Overview on selective breeding and genetic improvement in bivalve shellfish

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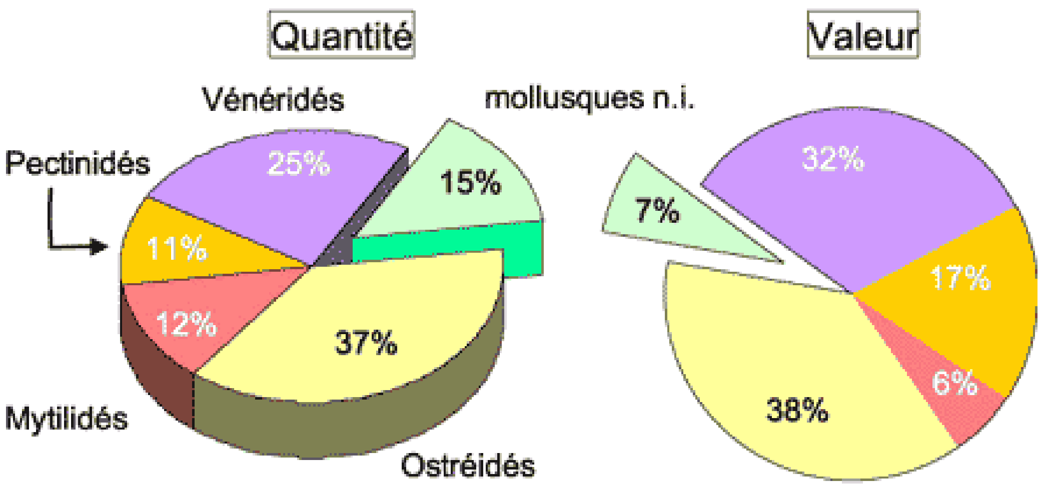
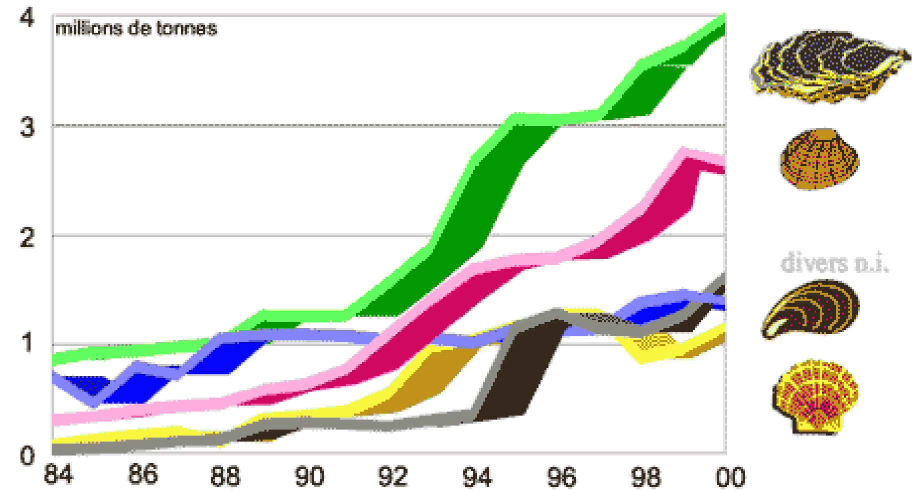
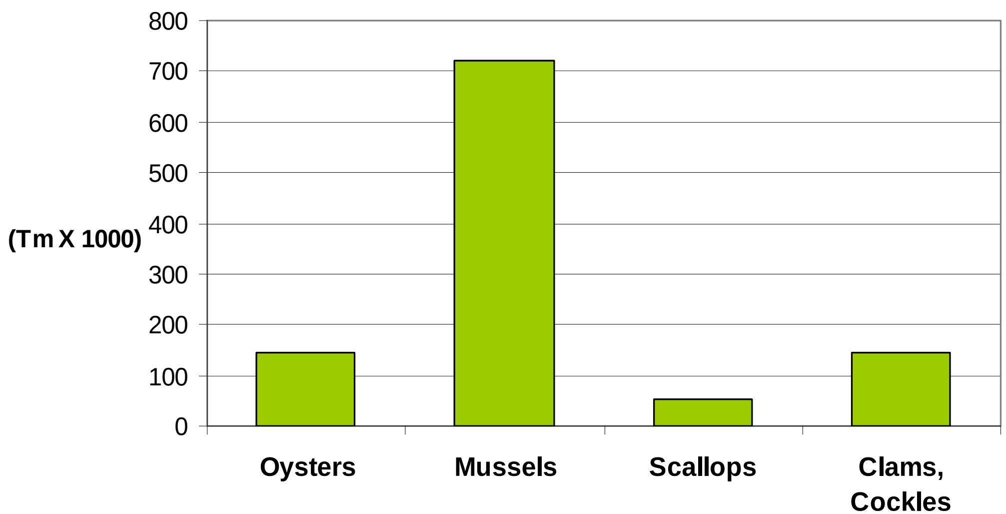
Aquaculture of bivalves

➢ **World production :**





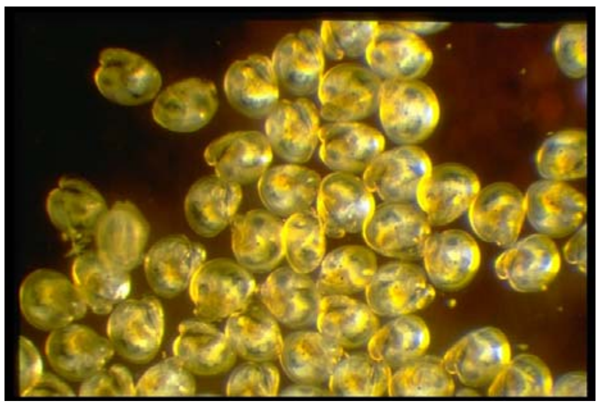
➢ **European production :**

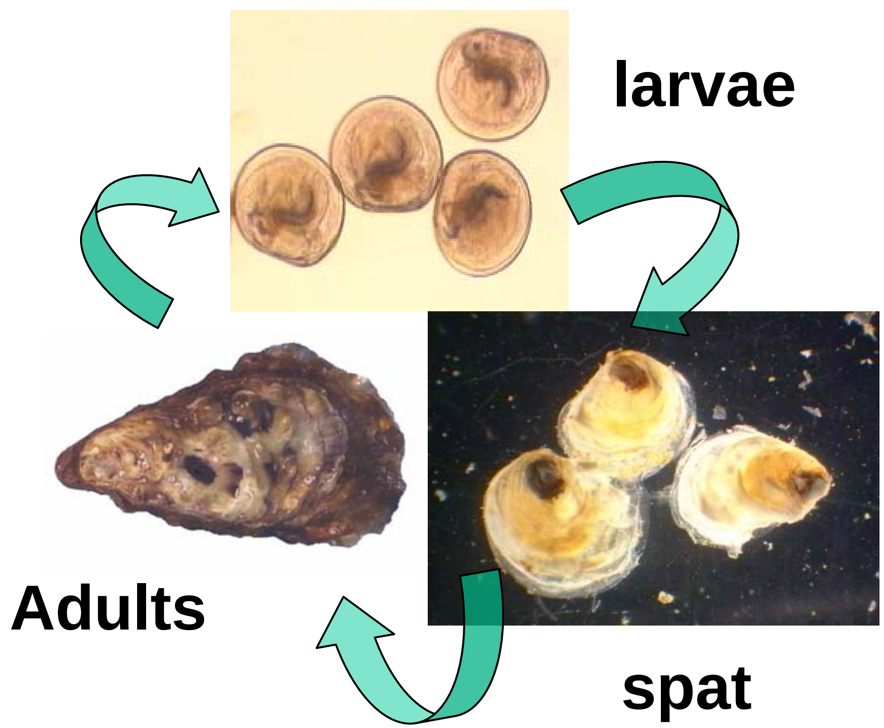


Two possible sources of seed

(1) natural settlement (native or introduced species)

