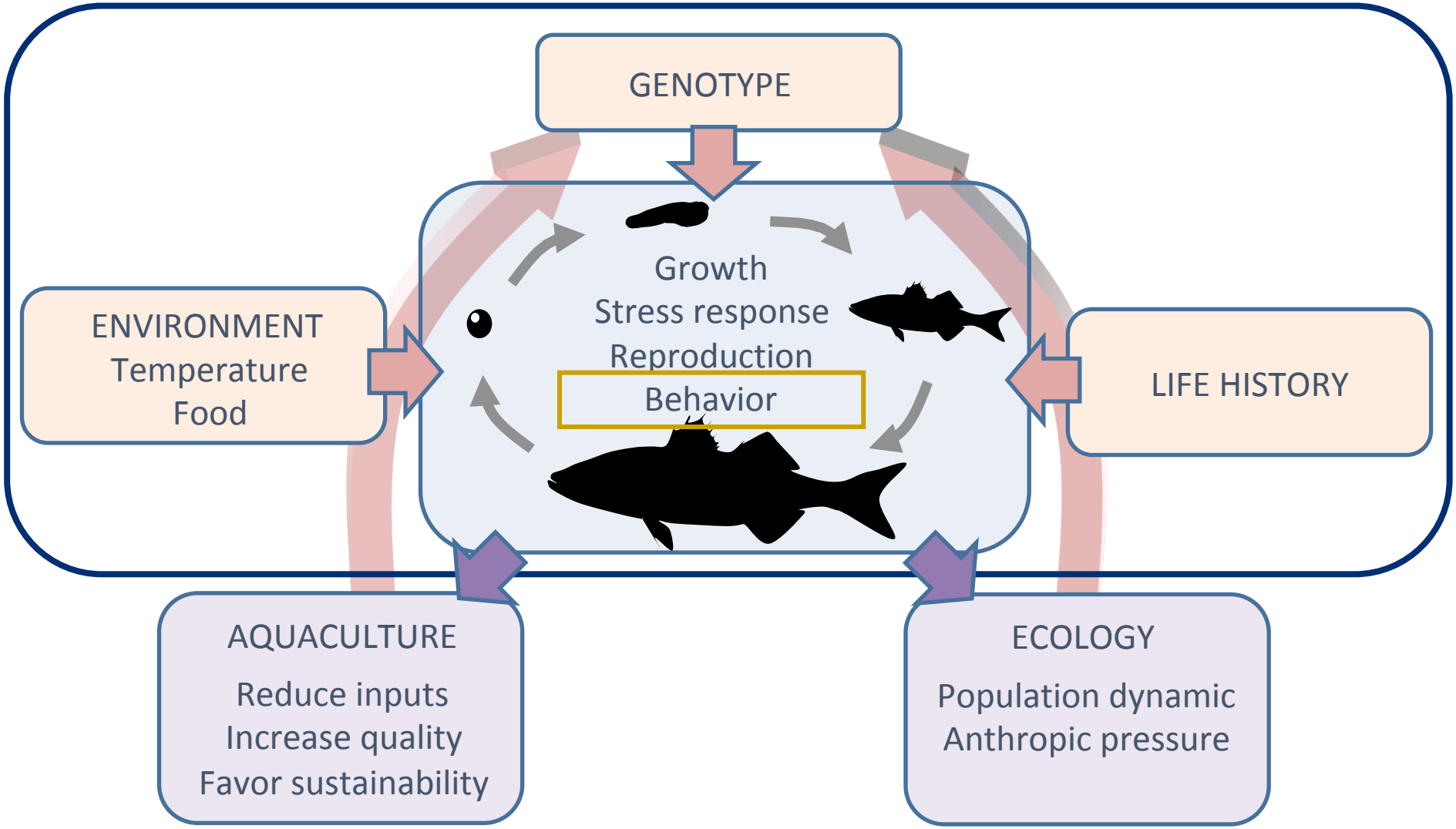
Accounting for genetic variability in fitness-related traits using a Dynamic Energy Budget model, an example on European Seabass

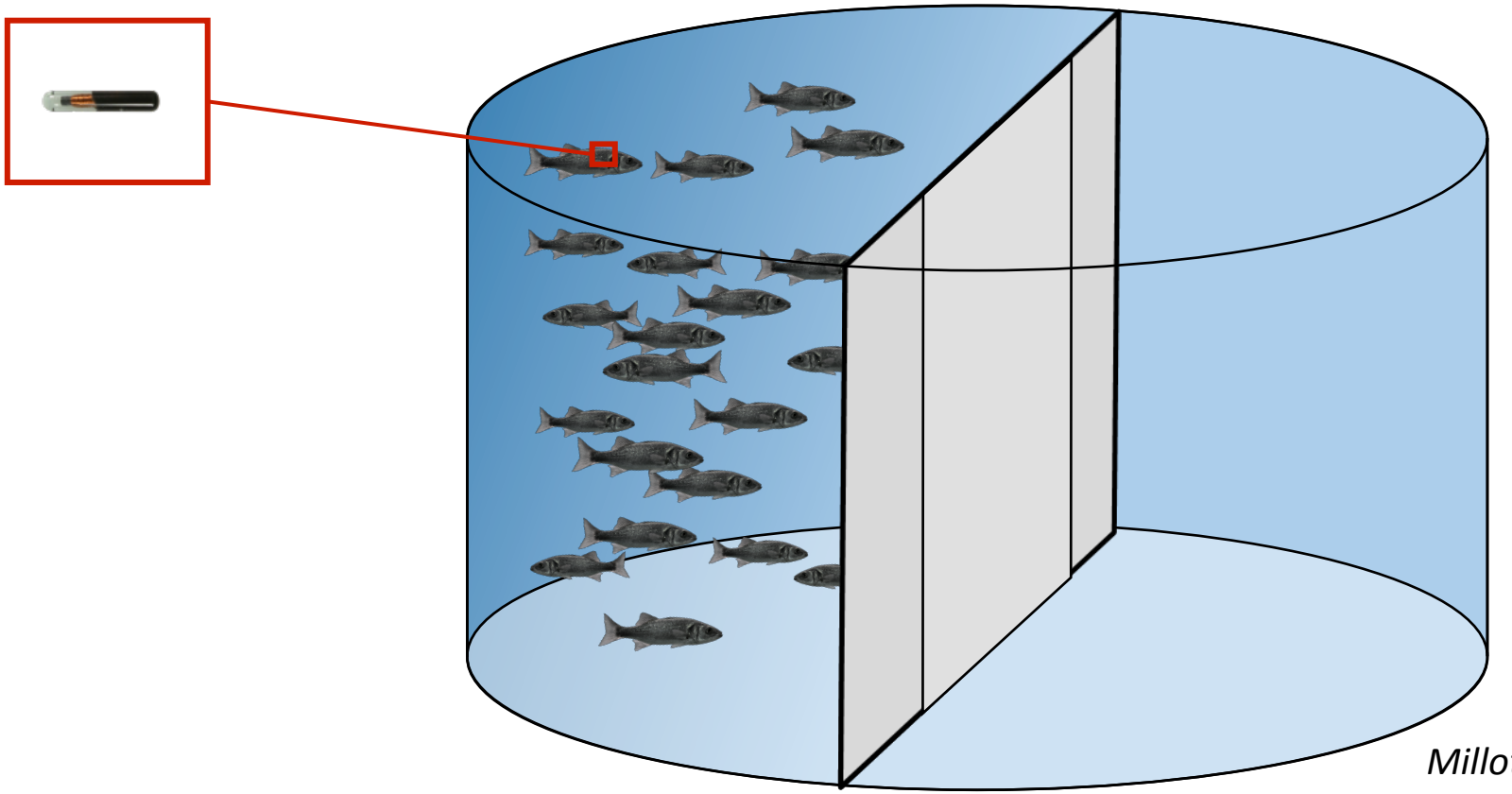
DEB2019

M. Besson, M. Vandeputte, F. Allal, P. Prunet , M.L. Bégout, B. Sadoul

Inter-individual variability



Inter-individual variability in risk taking behavior

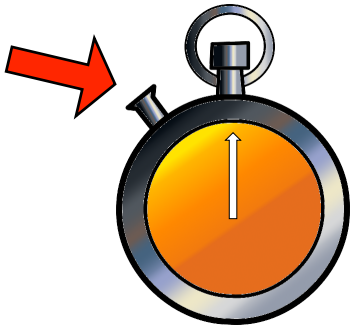


Millot et al., 2009

Inter-individual variability in risk taking behavior

Bold-shy continuum

Shy — Bold



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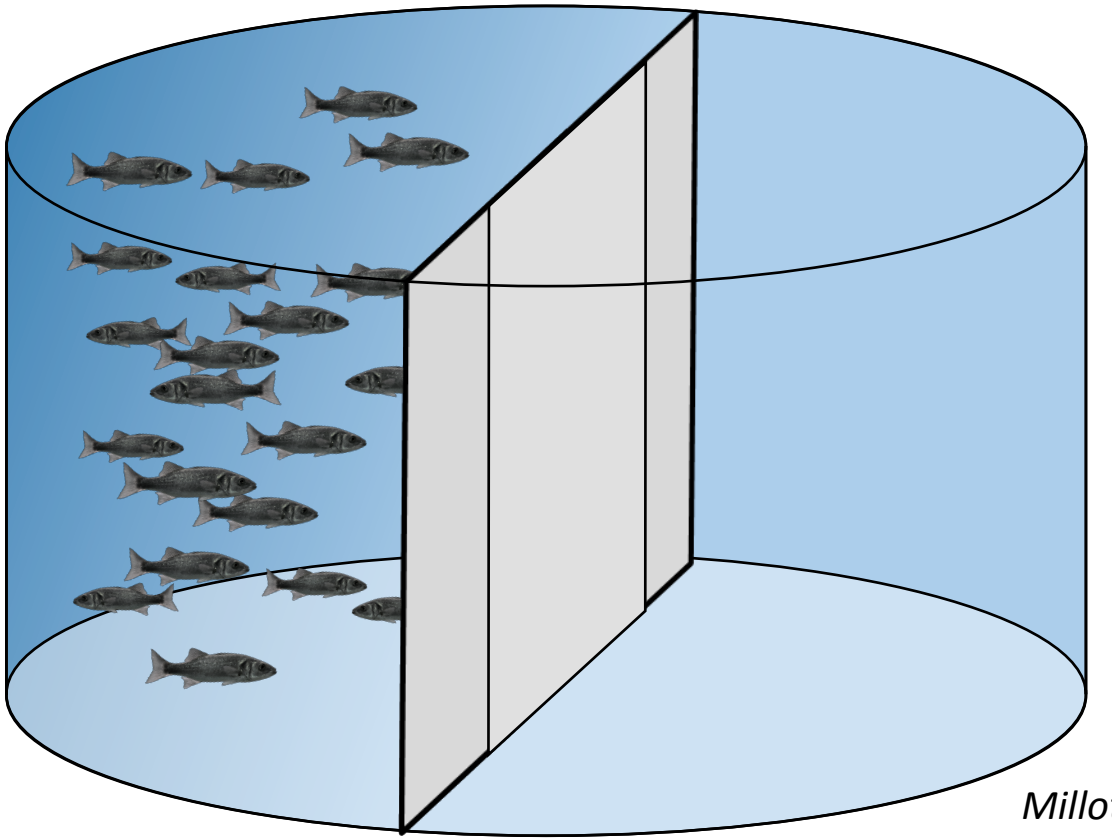


