GENETICAL BASIS OF THE PLASTICITY OF RESOURCE ALLOCATION IN THE PACIFIC OYSTER (*Crassostrea gigas)*

Bruno Ernande

CNRS-CREMA L'Houmeau, France

Joel Haure

IFREMER-LCPL Bouin, France

Lionel Degrémont, **Edouard Bédier**, **Pierre Boudry**

IFREMER-LGP, La Tremblade, France

Introduction

Oysters are fixed animals, living in a highly variable environment :

➔ ***Unlike most animals, individuals cannot "escape" when the environment deteriorates***

Hypotheses: oysters have developed a high ability to face variable environmental conditions :

Physiological plasticity of an individual facing ***temporal*** variability
Phenotypic plasticity of a genotype facing ***spatial*** variability

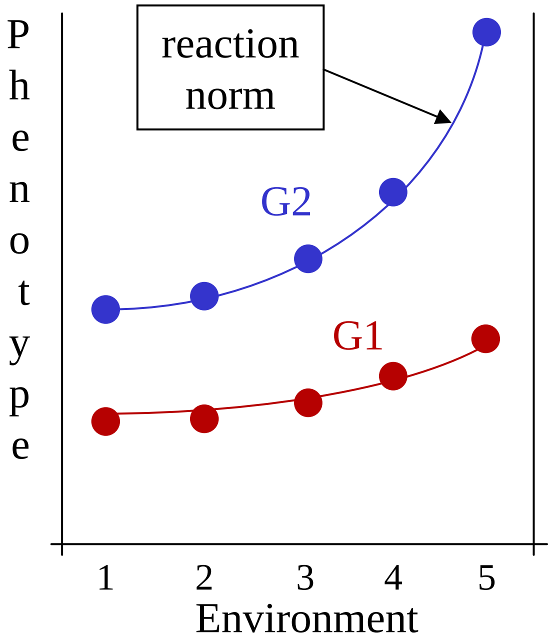
Definitions

- ***Phenotypic Plasticity***

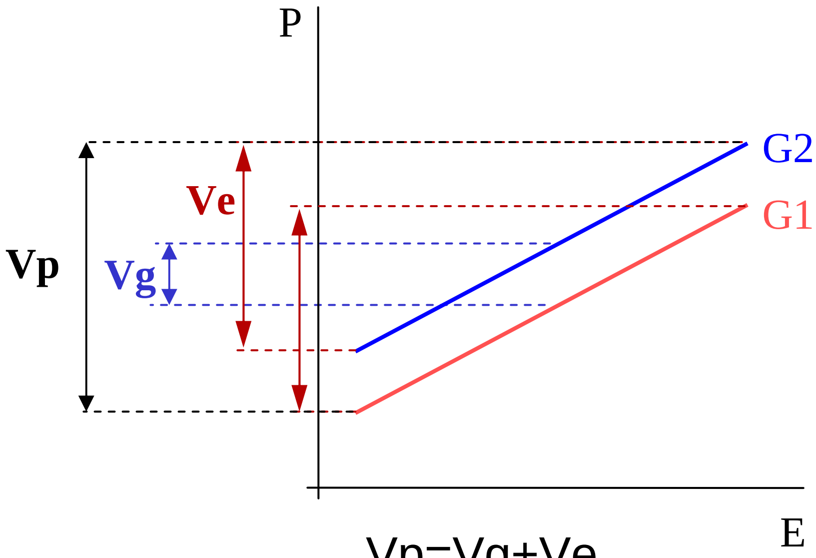
  A given genotype Gi produces different phenotypes Pij according to the environment Ej.

- ***Reaction norm***

  The profile of phenotypes that a single genotype expresses in response to a given range of environments

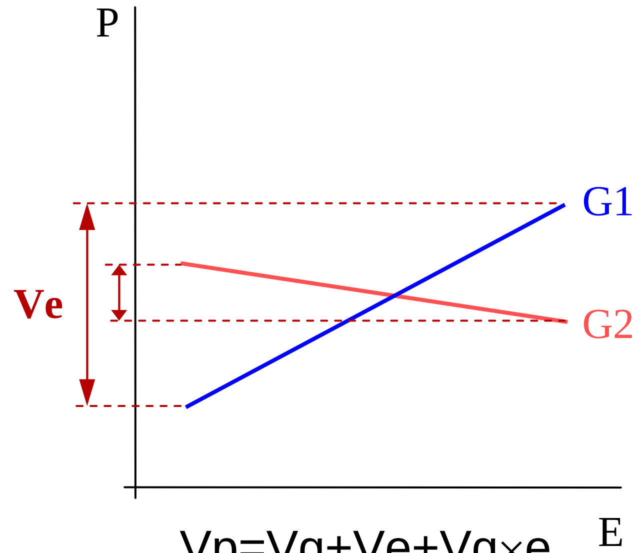


How to quantify the genetic basis of plasticity ?