(2) hatchery propagation



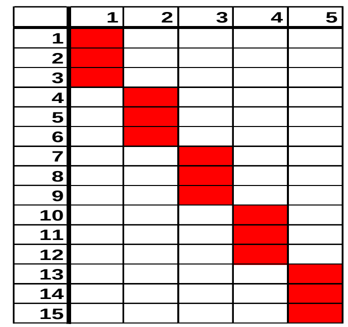


Genetic improvement of bivalves ?

<u>Ploidy manipulations</u>:
- triploids
- tetraploids

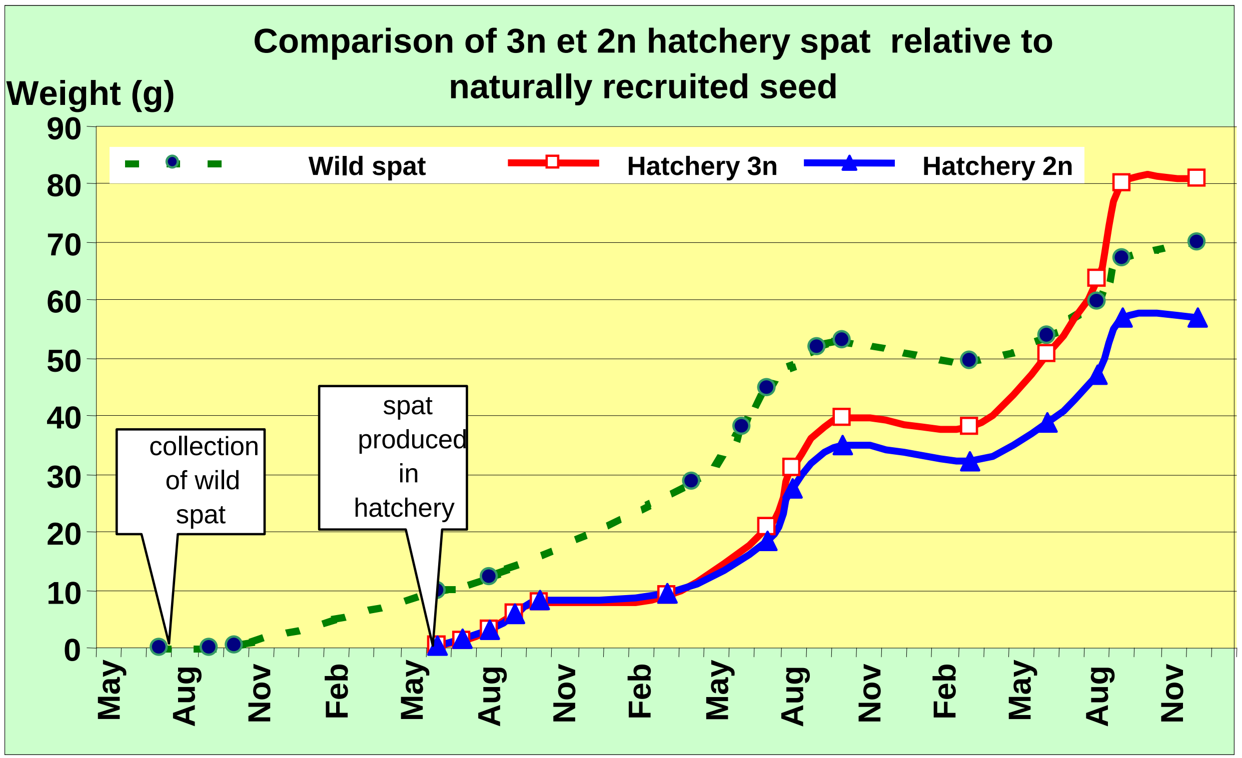
(4n x 2n = 3n)

<u>Selective breeding</u>:
- heritability estimates
- genetic correlations and trade-offs
- mass *versus* familly-based selection



Triploidy : a “single step” improvement

Re-allocation of energy from reproduction to maintenance and growth in triploid oysters

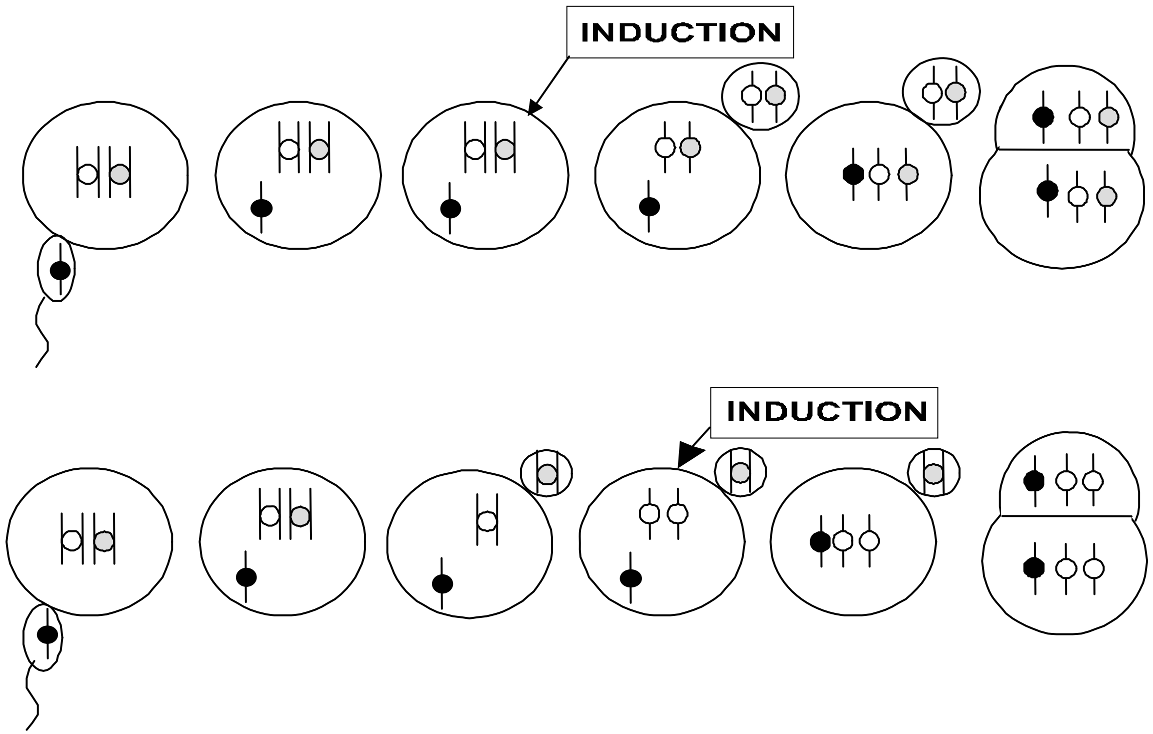


CREAA

- Nell, J.A. (2002). Farming triploid oysters. Aquaculture 210: 69-88

How to produce triploid bivalves ?