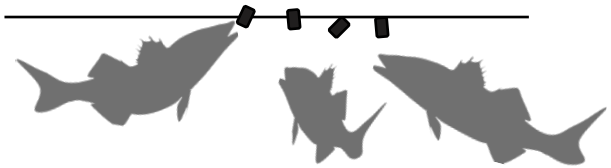
Millot et al., 2009

Inter-individual variability in risk taking behavior

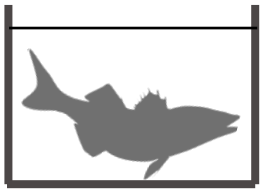
Bold-shy continuum

Shy — Bold

Feeding behavior



Stress response



Learning capacities

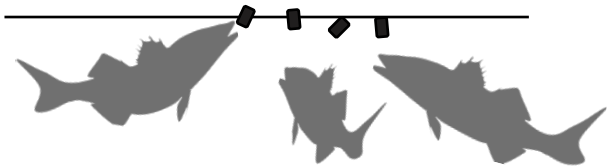
Sih et al. 2004
Koolhaas et al. 1999
Sih & Del Giudice 2012

Inter-individual variability in risk taking behavior

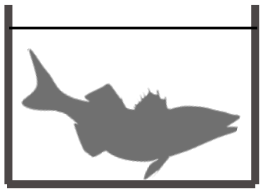
Bold-shy continuum

Shy — Bold

Feeding behavior



Stress response



Learning capacities

→ Physiological parameters
(gene expression, cortisol response, immune system, ...)

Inter-individual variability in risk taking behavior

Bold-shy continuum

Shy — Bold

Tendency to be impacted by fishing pressure

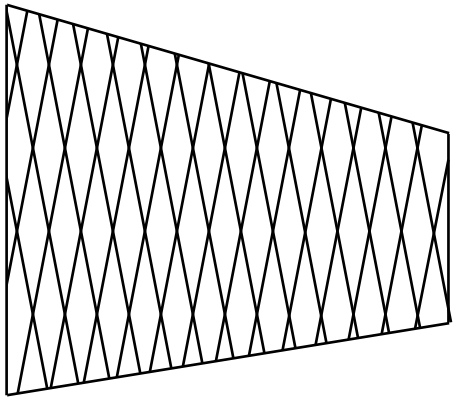
PNAS

Rapid depletion of genotypes with fast growth and bold personality traits from harvested fish populations

Peter A. Biro*† and John R. Post‡

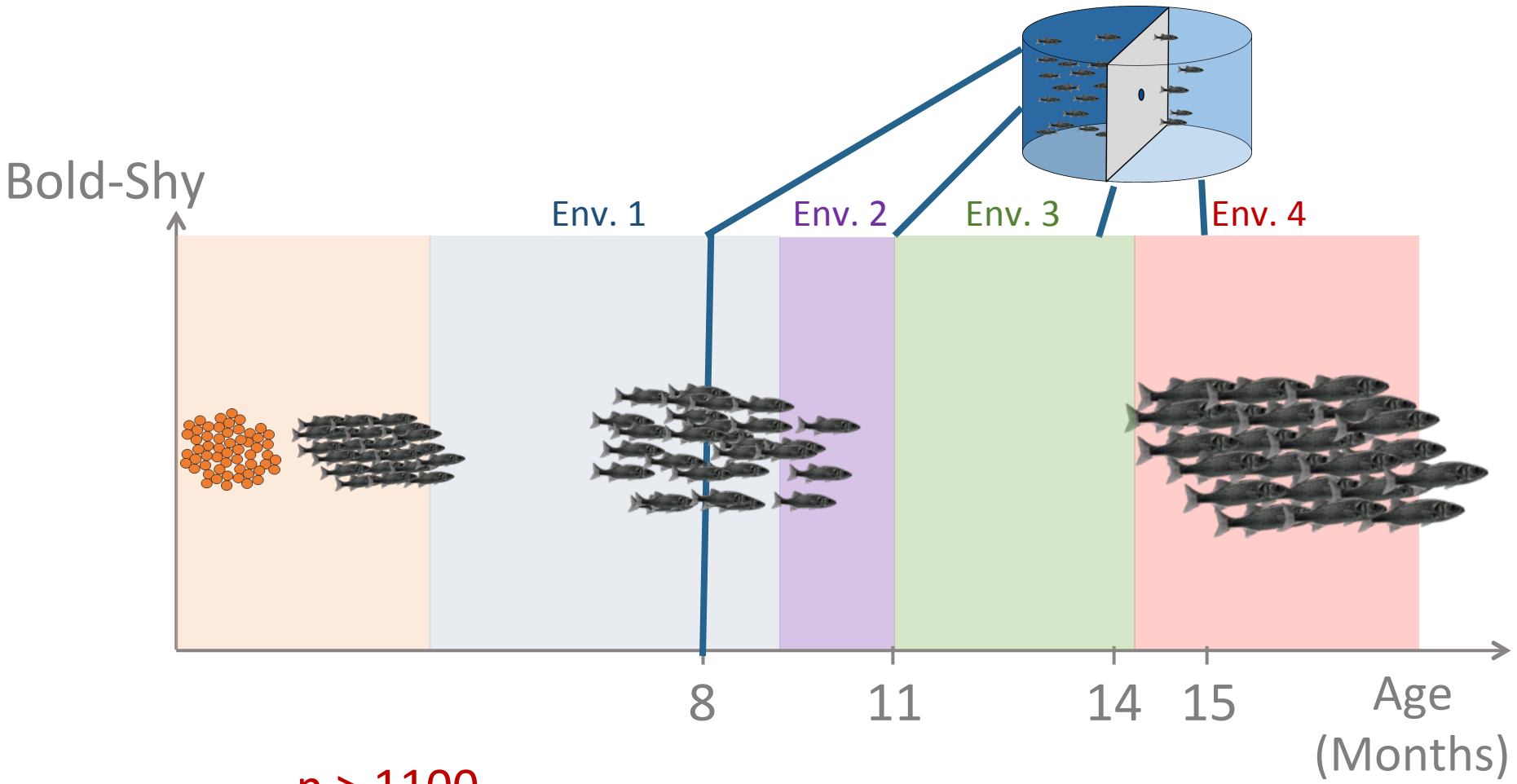
*Department of Environmental Science, and Institute for Water and Environmental Resource Management, University of Technology Sydney, Box 123, Broadway, NSW 2007, Australia; and ‡Department of Biological Sciences, University of Calgary, 2500 University Drive NW, Calgary, AB, Canada T2N 1N4

Edited by Carl Walters, University of British Columbia, Vancouver, BC, Canada, and accepted by the Editorial Board January 7, 2008 (received for review August 28, 2007)