Vp=Vg+Ve

No genetic variance for plasticity

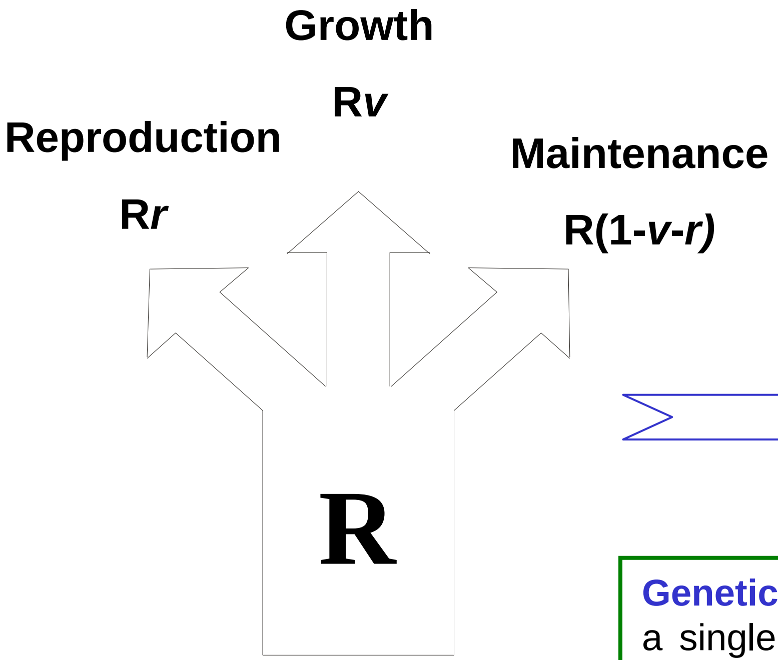


Vp=Vg+Ve+Vg×e

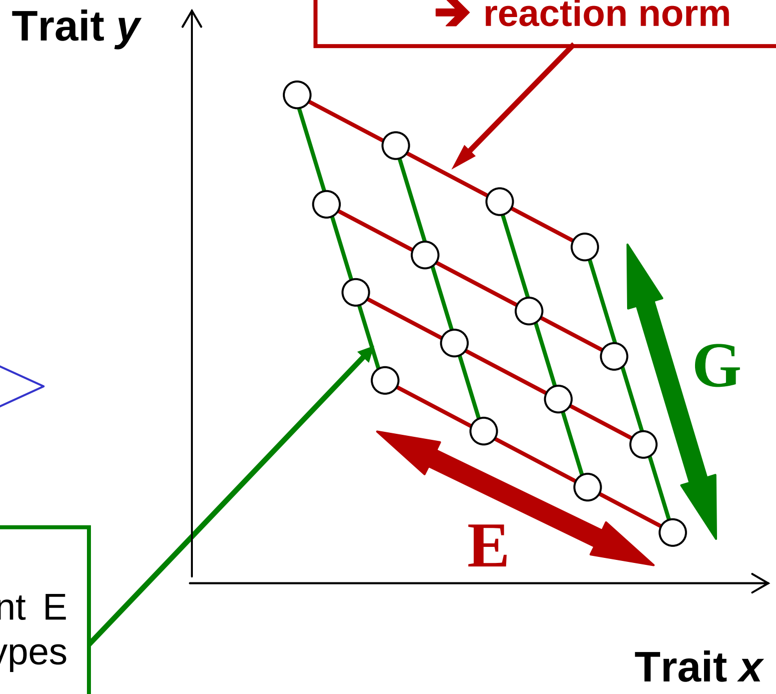
Plasticity is genetically based and variable

- **Heritability:** the proportion of phenotypic variance which originates in **genetic variance :**
  - **Heritability of mean trait = Vg / Vp**
  - **Heritability of plasticity = Vg×e / Vp**

Resource allocation and trade-offs



Physiological trade-off:
a single genotype G and different environments E:
➔ **reaction norm**

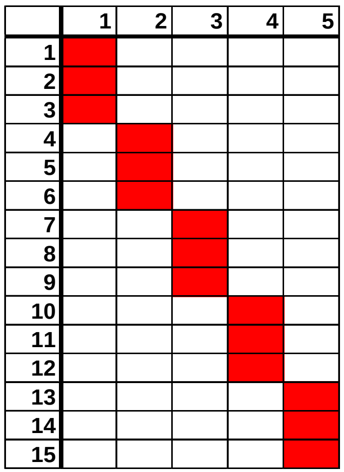


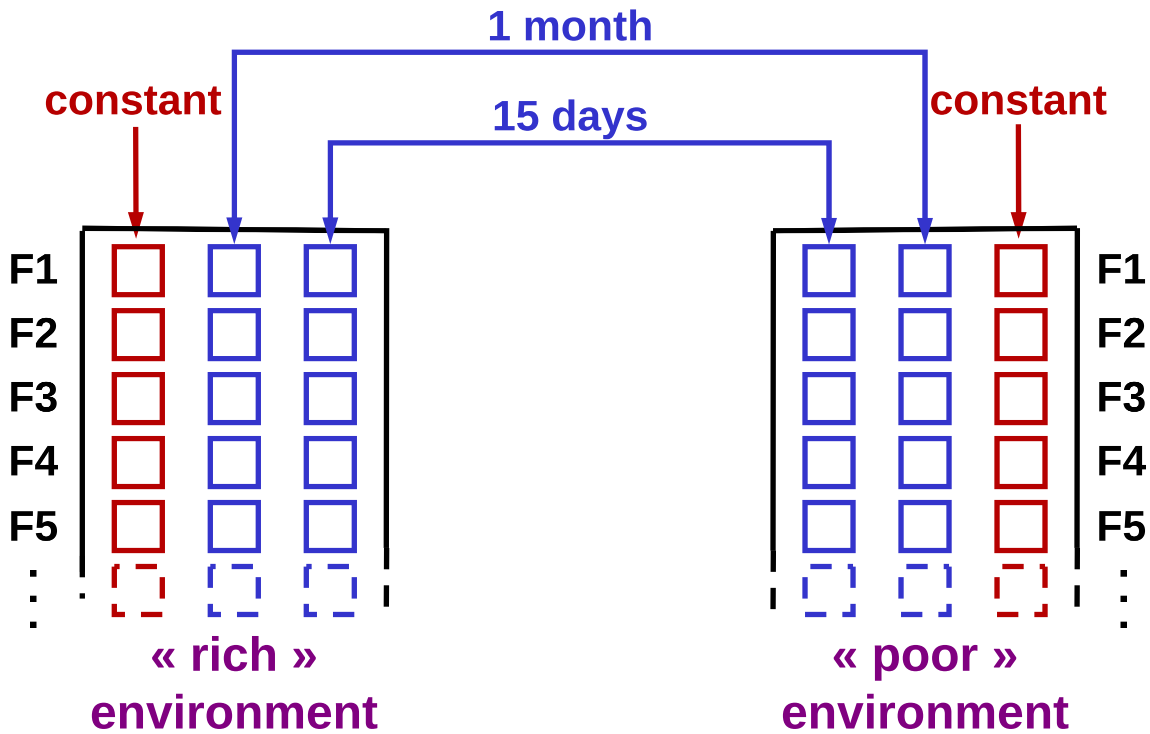
Genetic trade-off:
a single environment E and different genotypes G:
➔ **genetic correlation**

Is the plasticity of resource allocation-related traits genetically variable in *C. gigas* ?