1) Chemical treatment of fertilized eggs using Cytochalasine B or 6-DMAP



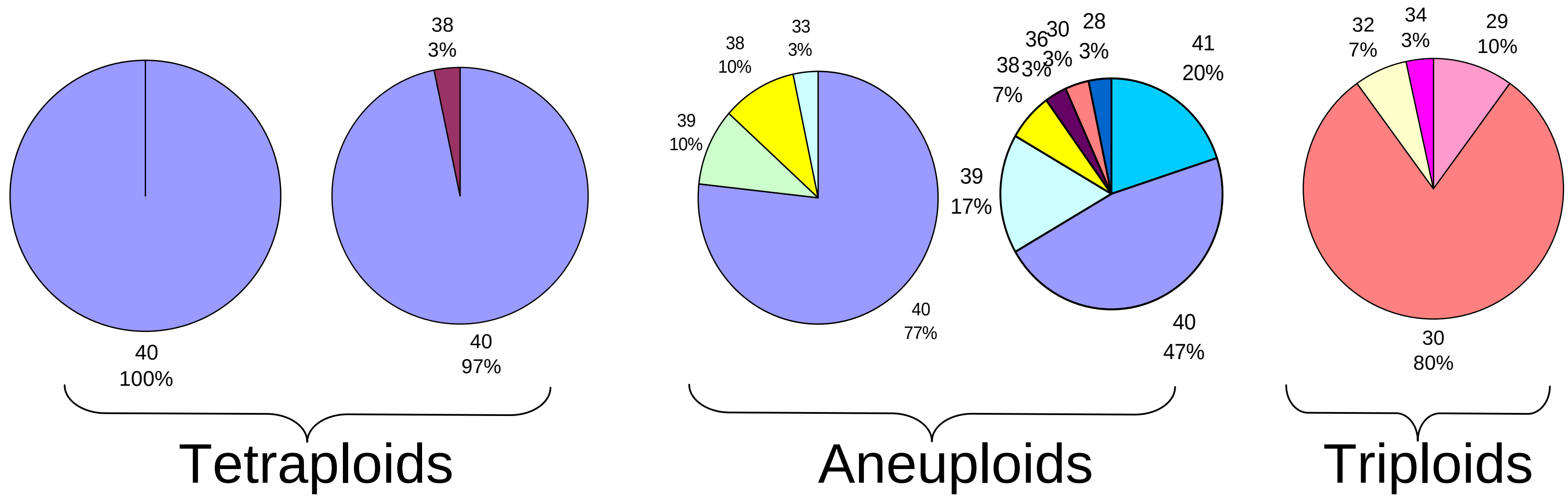
successfully applied on oysters, pearl oysters, mussels...

How to produce triploid bivalves ?

2) Tetraploid x diploid = 100 % triploid

- Tetraploid oysters first obtained in 1994
- Production and maintenance of tetraploids is rather difficult : confinement, chromosome set instability

Chromosome number variation in 4n x 4 n progenies :



Selective breeding of oysters

- U.S.A. : **<u>yield</u>**
  - WRAC: « Crossbreeding » and heterosis
  - MBP (http://www.hmsc.orst.edu/projects/mbp)

  <u>disease resistance</u>
  - VIMS
  - Rutgers University

- Australia: **<u>Growth</u>**
  - CSIRO

- New Zeland: **<u>Growth</u>**
  - Cawthron Institute

- France : **<u>Stress and disease resistance</u>**
  - Ifremer

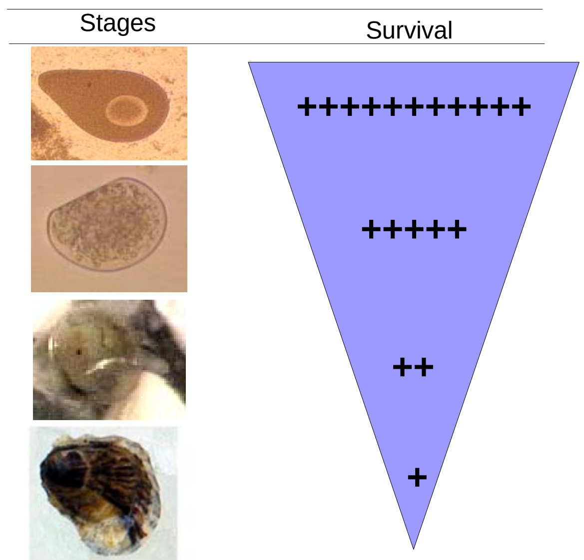
Mass (individual) selection

- <u>Targeted traits</u> : growth, disease resistance

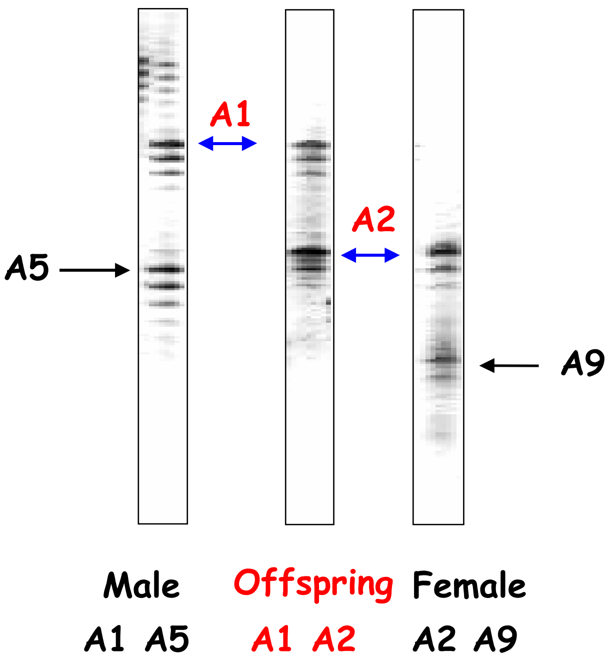
  - ·**Bonamiosis resistance in *O. edulis* (Naciri-Graven *et al*., 1998; Culloty *et al*., 2001)**
  - ·**Growth in *S. commercialis* (Nell *et al*., 2000)**

- <u>Main constrain</u> : rapid loss of genetic variability

  - ➢**low number of effective parents (e.g. Launey *et al*., 2001)**
  - ➢**high variance in reproductive success (Boudry *et al*., 2002)**