→ Importance for fisheries sciences

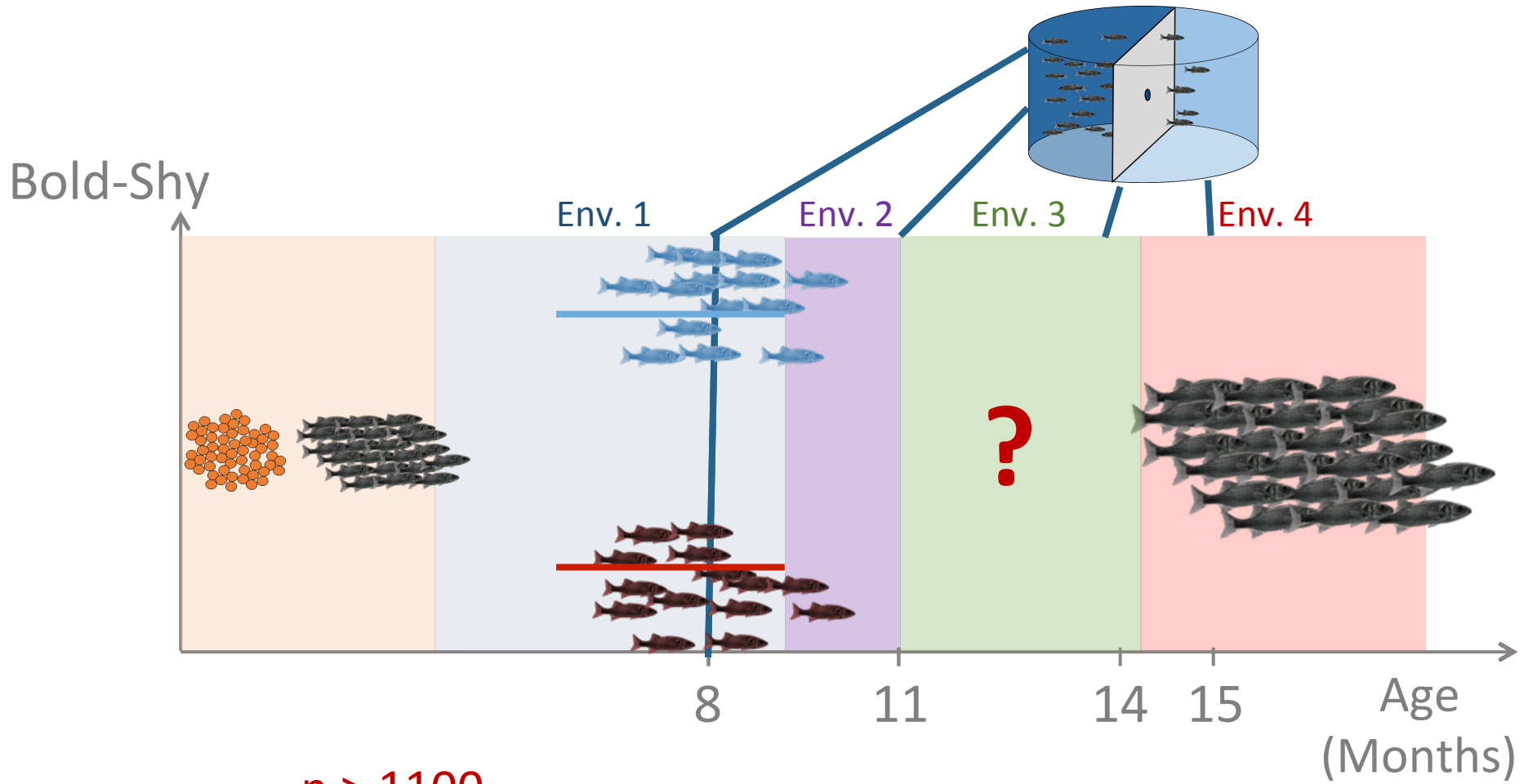
A robust behavior



n > 1100

Sadoul, Biro et al., In prep

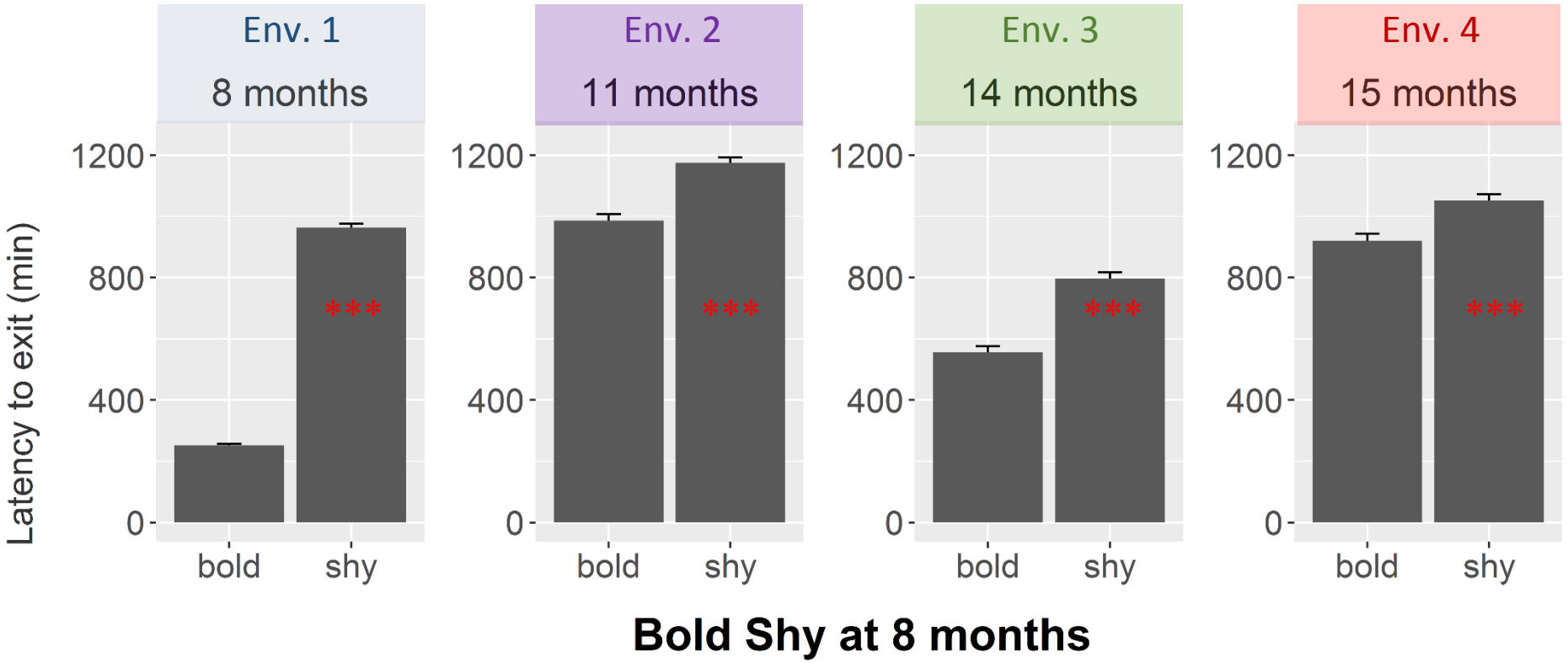
A robust behavior



n > 1100

Sadoul, Biro et al., In prep

A robust behavior



→ A consistent trait over time and contexts

Sadoul, Biro et al., In prep

A robust behavior

PLOS ONE

RESEARCH ARTICLE

Heritability of Boldness and Hypoxia Avoidance in European Seabass, *Dicentrarchus labrax*

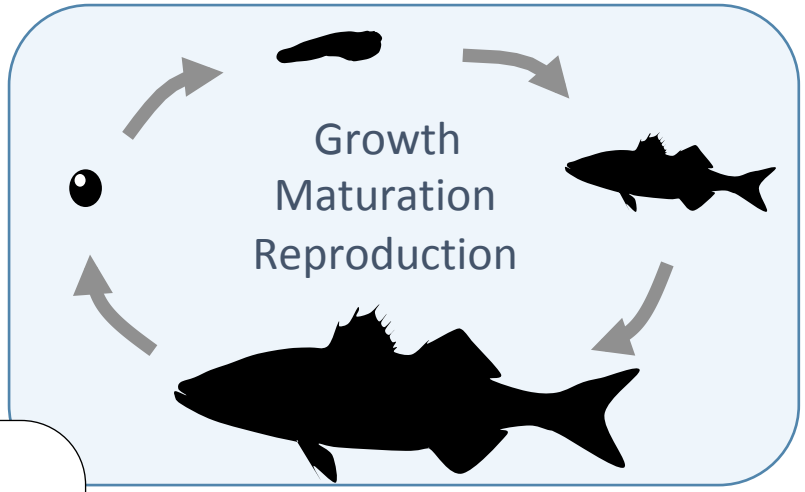
Sébastien Ferrari[1☯]*, Khaled Horri[2☯], François Allal[2], Alain Vergnet[2], David Benhaim[3,4], Marc Vandeputte[5,6], Béatrice Chatain[2], Marie-Laure Bégout[1]*

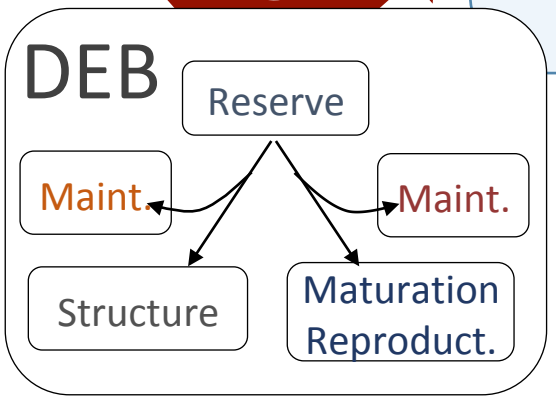
→ A genetically-driven behavior

Ferrari et al. 2016

Hypothesis

Risk taking behavior can explain part of the genetic variability in life history traits

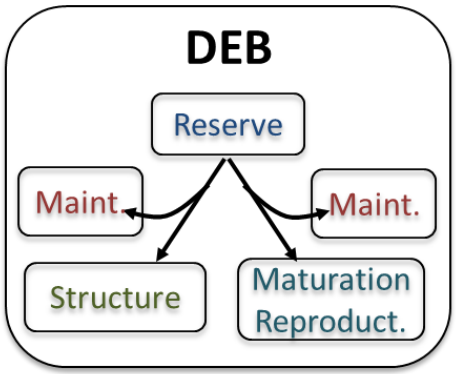


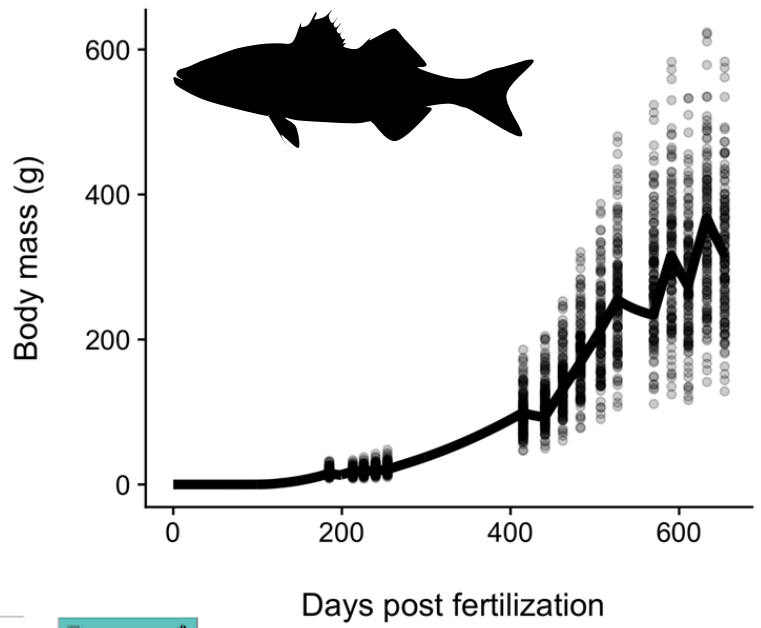


Prediction

DEB: Dynamic Energy Budget

Environment
Temperature
Food availability





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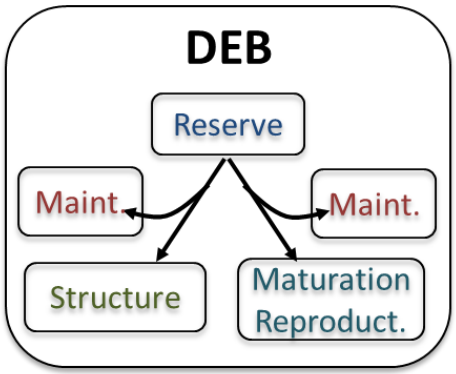
A DEB model for European sea bass (*Dicentrarchus labrax*): Parameterisation and application in aquaculture