Experimental design

Nested half-sib mating design:
15 FS = 5 HF families





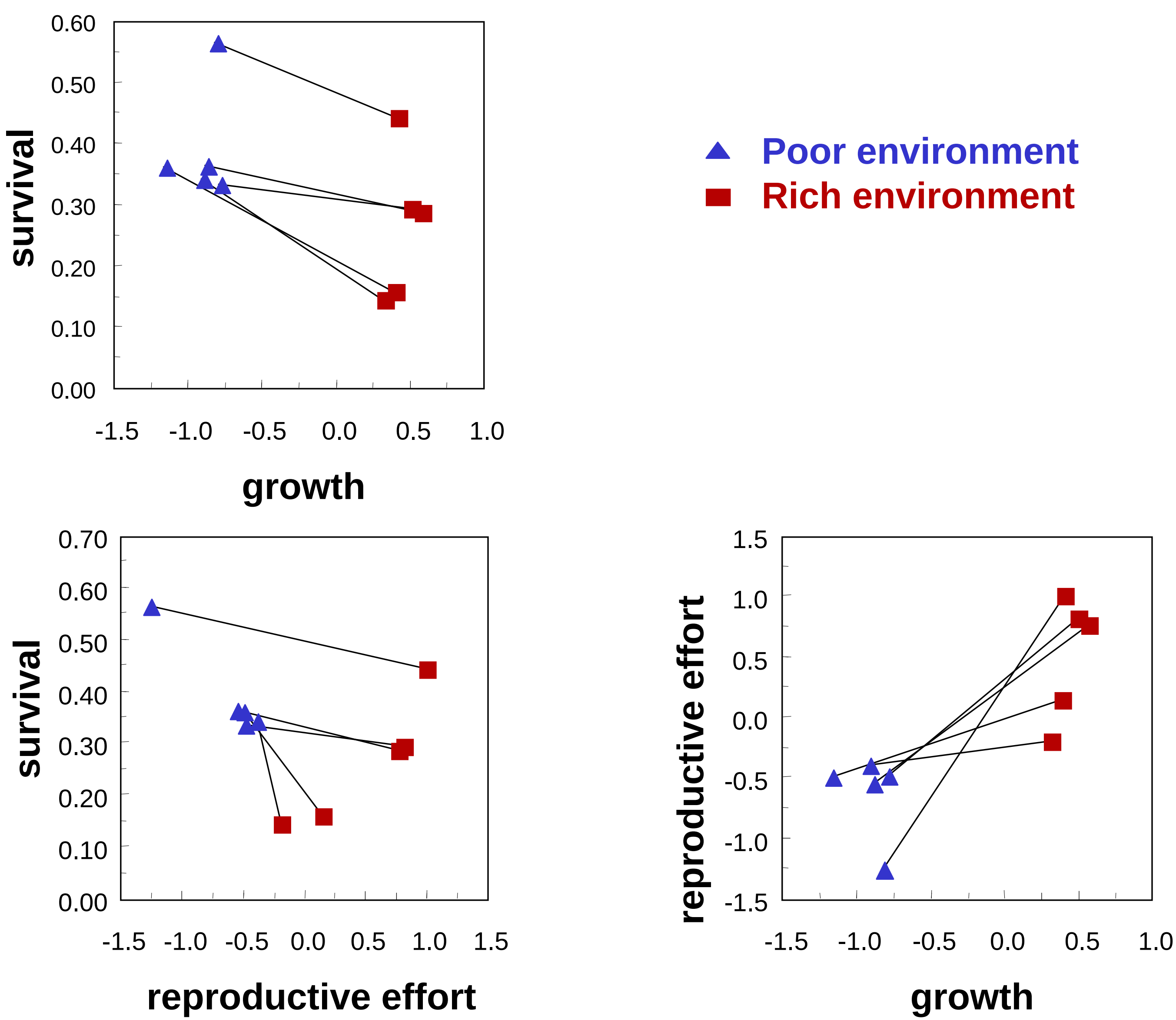
During 6 months, every 2 weeks:

- **Survival: 120 individuals/ family/treatment**
- **Growth: 30 individuals/family/treatment**

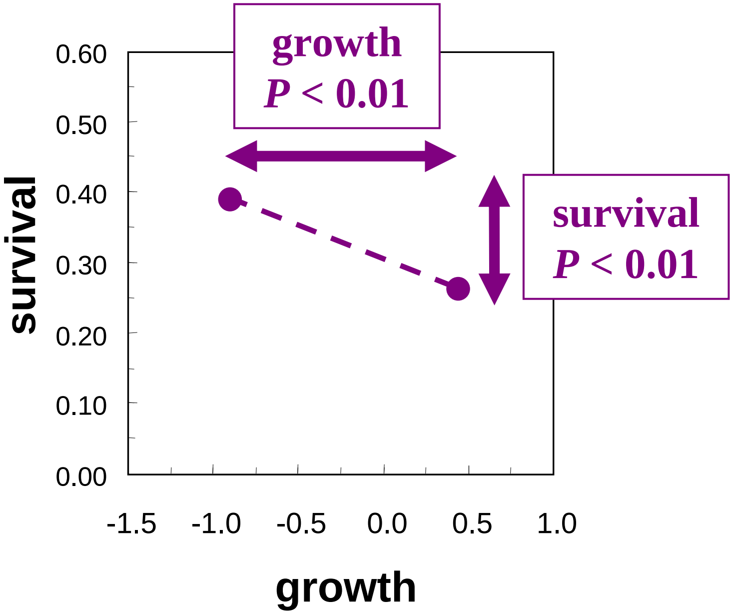
Once during the summer:

- **Reproductive effort: 30 individuals/family/treatment**

Results

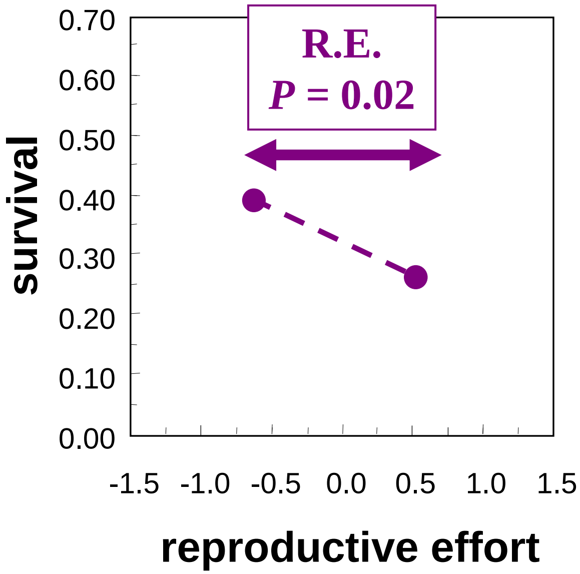

Poor environment
Rich environment
survival
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-1.5
-1.0
-0.5
0.0
0.5
1.0
growth
survival
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-1.5
-1.0
-0.5
0.0
0.5
1.0
1.5
reproductive effort
reproductive effort
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-1.5
-1.0
-0.5
0.0
0.5
1.0
growth

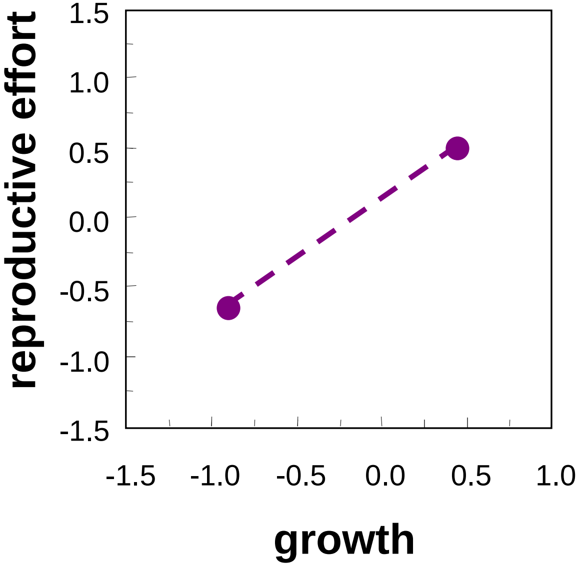
Physiological trade-offs



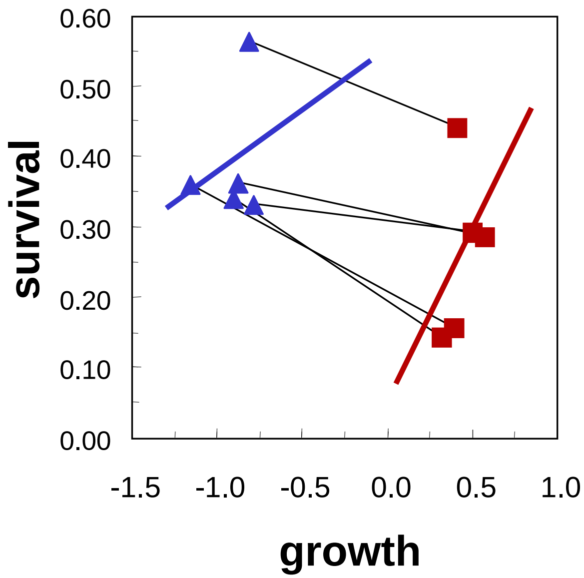
The environmental effect reveals a physiological trade-off between :