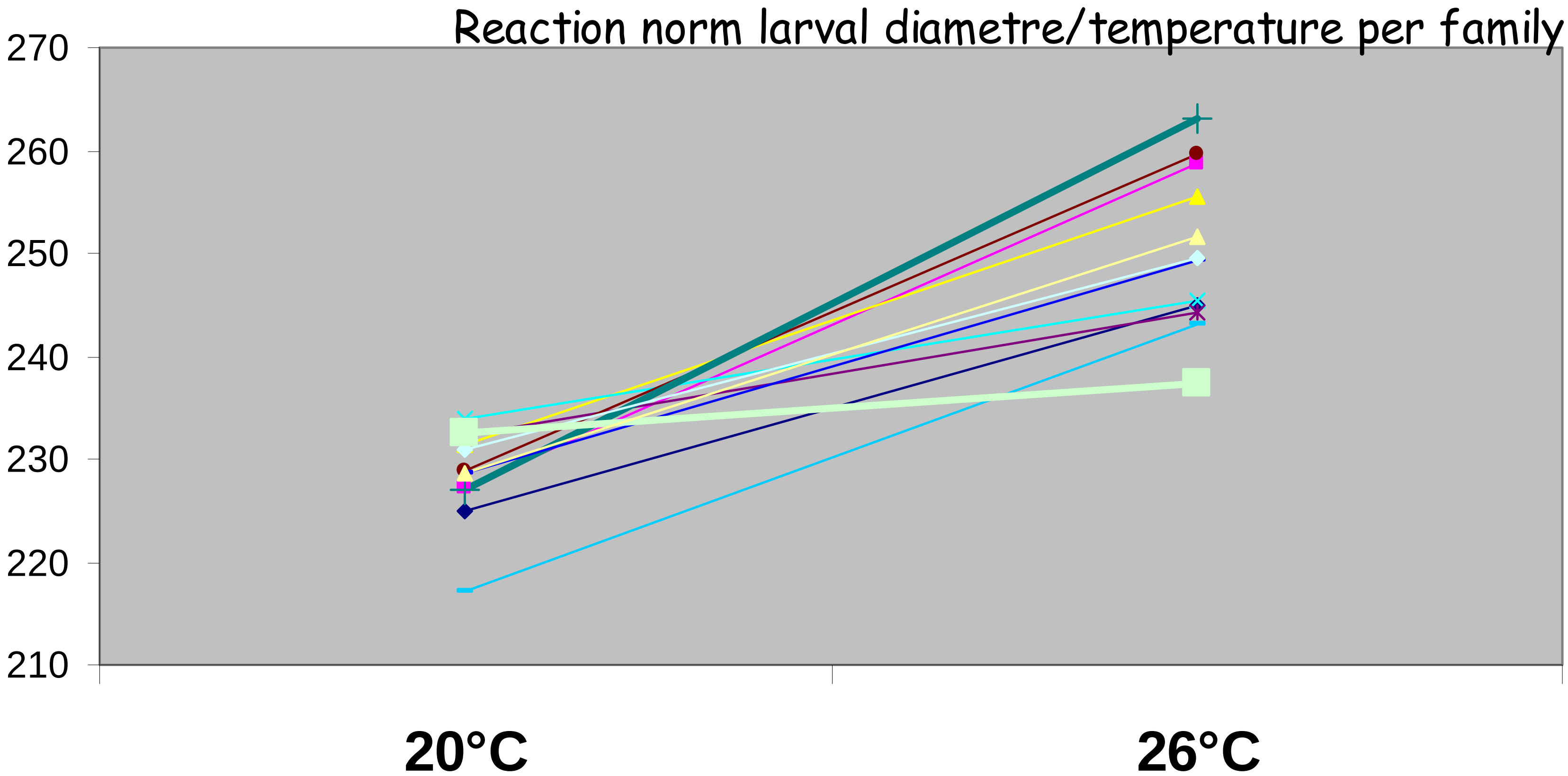
Microsatellite-based parentage analysis



5 females x 5 male cross :

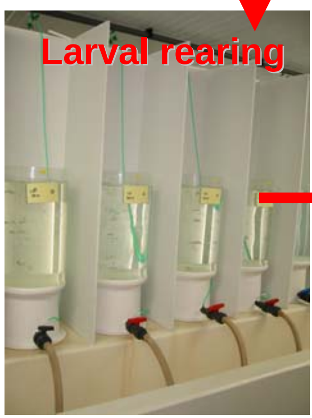
	Males					
Females	M1	M2	M3	M4	M5	
F1	0.6	1.5	1.5	2.1	0.0	5.7
F2	0.0	0.9	3.9	1.5	0.9	7.2
F3	0.0	0.3	0.6	0.0	0.9	1.8
F4	3.0	11.4	21.4	21.1	8.7	65.7
F5	1.8	2.7	7.8	5.7	1.5	19.6
	5.4	16.9	35.2	30.4	12.0	100.0

Microsatellite-based genetics of larval traits



Male	ns	$p<0.05$
Female	ns	$p<0.05$

Family-based genetics and selective breeding



Relative performance of (many) families reared under <u>common</u> conditions to estimate their genetic value

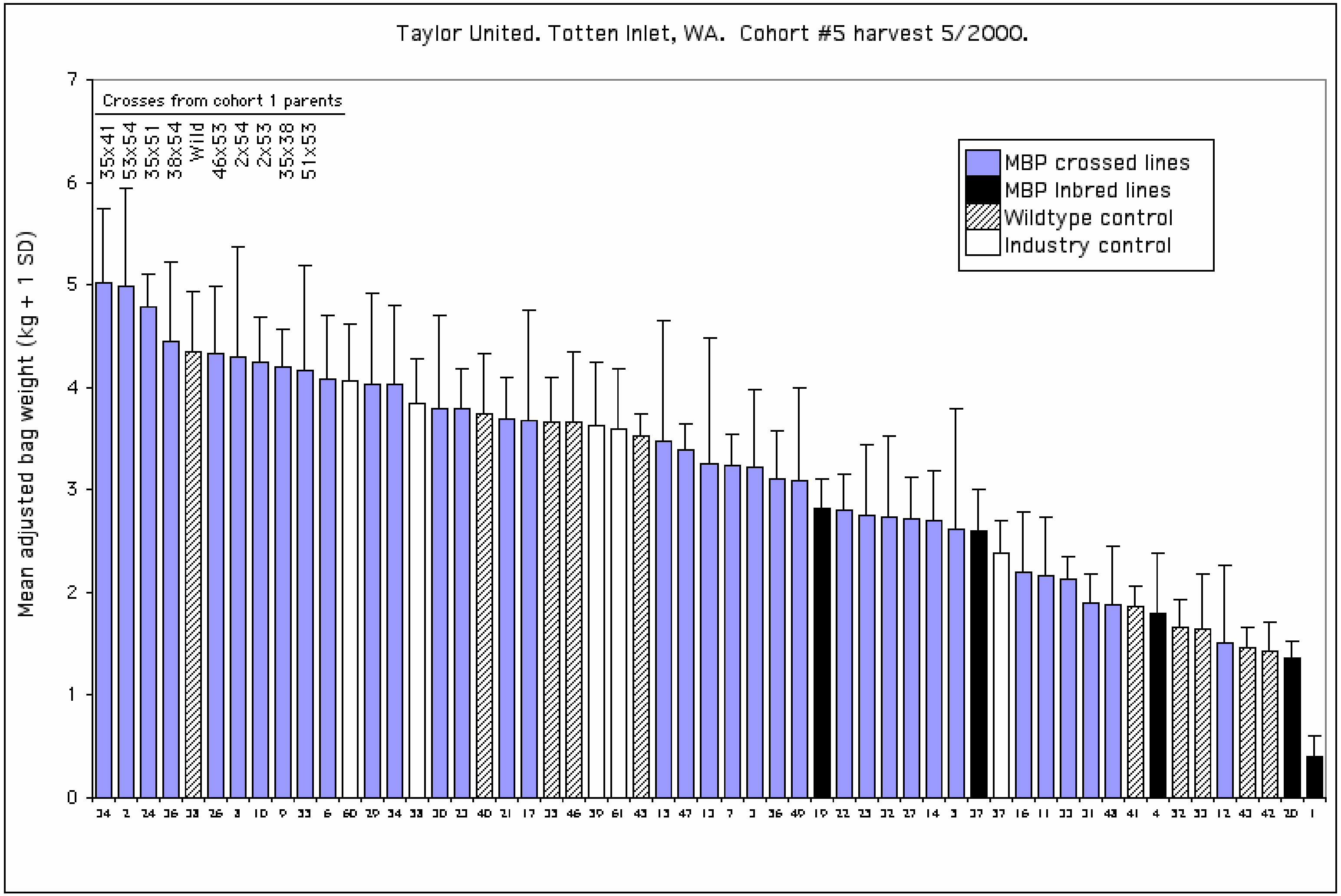
Female	Male 1	2	3	4	5	6
1, 2, 3, 4	Half-Sib 1					
5, 6, 7, 8		Half-Sib 2				
9, 10, 11, 12			Half-Sib 3			
13, 14, 15, 16				Half-Sib 4		
17, 18, 19, 20					Half-Sib 5	
21, 22, 23, 24						Half-Sib 6

