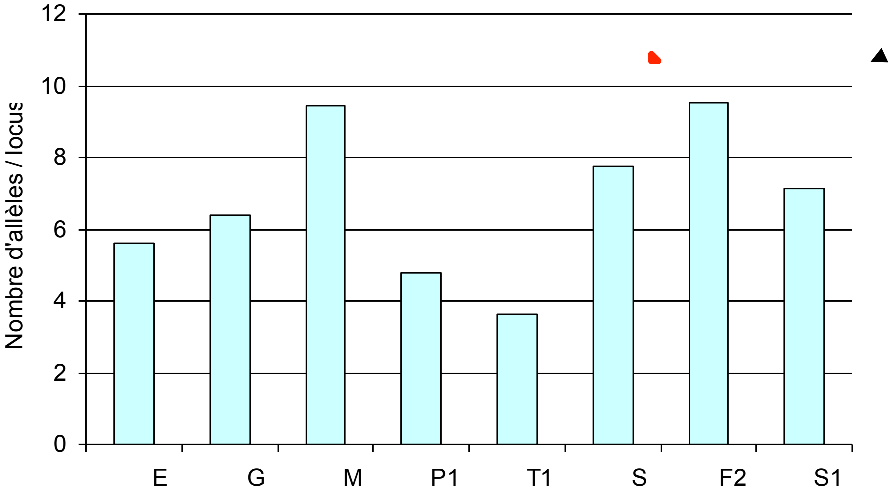
Genetic variation of the French broodstocks of the meagre ?

Haffray et al., 2014, EAS Aquaculture Conference. San Sebastian

(Argyrosat research project, 2008-2010)

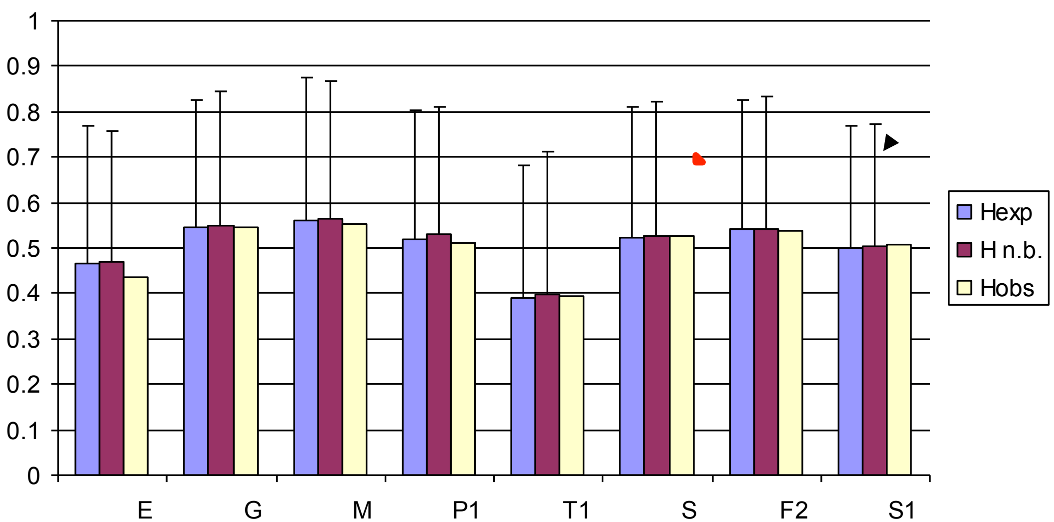
Syndicat des Sélectionneurs Avicoles et Aquacoles Français

Genetic variation of French broodstocks in 2009?



- A high number of alleles

- Same range of within-population heterogeneity



- French broodstock collected in 2009 were variable and non-inbred

What do we know about traits that can be selected in the meagre?

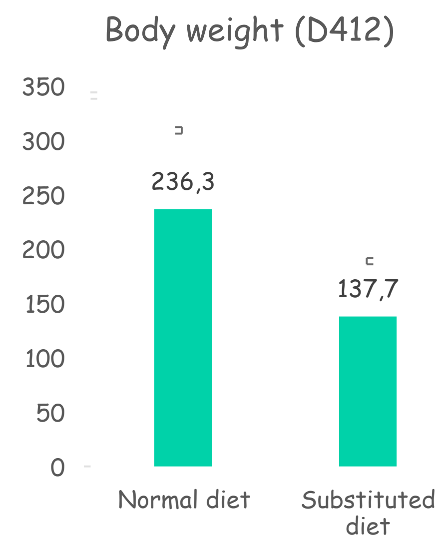
Bestin et al., 2014, 10th World Congress on Genetics Applied to Livestock