- **survival and growth**
- **survival and reproduction**



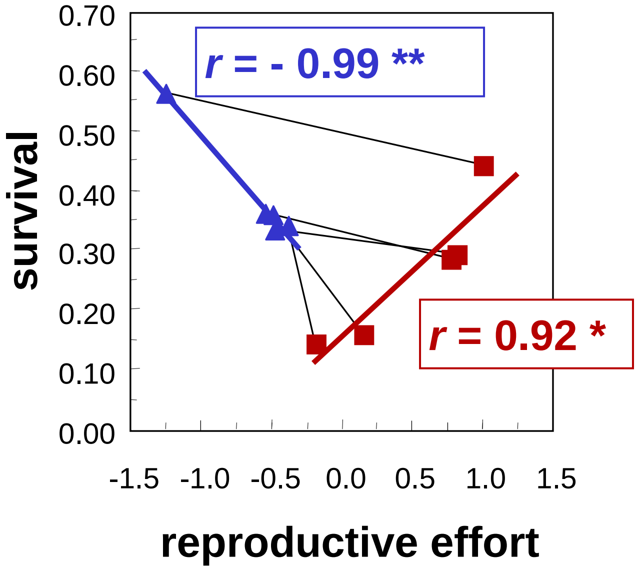


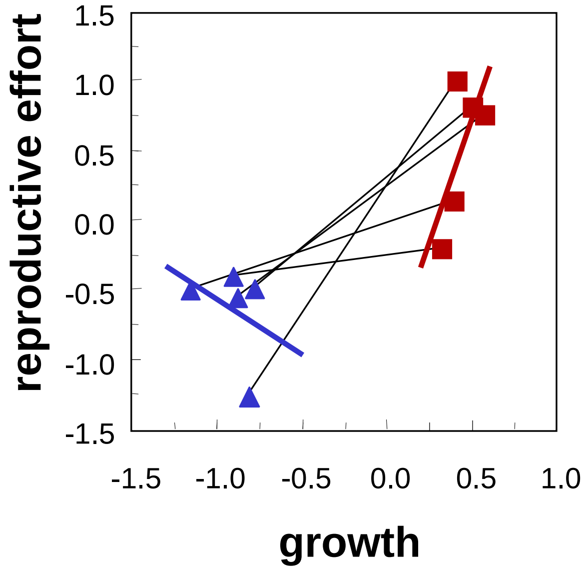
Genetic trade-offs



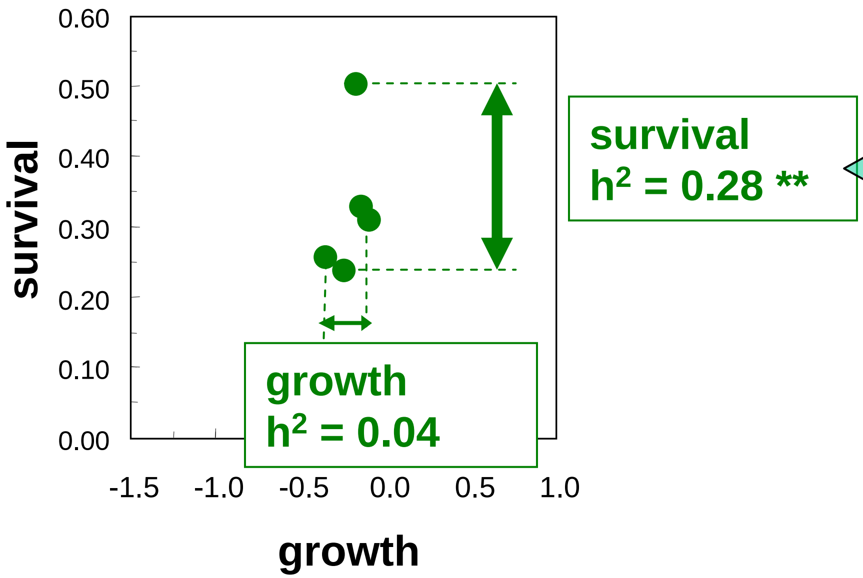
The genetic trade-off between reproductive effort and survival is