Female	Male 7	8	9	10	11	12
25, 26, 27, 28	Half-Sib 7					
29, 30, 31, 32		Half-Sib 8				
33, 34, 35, 36			Half-Sib 9			
37, 38, 39, 40				Half-Sib 10		
41, 42, 43, 44					Half-Sib 11	
45, 46, 47, 48						Half-Sib 12

Female	Male 13	14	15	16	17	17
49, 50, 51, 52	Half-Sib 13					
53, 54, 55, 56		Half-Sib 14				
57, 58, 59, 60			Half-Sib 15			
61, 62, 63, 64				Half-Sib 16		
65, 66, 67, 68					Half-Sib 17	
69, 70, 71, 72						Half-Sib 18

Family-based selective breeding programs

- Molluscan Broodstock Program (MBP): selection for yield



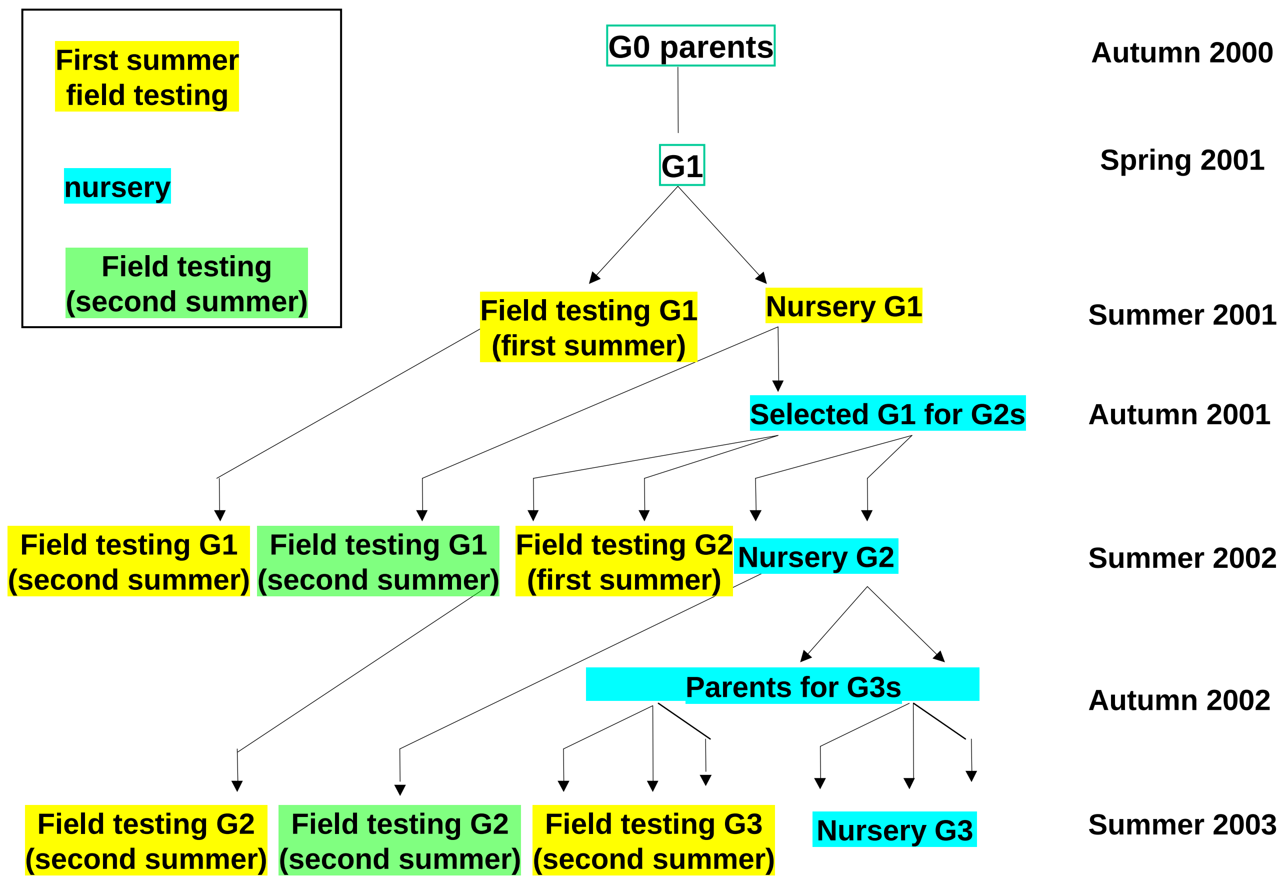
http://www.hmsc.orst.edu/projects/mbp

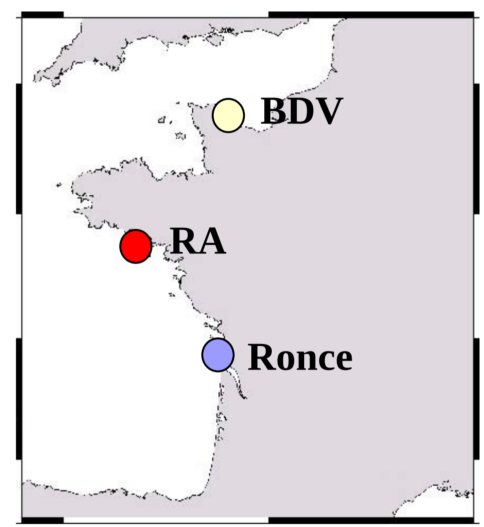
Family-based selective breeding programs