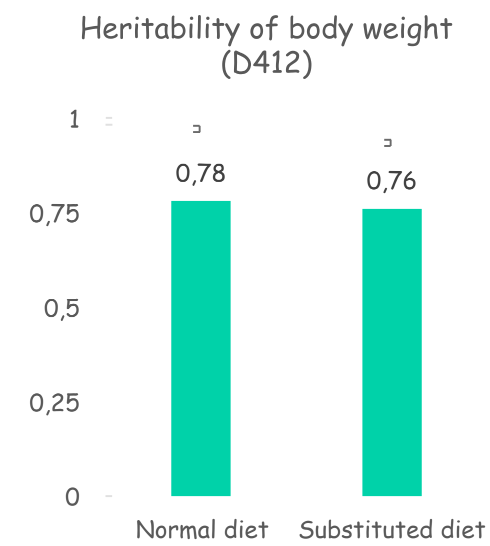
(VEGEAQUA FUI French research project, 2009-2012)

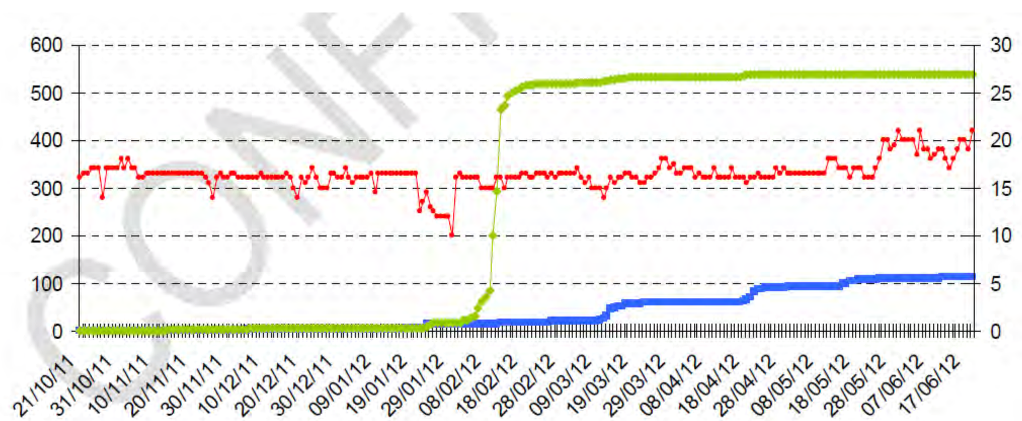
Syndicat des Sélectionneurs Avicoles et Aquacoles Français

Genetic parameters for growth and winter survival and GxE interaction with feed substitution

- **Protocole**
  - 3 ♀ x 14 ♂ males (Ne = 10)
  - 42 families
  - 2 feeds from 33 g (D150)
    - Normal diet
    - Substituted diet (2% FM and 2 % FO)
  - DNA-Parentage assignment







- **Unwanted sudden drop of temperature to 10°C**
  - Survival = 8,6 % ± 13.8 % (0%-57%)
  - $h^2 = 0,38 \pm 0,05$

Syndicat des Sélectionneurs Avicoles et Aquacoles Français

SYSAAF

Potential genetic risks associated with escapement?

- **Early domestication and no proof of impact**

- **Different situations :**
  - Threatened wild population in Turkey and Egypt
  - No known wild population in Western Mediterranean
  - Major wild stocks in Atlantic (Mauritania, Morocco, Spain)

- **Unknown interaction between escapement and homing (to where and with what success?)**

- **Solutions, if needed?**
  - Local stocks? More advanced selection?
  - Sterilisation (triploids or hybrids)?

(Karahan et al., 2014, EAS, San Sebastian)

Summary for the meagre selective breeding

- **Genetic basis for the initiation of meagre breeding programs are there**
  - Characterization of wild and domesticated broodstocks
  - Panels of microsatellites for DNA parentage assignment
  - Heritability for body weight → $h^2 > 0{,}30$

Les poissons du Soleil

- **Major difficulties**
  - Long generation interval and very big size of the broodstock → High cost of the post-growing phase (between 2 and 7 years) and reproduction for a limited gain/ year
  - Limited and variable production → Size of breeding program to be adapted to the lower tide of market capacity

- **Needs?**
  - Characterize remaining wild population and farmed broodstock with other markers mtDNA, SNP)
  - Heritability of new traits for disease resistance?

DIVERSIFY

Thank you for your attention and
thanks to Costas, Dinos, Neil et Pascal for their invitation