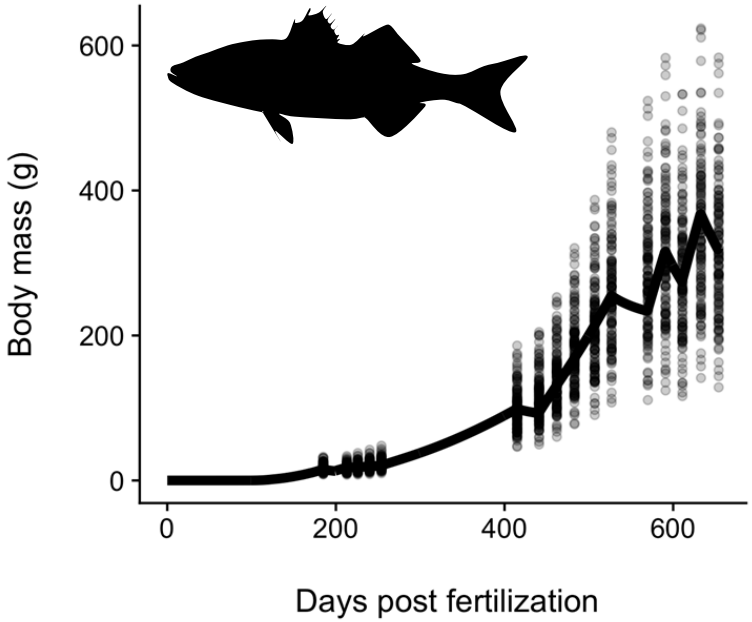
Orestis Stavrakidis-Zachou[a,b], Nikos Papandroulakis[a], Konstadia Lika[b,*]

Kooijman 2010

DEB: Dynamic Energy Budget

Environment
Temperature
Food availability

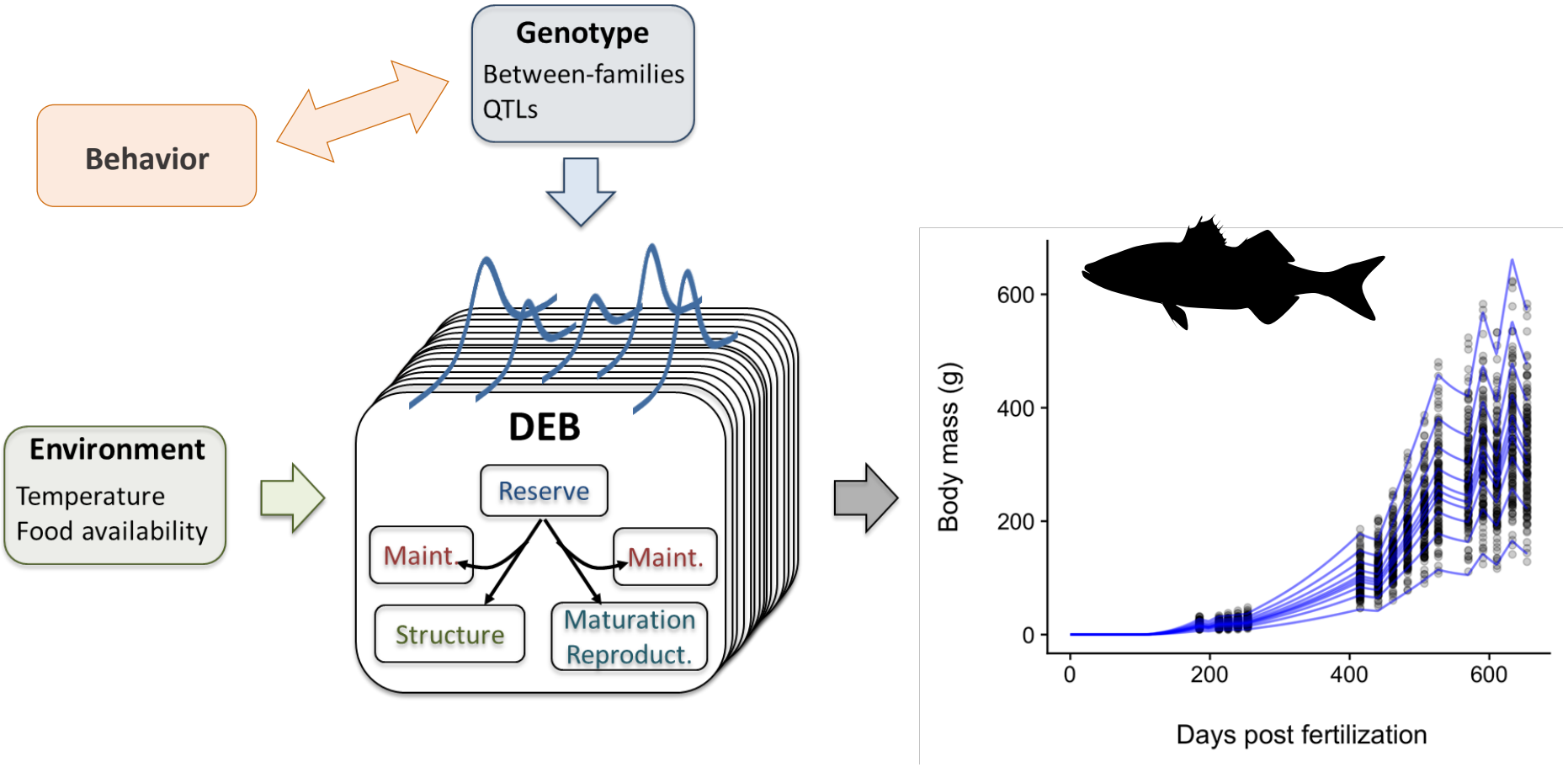




→ For the <u>average</u> animal

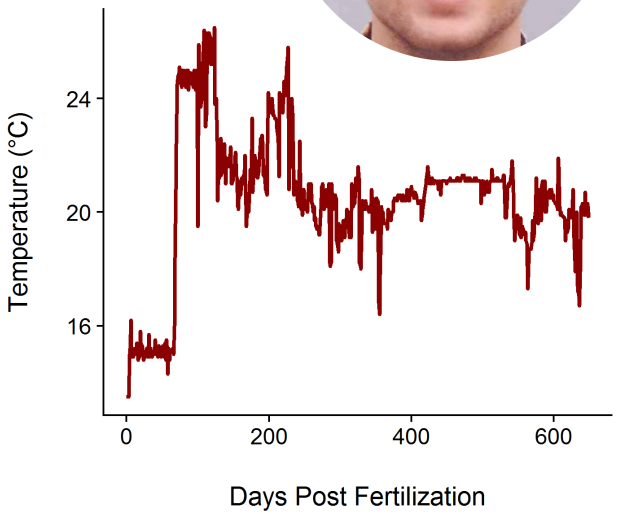
Kooijman 2010

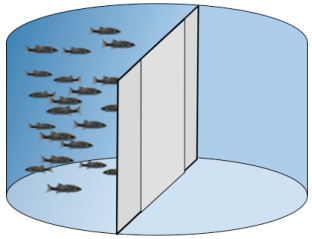
Aim: individual model

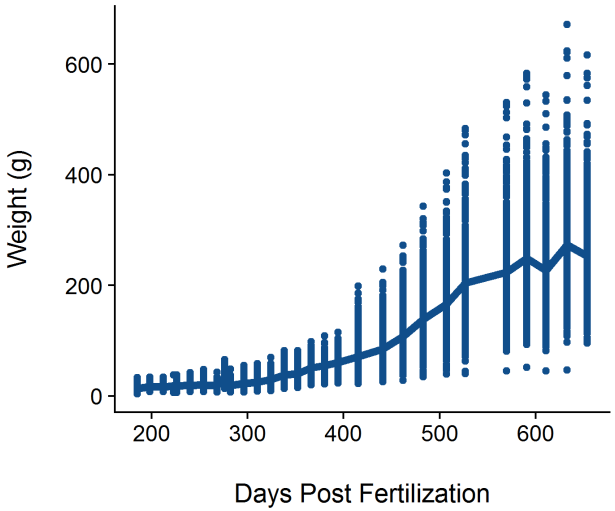


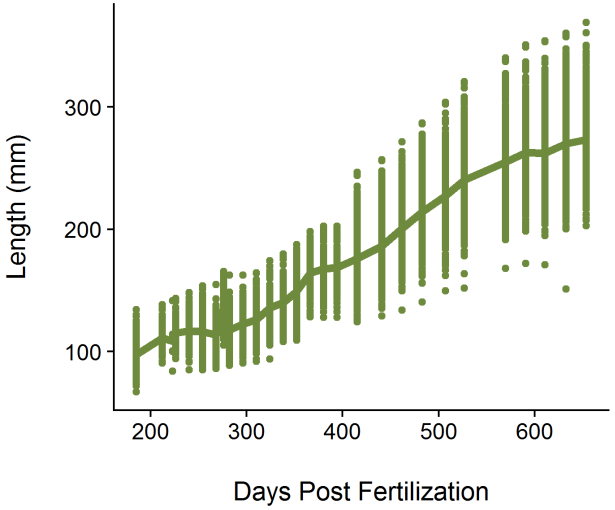
Method

- X 588
- Individually tagged
- Genotyped (3000 markers)
- Risk taking behavior at 6 months
- W, L et Temp up to 2 years