- **Negative in the poor environment**
- **Positive in the rich environment**

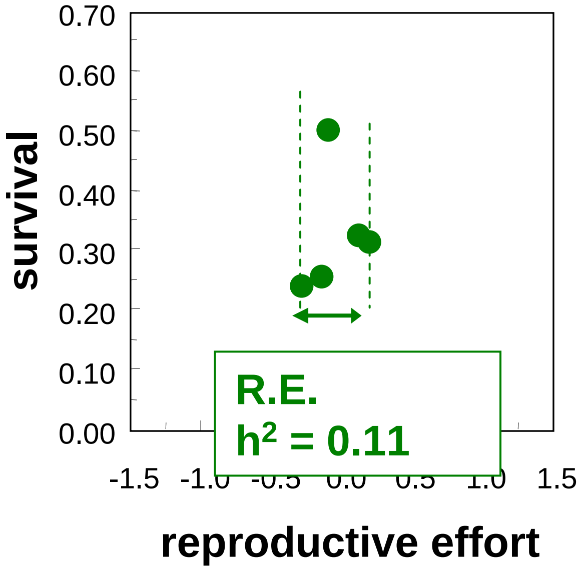


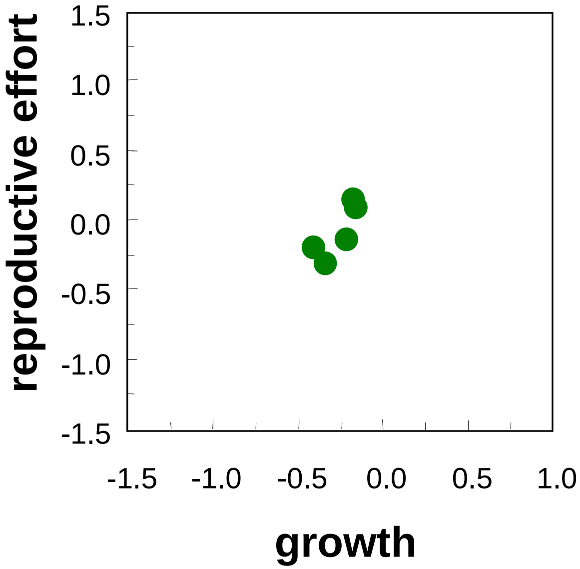


Heritability of the mean traits

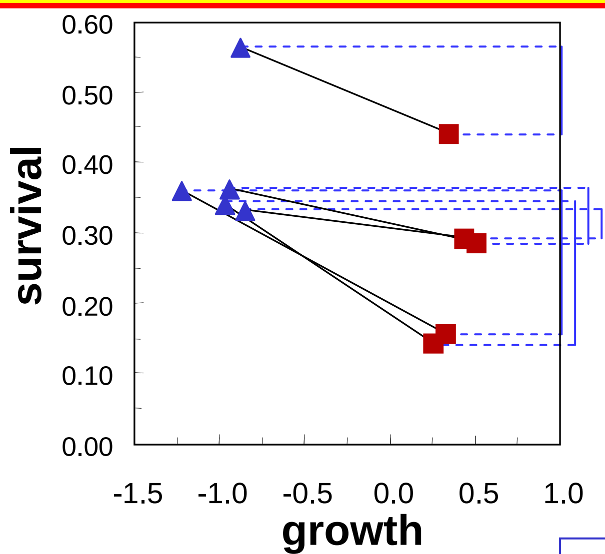


Surprisingly, survival exhibits the highest heritability value





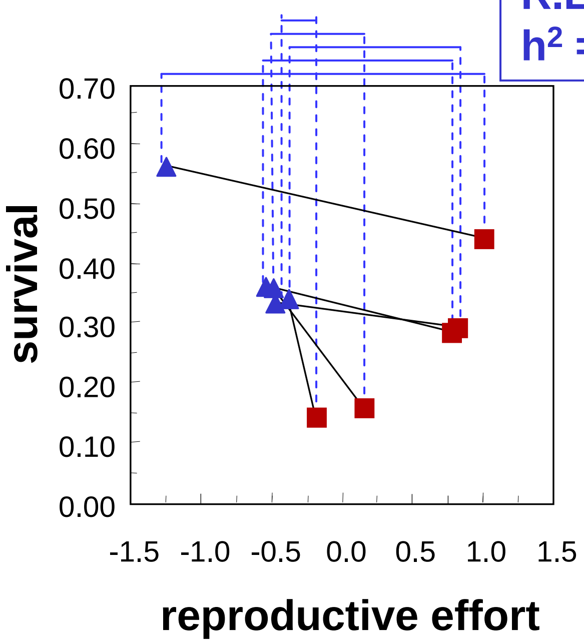
Heritability of the traits' plasticity



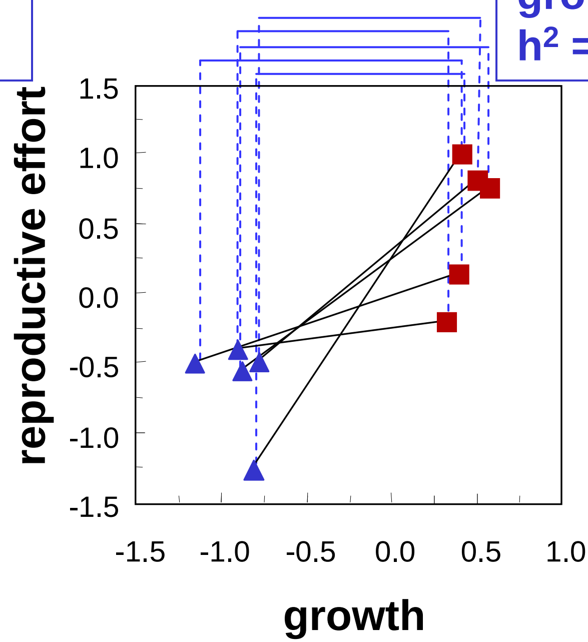
survival
$h^2 = 0.00$

Reproductive effort exhibits a high plasticity of its plasticity

R.E.
$h^2 = 0.58$ **



growth
$h^2 = 0.03$ *

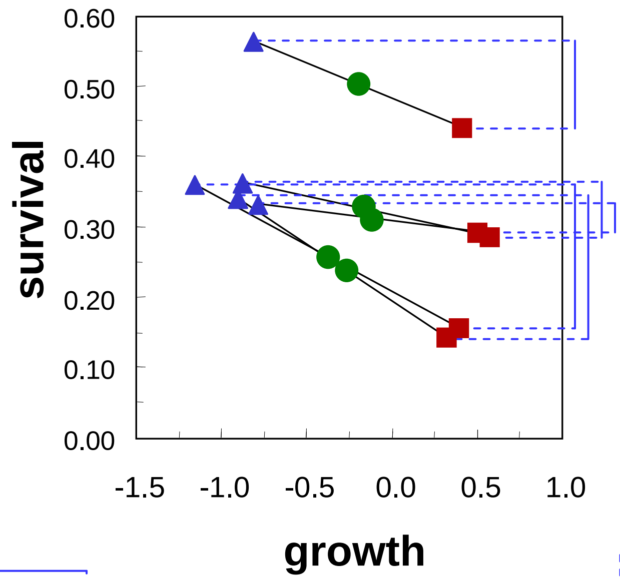


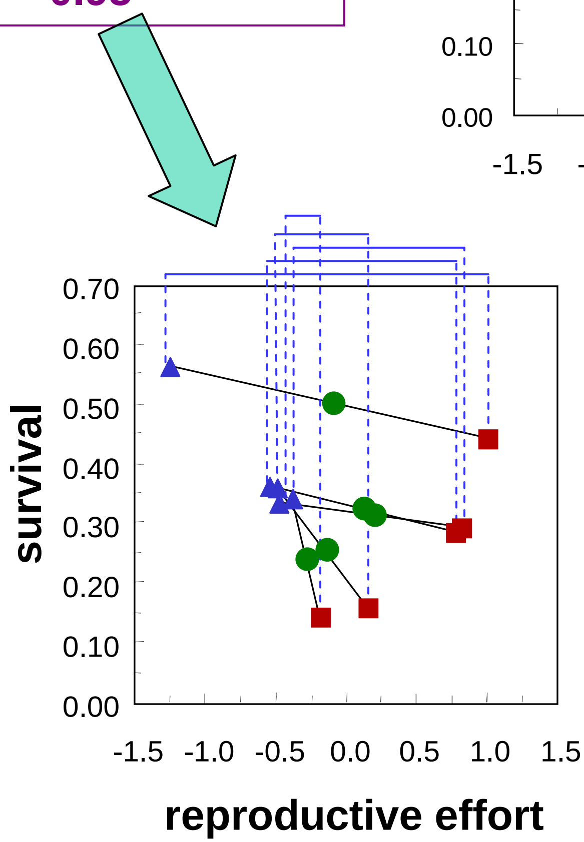
Genetic correlation between traits' plasticity and mean traits

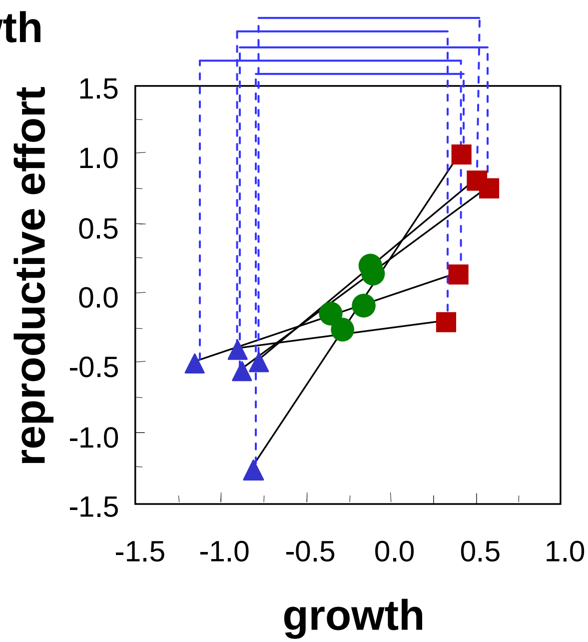
▲ **Poor environment**
■ **Rich environment**

Genetic correlation between mean survival and R.E. plasticity:

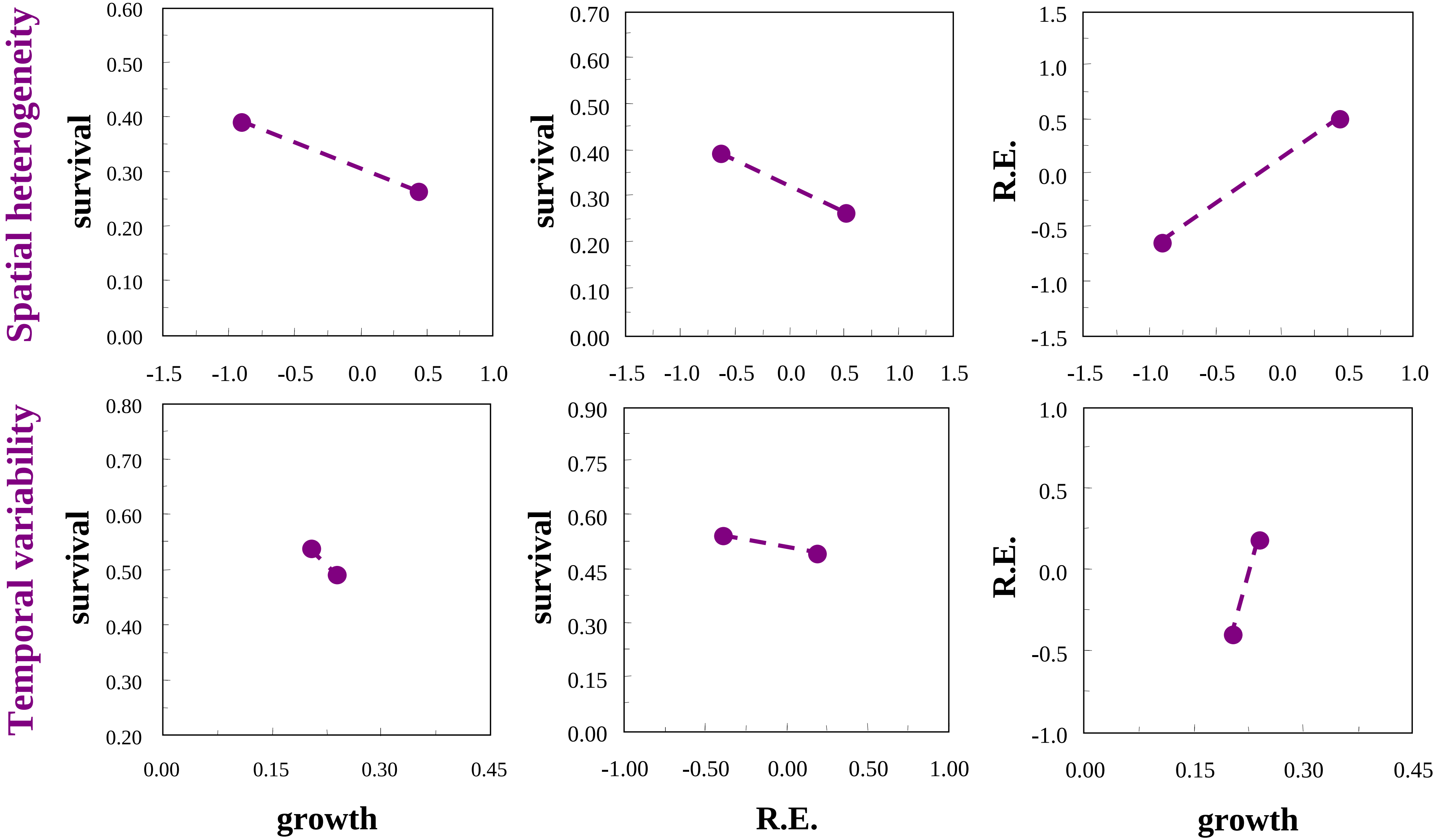
***r* = 0.95 ***





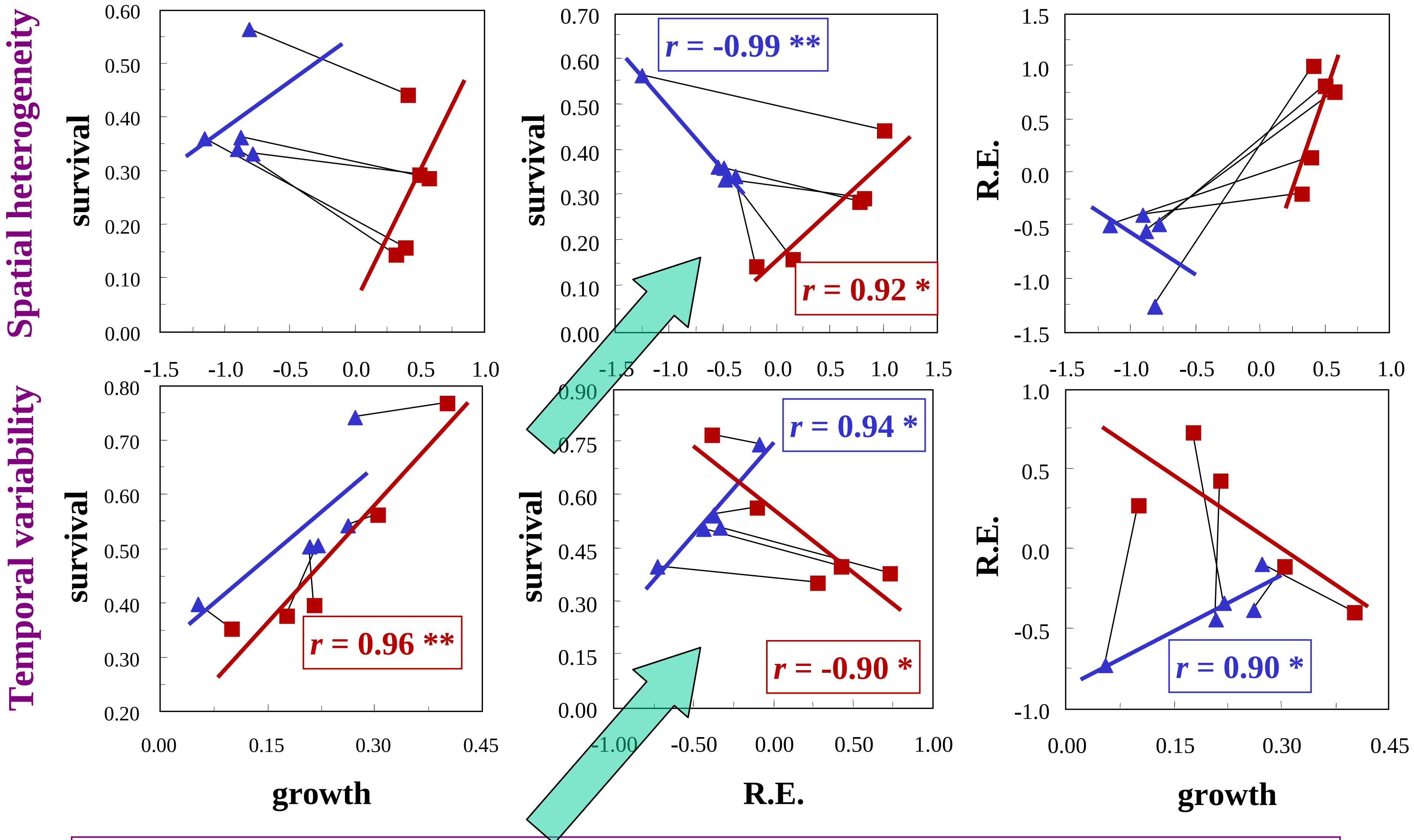


Effect of spatial *versus* temporal variability



The patterns of plastic covariation of the traits are qualitatively similar but...

Effect of spatial *versus* temporal variability



Sign reversals of significant genetic correlations are observed in the two cases

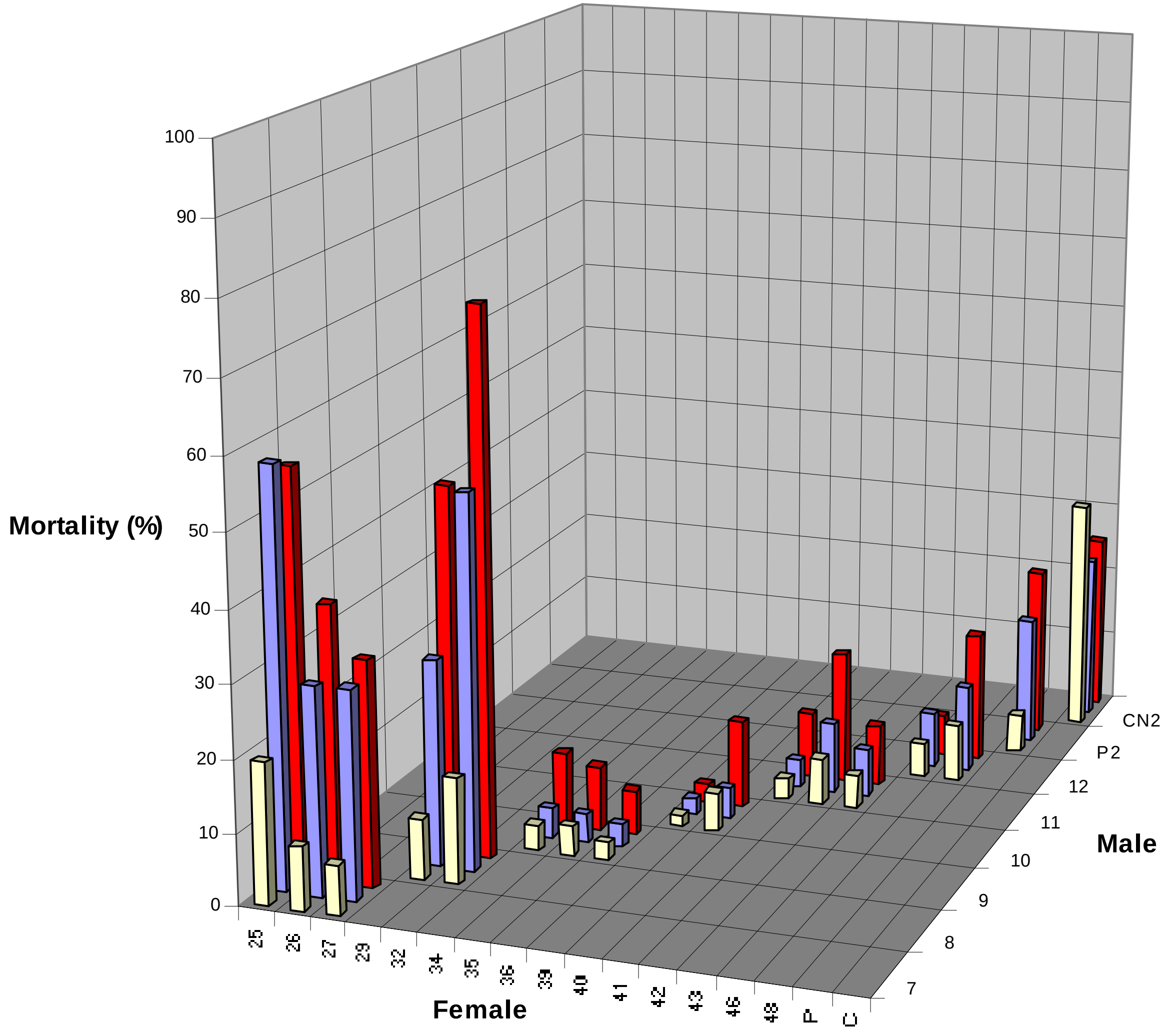
Conclusions

- **The observed physiological and genetic trade-offs must be taken into account when natural evolution and/or artificial selection of the studied traits are considered.**
- **Genetic polymorphism in reaction norms can be responsible for sign reversals of genetic correlations. This shows how correlated responses to selection can vary according to the environment.**
- **Results must be considered cautiously due to the limited number of half-sib families**

Work in progress

In 2001, the same crossing design was replicated 3 times, generating 45 FS families (= 17 half-sib families) and tested in 3 sites

Latest data



Mortality (%)
100
90
80
70
60
50
40
30
20
10
0
25
26
27
29
32
34
35
36
39
40
41
42
43
46
48
P
C
Female
CN2
P2
12
11
10
9
8
7
Male