- "WRAC" : development of inbreed lines and crossbreeding

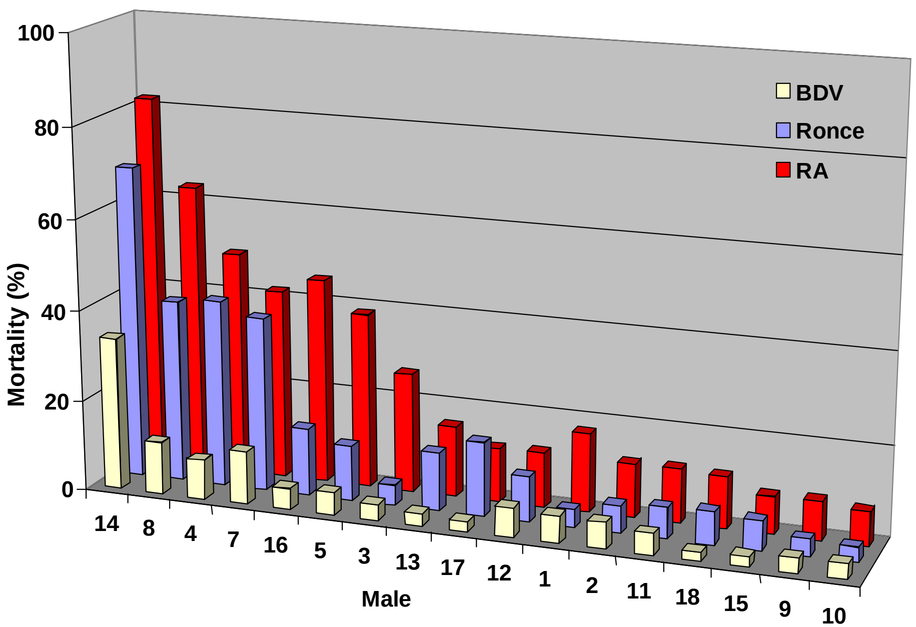
http://hmsc.oregonstate.edu/projects/wrac/

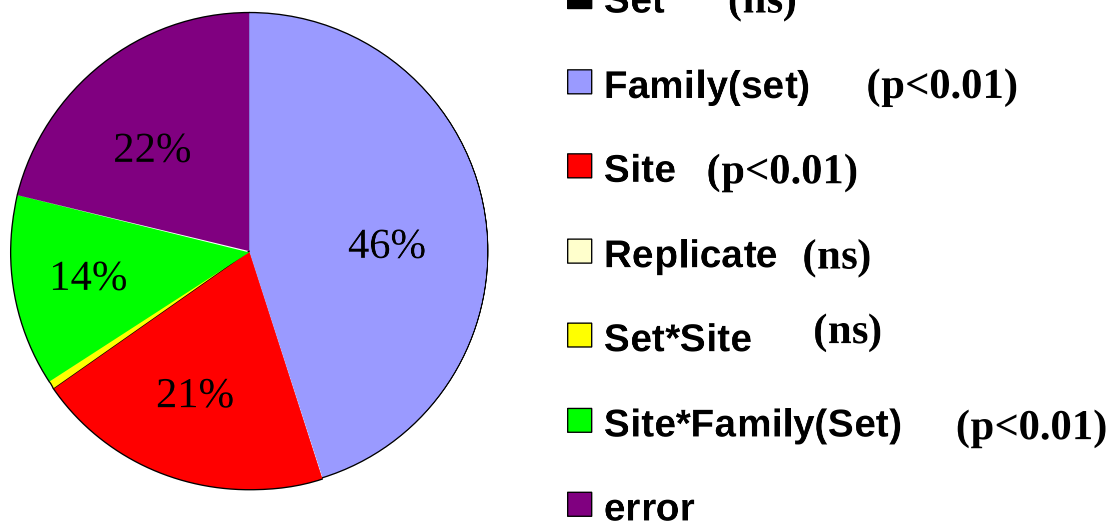
Selective breeding experiment on spat survival





G1 half-sib families: mortality in the field

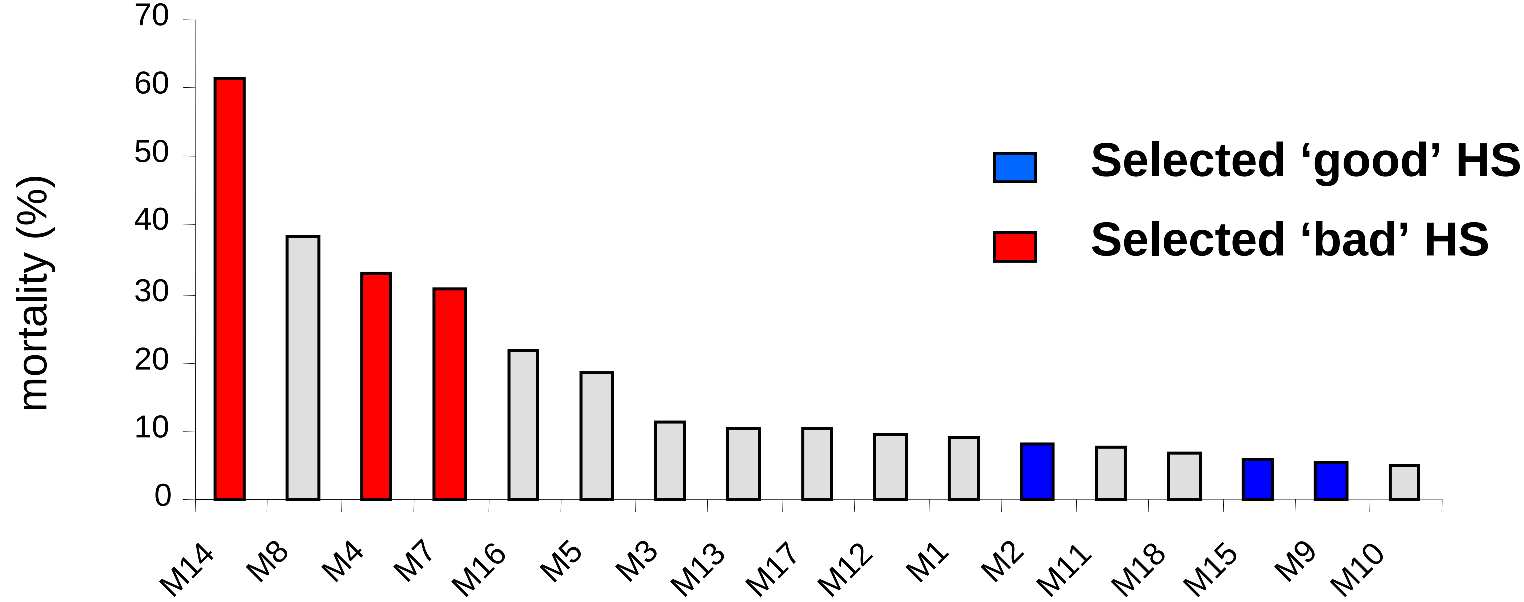




$h^2 = 0.81 \pm 0.29$

Dégremont, 2003

Second generation (G2SD): divergent selection



Low selected group ‘S’