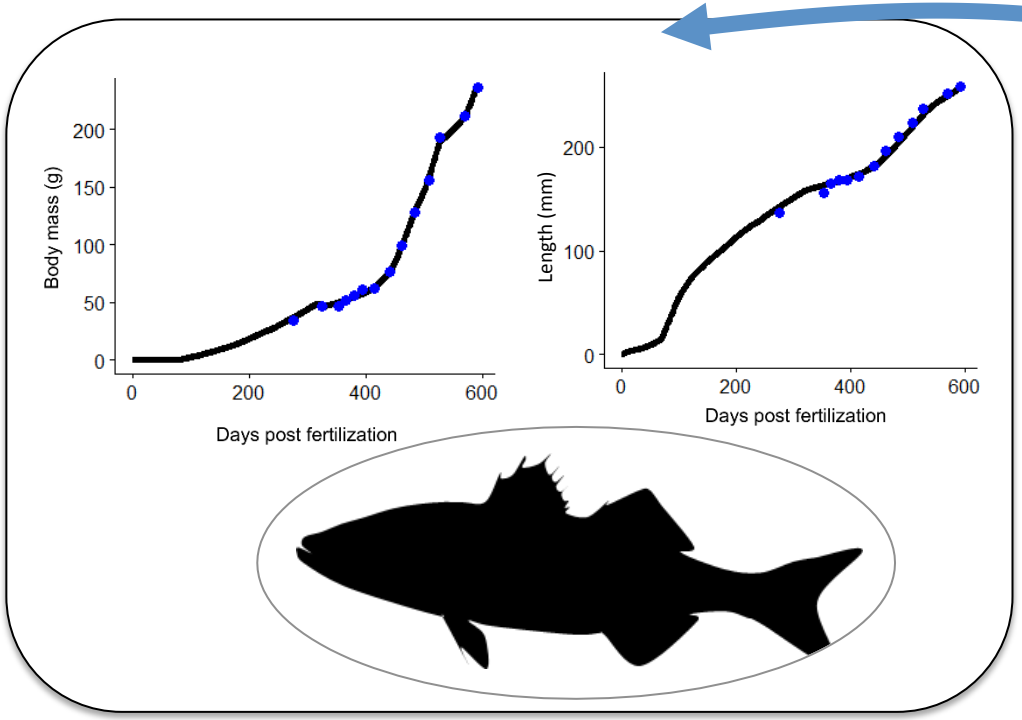




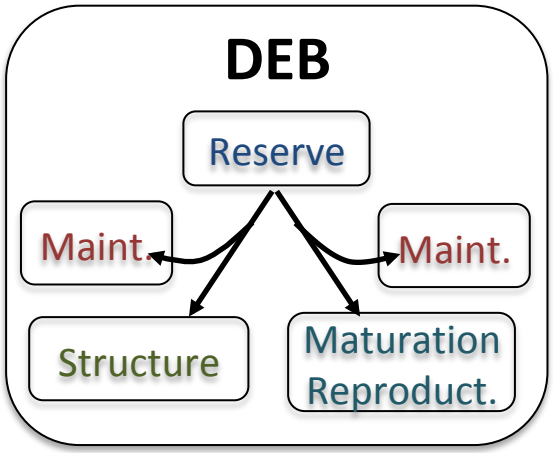


Method

1. Let one parameter vary for each individual

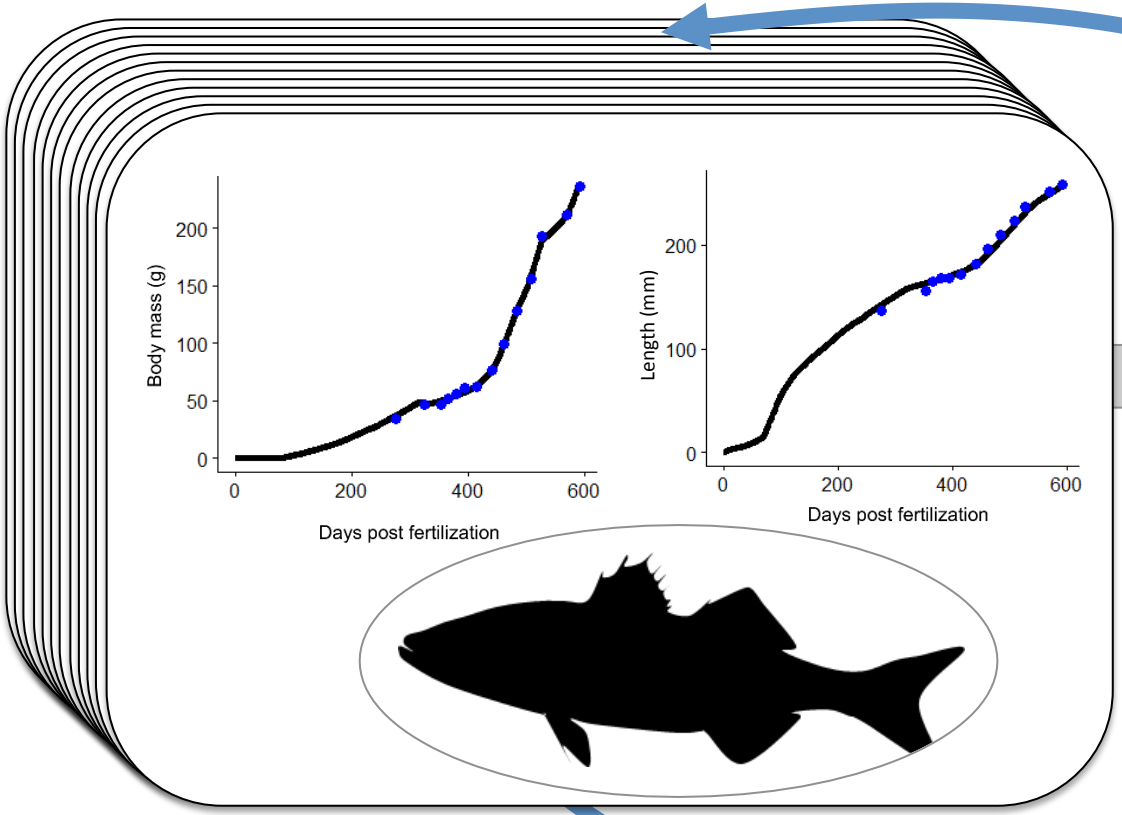


Optimize one parameter

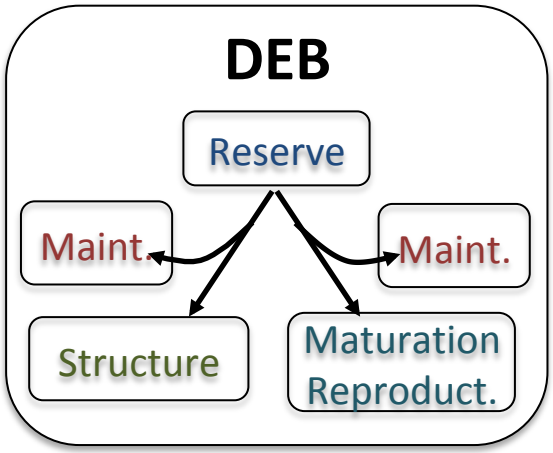


Method

1. Let one parameter vary for each individual



Optimize one parameter



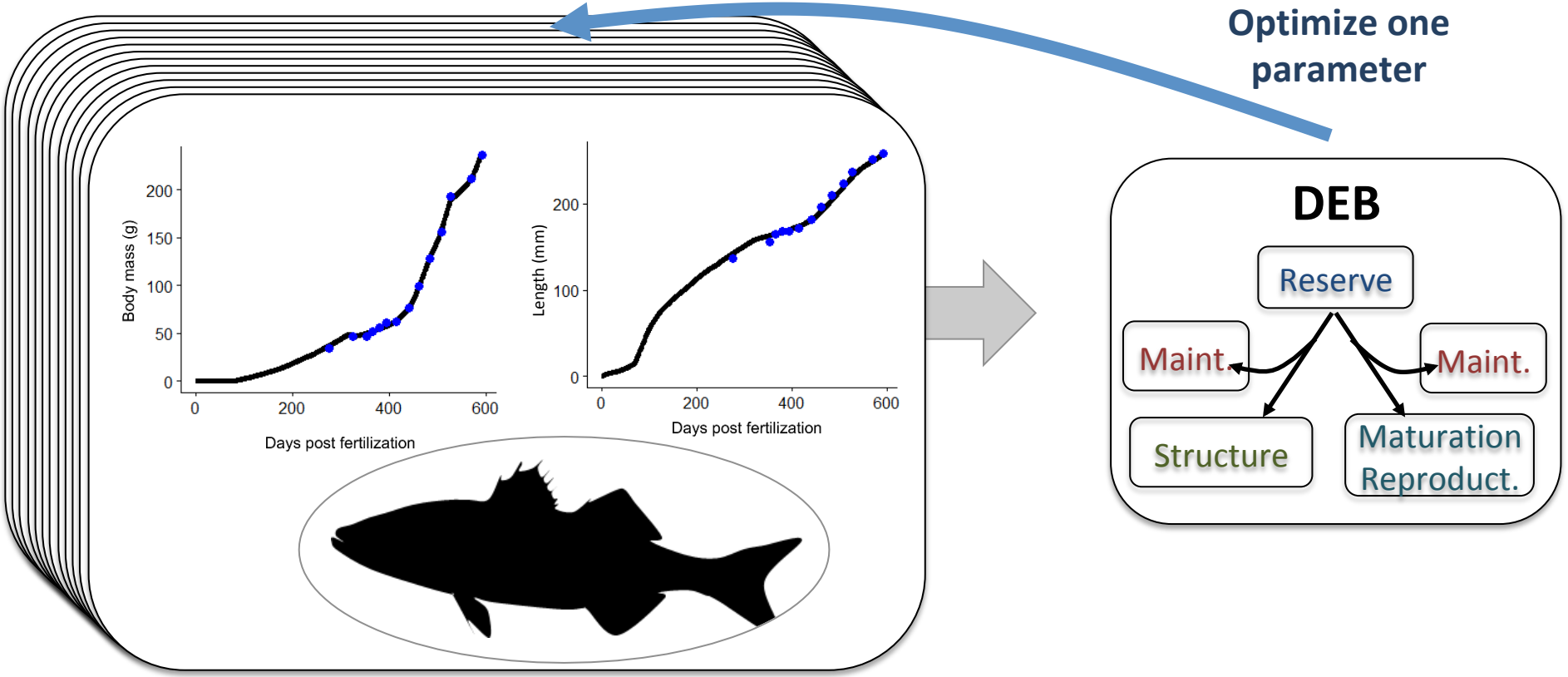
Mean relative error

$$\mathrm{MRE} = \frac{1}{n}\sum_{i=1}^{n}\mathrm{RE}_i$$

i = individual

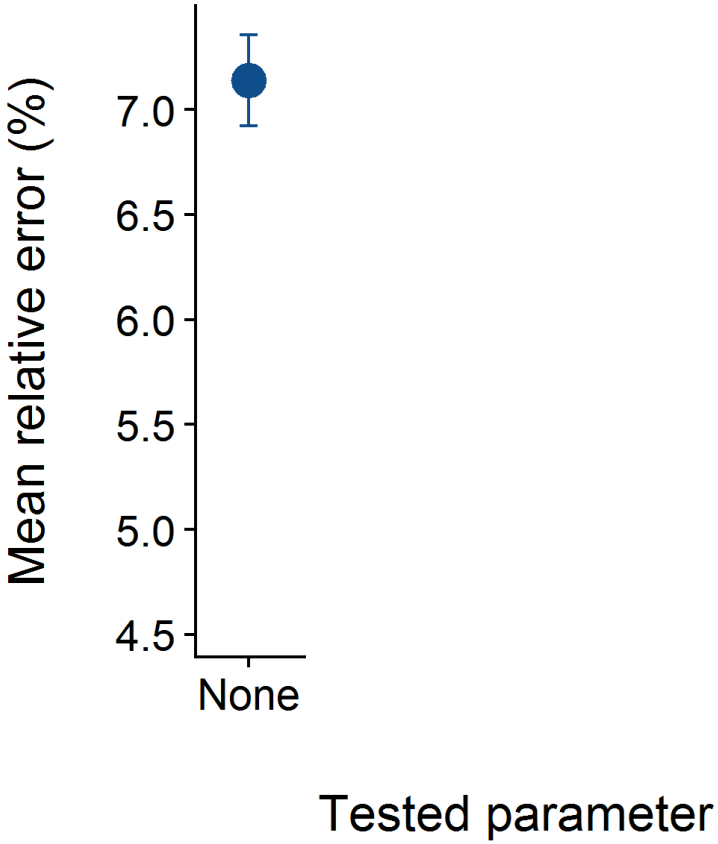
Method

1. Let one parameter vary for each individual

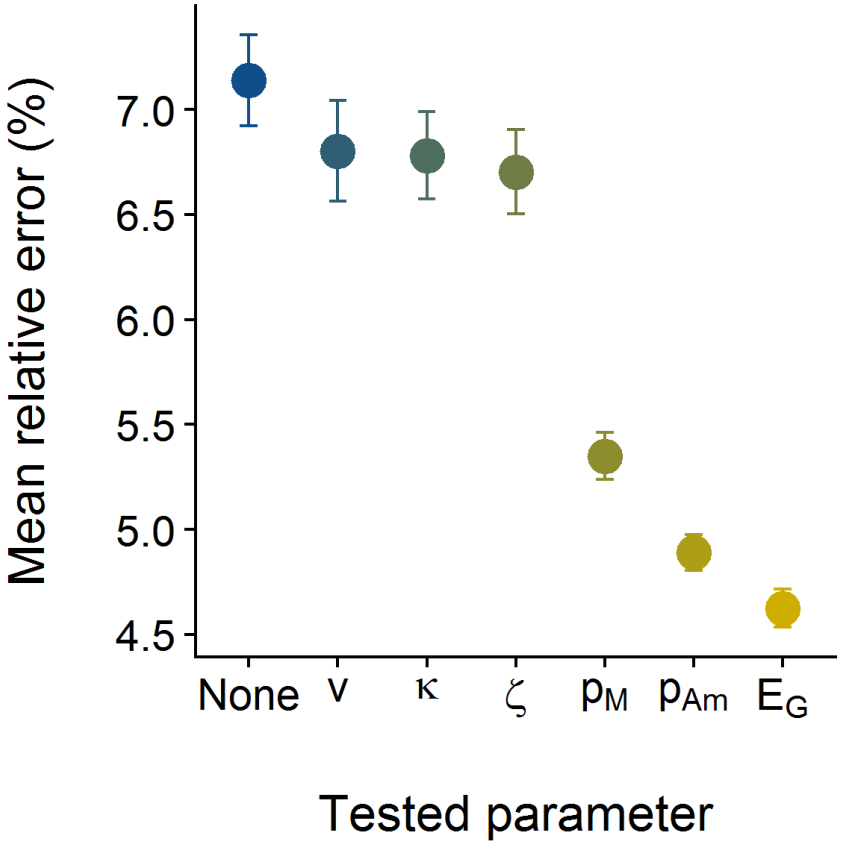


2. Choose the best parameter and verify if it makes genetical and biological sense

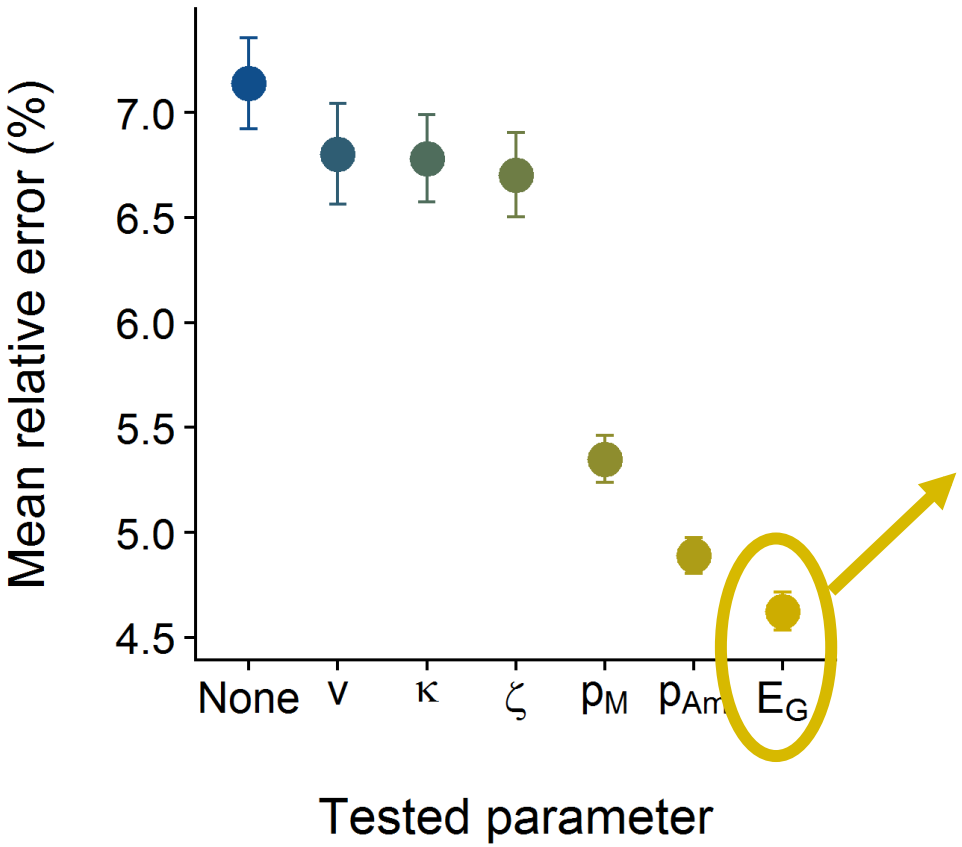
Results



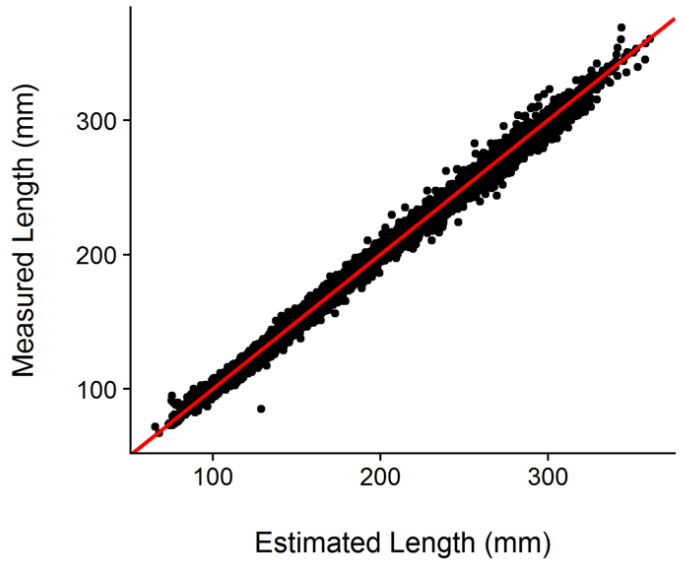
Results

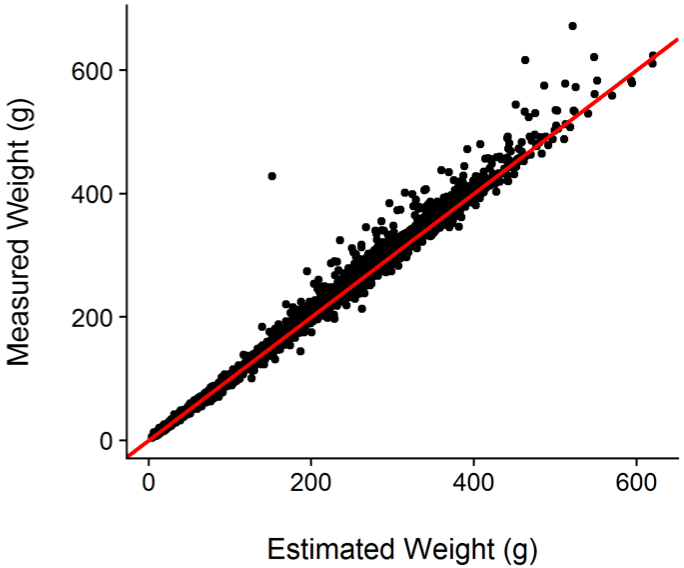

Mean relative error (%)
7.0
6.5
6.0
5.5
5.0
4.5
None
v
κ
ζ
pM
pAm
EG
Tested parameter

Results



E_G : Energetic cost for structure





Results

E_G

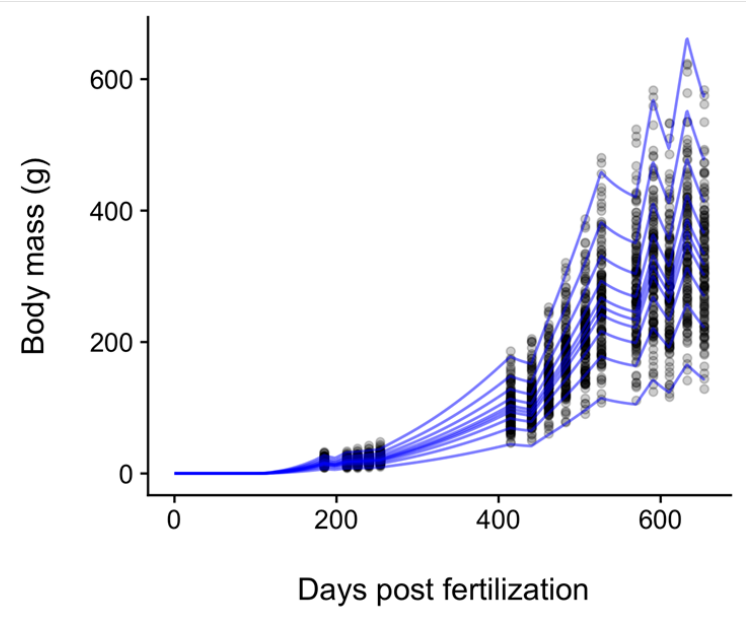
Heritability = 0.7

- Strong genetic factor
- Similar values between brothers and sisters

Genotype
Between-families QTLs

Environment
Temperature
Food availability

DEB
Reserve
Maint.
Maint.
Structure
Maturation
Reproduct.