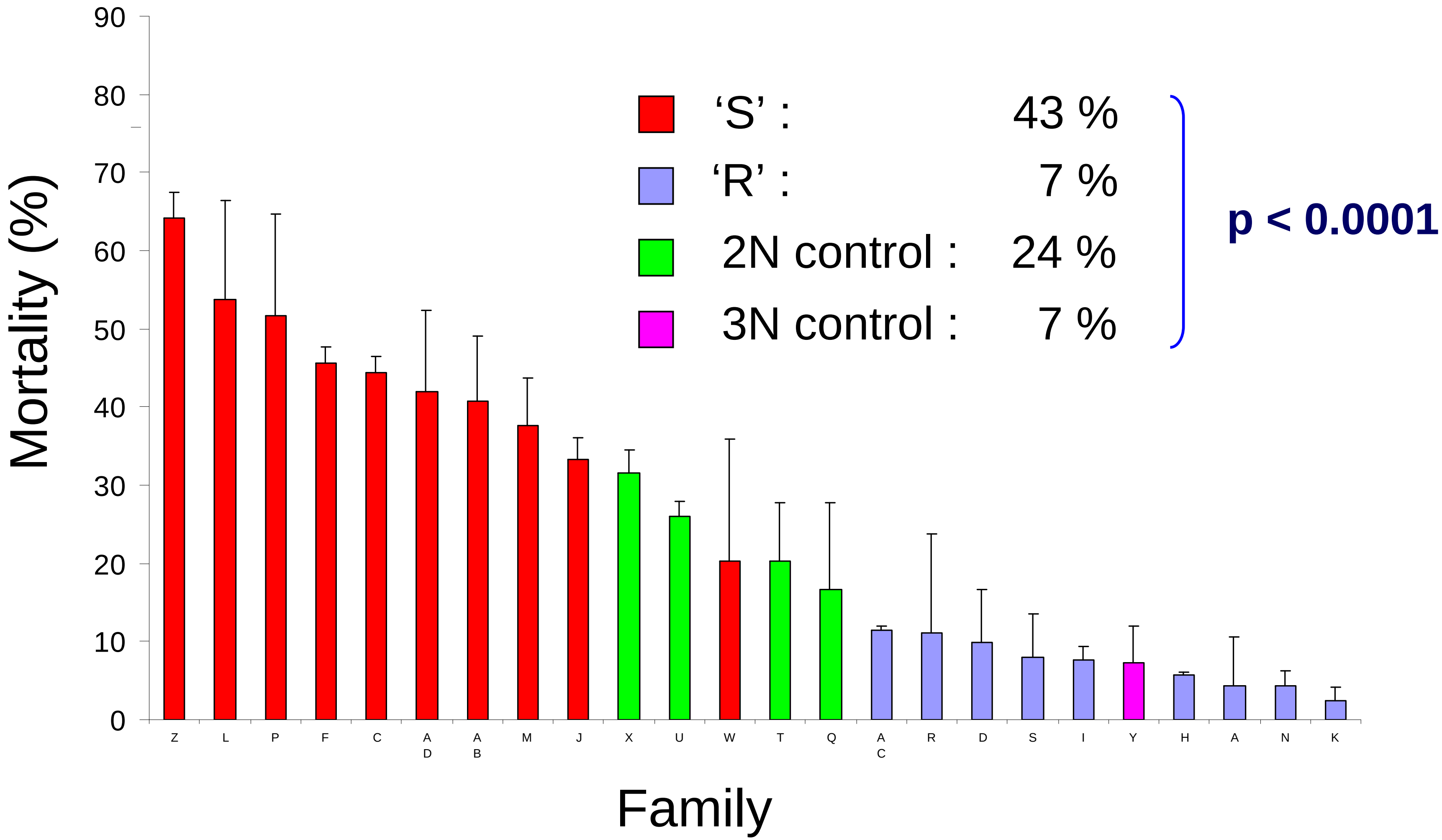
Male		*4*		*7*		*14*	
	Family	**F4-15**	**F4-16**	**F7-25**	**F7-26**	**F14-54**	**F14-55**
4	**F4-15**			13	14	17	18
	F4-16			15	16	19	20
7	**F7-25**					21	22
	F7-26					23	24
14	**F14-54**						
	F14-55						

High selected group ‘R’

Male		*2*		*9*		*15*	
	Family	**F2-5**	**F2-8**	**F9-35**	**F9-36**	**F15-57**	**F15-58**
2	**F2-5**			1	2	5	6
	F2-8			3	4	7	8
9	**F9-35**					9	10
	F9-36					11	12
15	**F15-57**						
	F15-58						

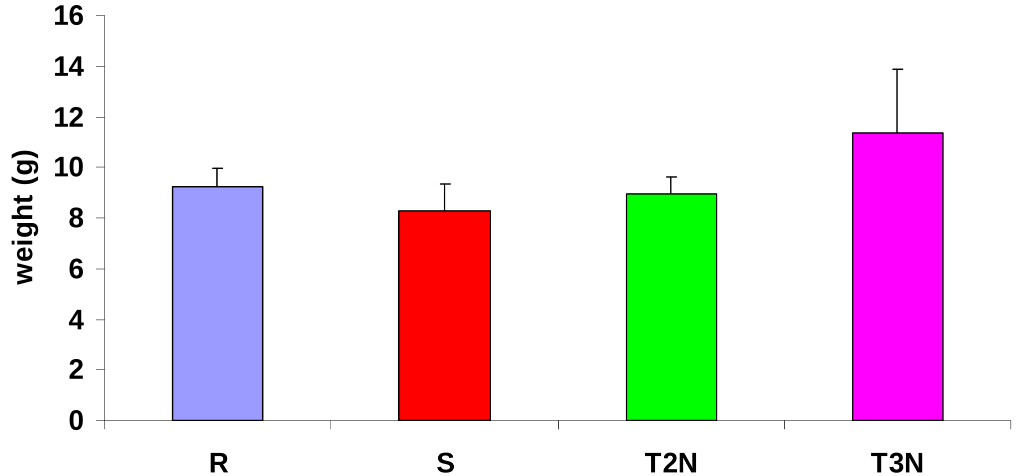
+ Controls : 2N and 3N

G2SD: Summer mortality in Brittany (RA)