Results

E_G

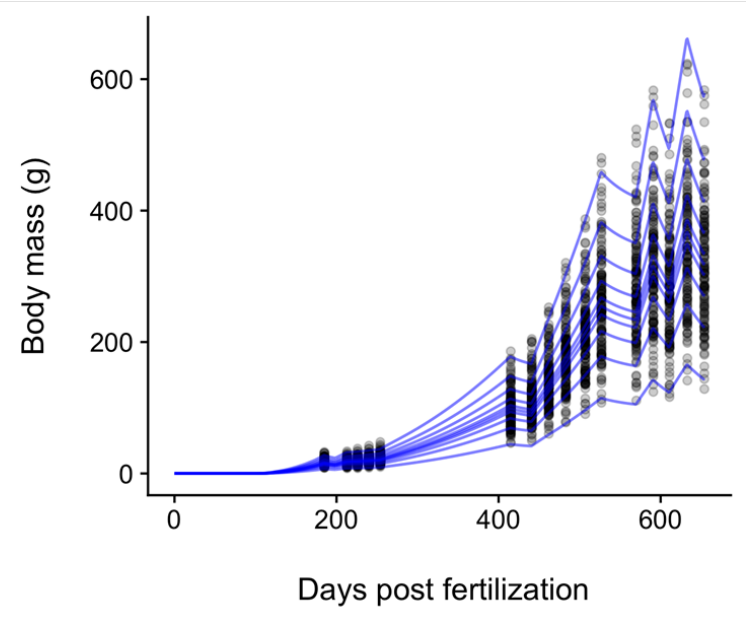
No QTL (Quantitative trait loci)

Complex trait (multiple genetic factors)

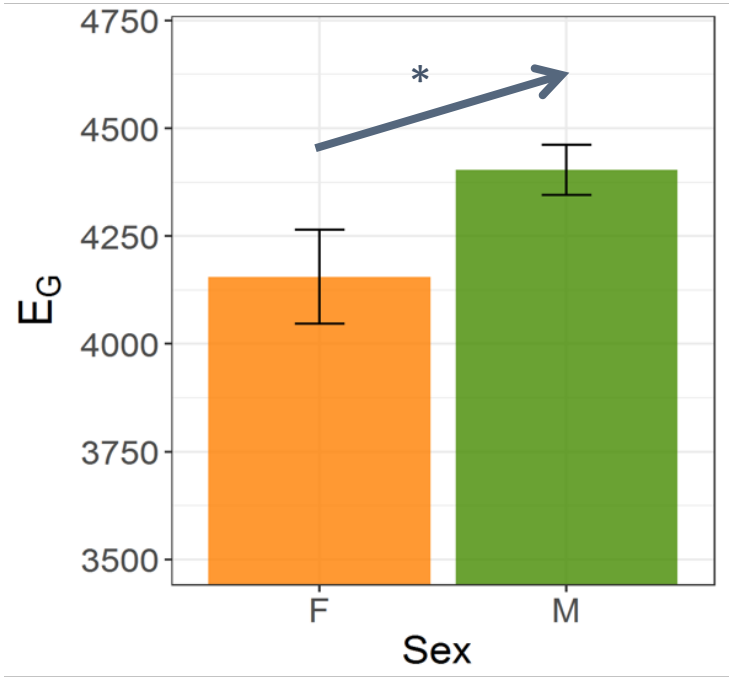
Genotype
Between-families QTLs

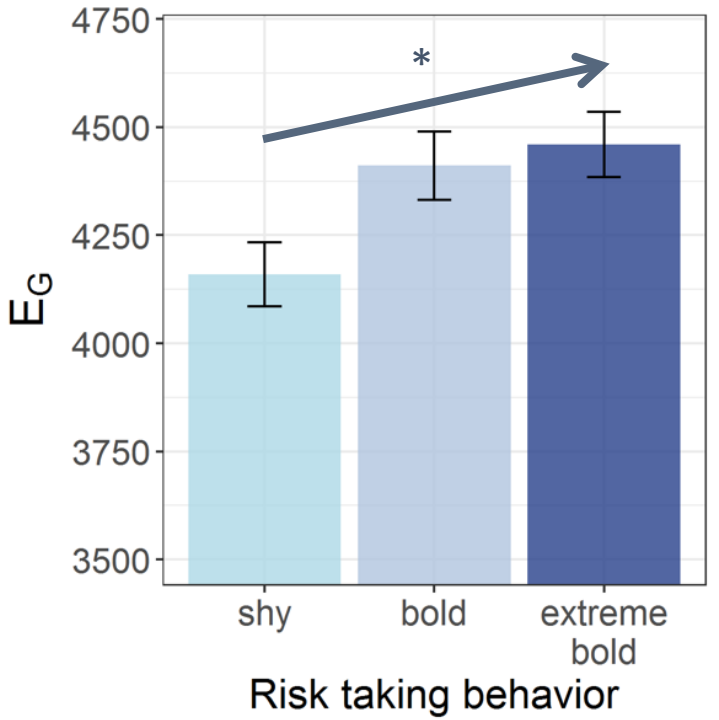
Environment
Temperature
Food availability

DEB
Reserve
Maint.
Maint.
Structure
Maturation
Reproduct.