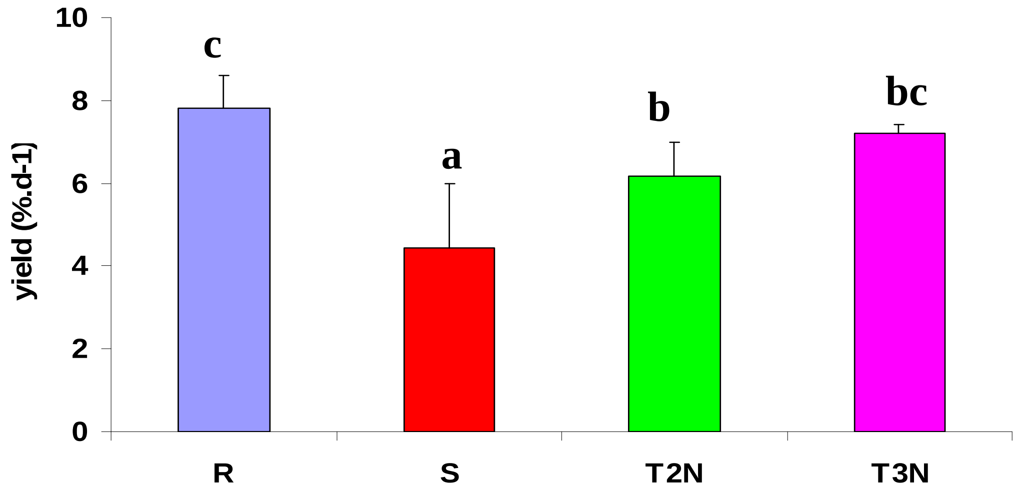
S > T2n > T3n = R

G2SD: Response to selection for survival on growth and yield



Growth

ns



Yield

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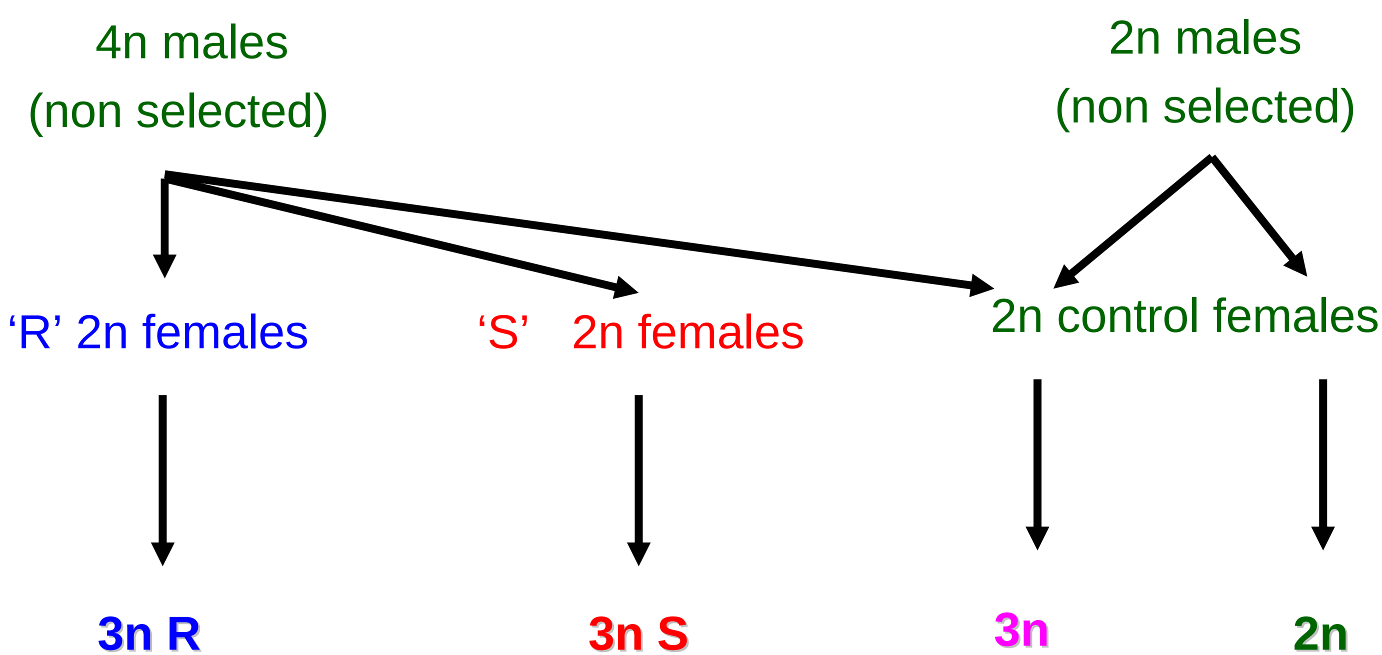
R^2 = 0.94

How to breed selected polyploids ?

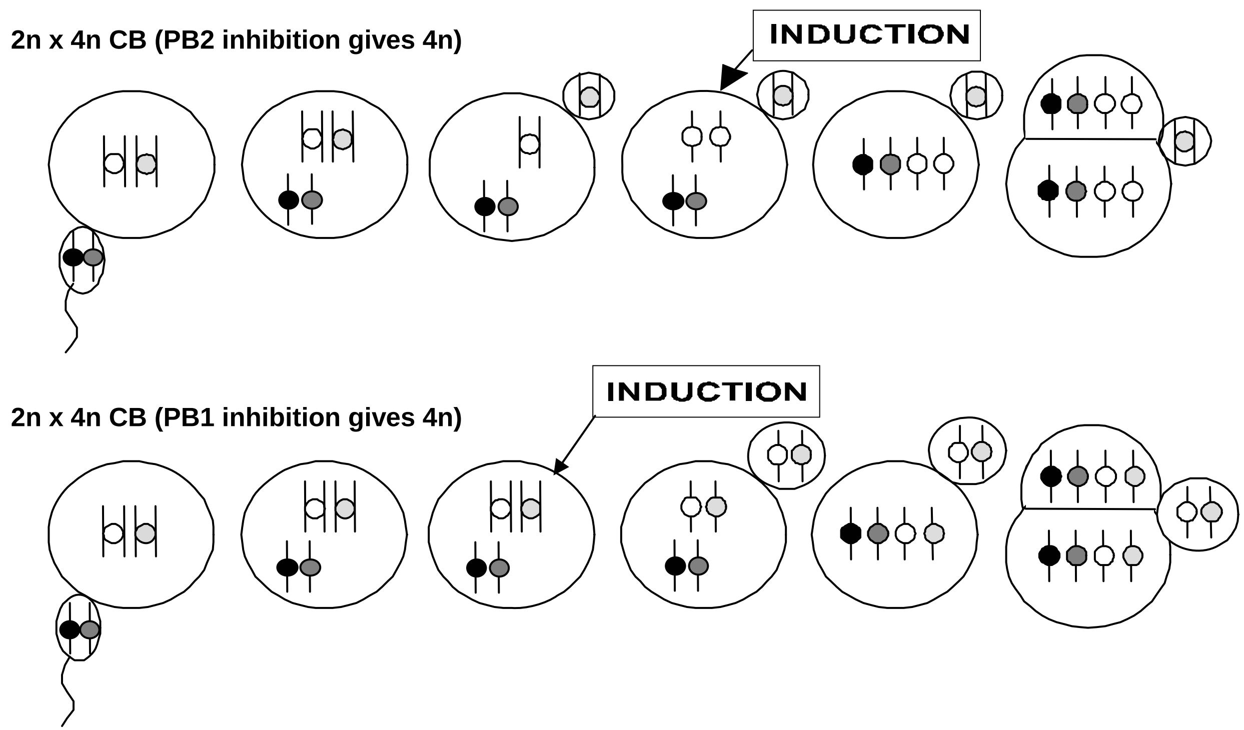


	3n R	3n S	3n	2n
Mortality :	**36 %**	**58 %**	**50 %**	**48 %**

3n R < 2n = 3n = 3n S

How to genetically improve tetraploids ?

- ➢Production of new 4n stock from genetically improved 2n
- ➢Direct selection of 4n
- ➢Combined selection of 4n and 2n on their 3n progeny
- ➢Introgression of selected traits from diploids to tetraploids :



McCombie et al., in press

Conclusions:

Until now, relatively limited impact on production

Concerns about the interaction with the environment

Genetically improved bivalves can be developed, assuming hatchery production is feasible <u>and</u> profitable, so that money can be invested in selective breeding programs

Combined selective breeding and polyploidy is complex but promising