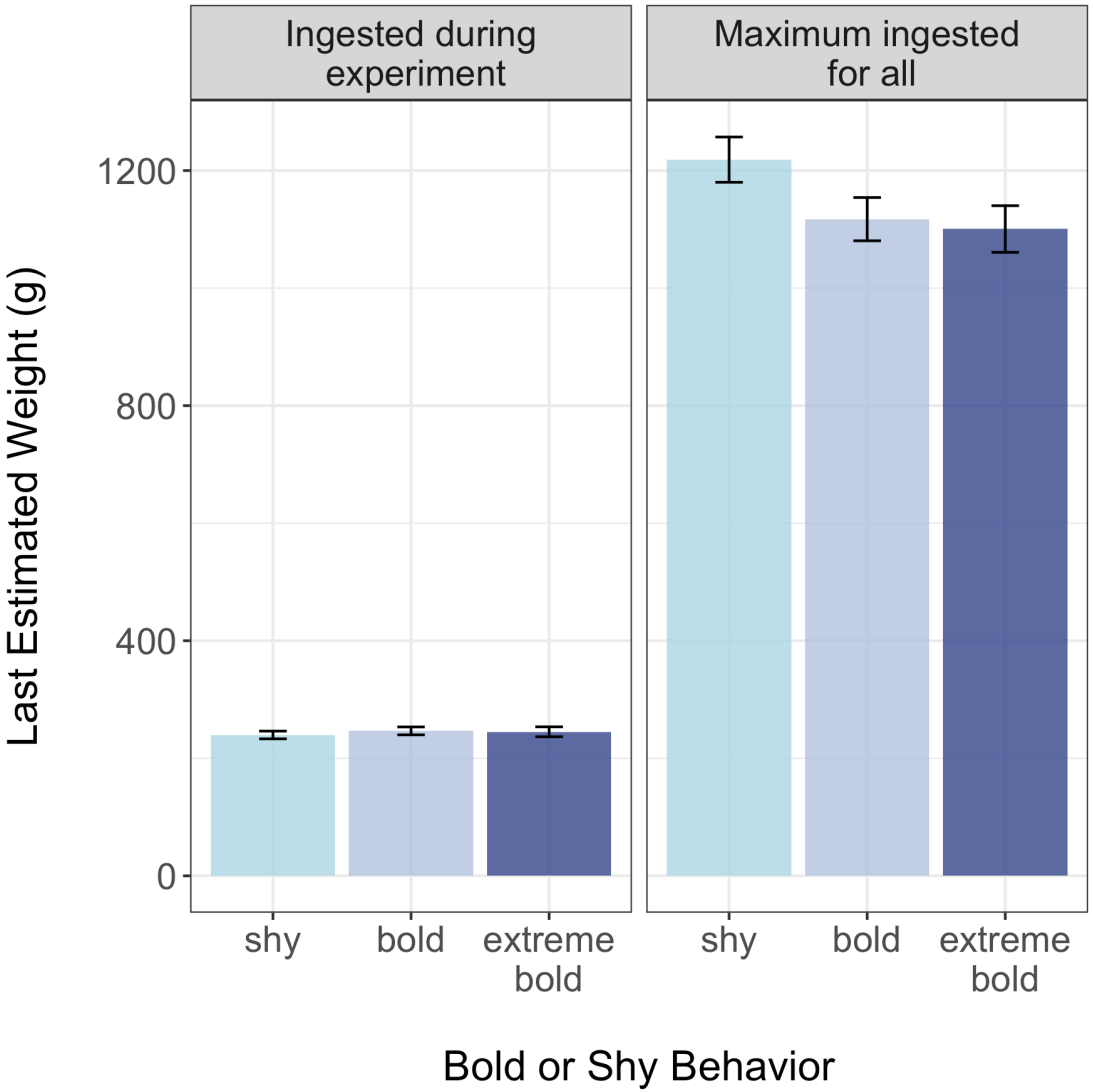


Results

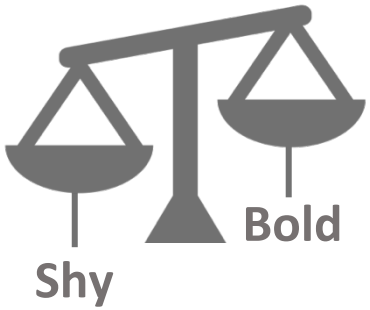

4750
4500
4250
4000
3750
3500
E_G
*
F
M
Sex


4750
4500
4250
4000
3750
3500
E_G
*
shy
bold
extreme bold
Risk taking behavior

Discussions

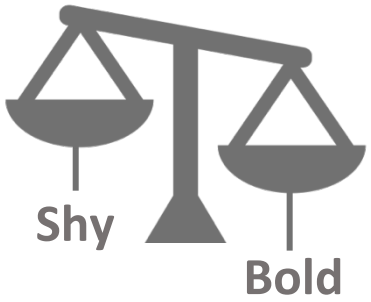


Non-competitive environment



Favored

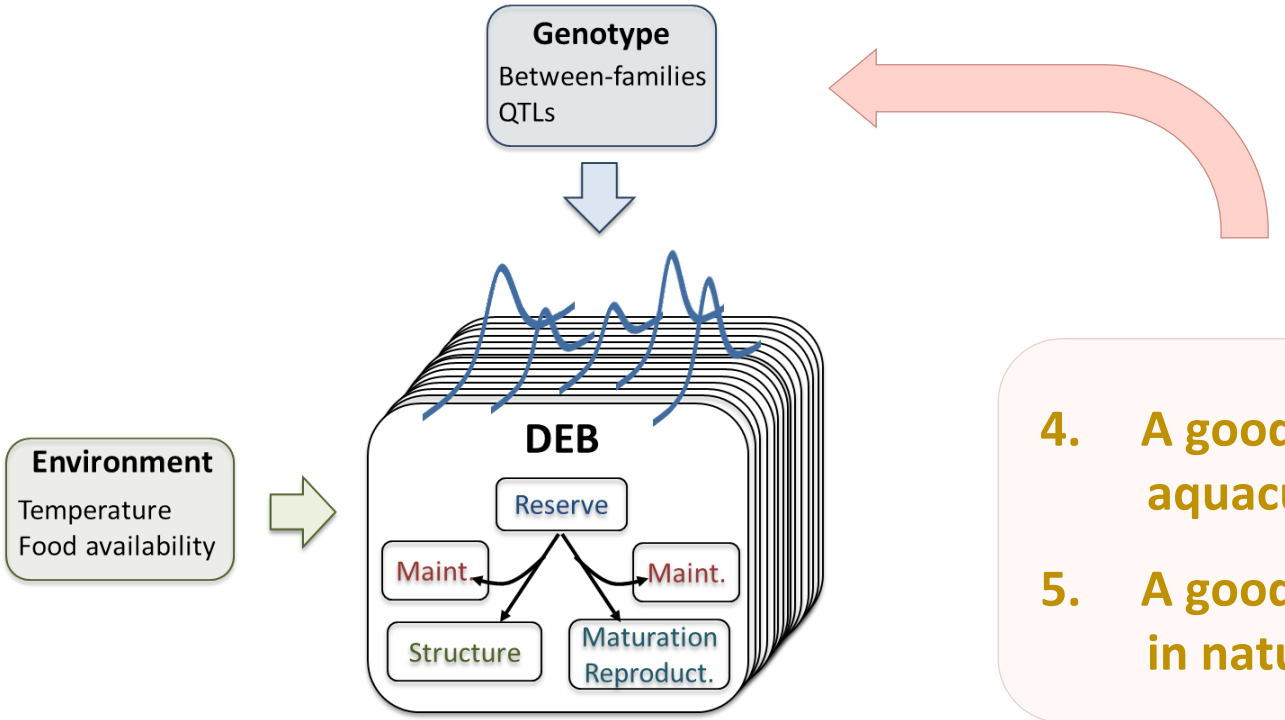
Competitive environment



Favored

Conclusions

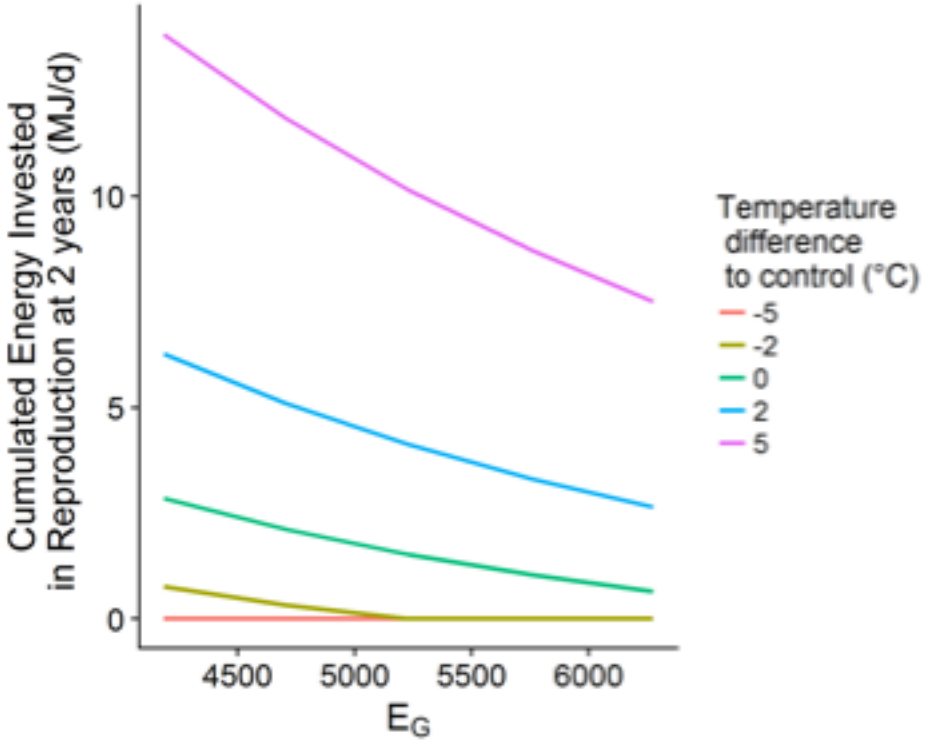
1. **Parameter E_G is the best parameter to describe phenotypic variability between-individuals in this experiment**
2. **This parameter is heritable and explains biological differences between individuals**
3. **Enables to make predictions in a new environment**

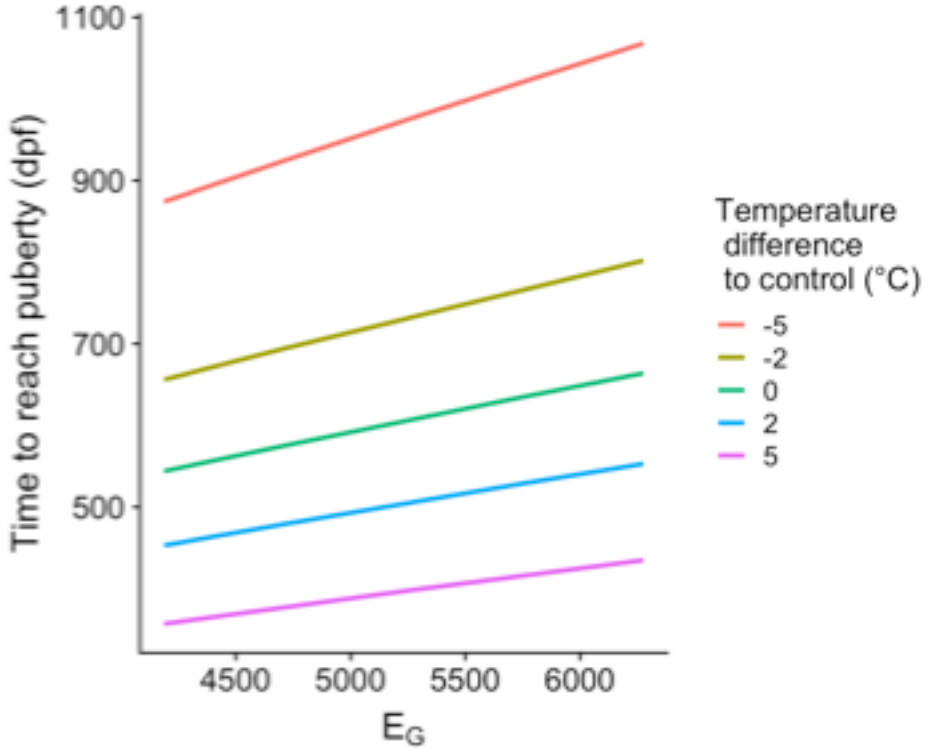


4. **A good selection criteria in aquaculture?**
5. **A good indicator of fitness in nature?**

THANK YOU FOR YOUR ATTENTION

SIMULATIONS WITH IDENTICAL FEED INTAKE



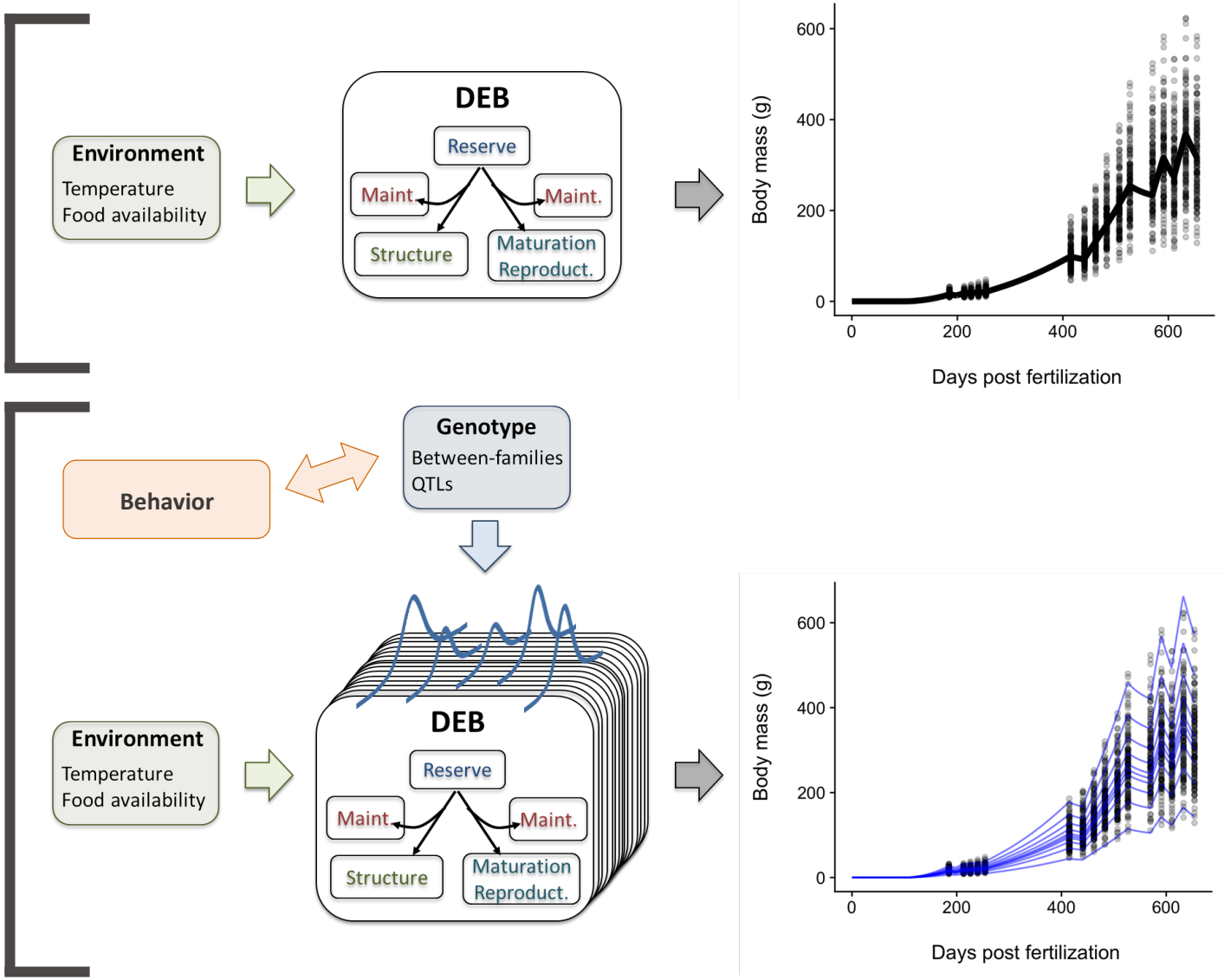


Aim

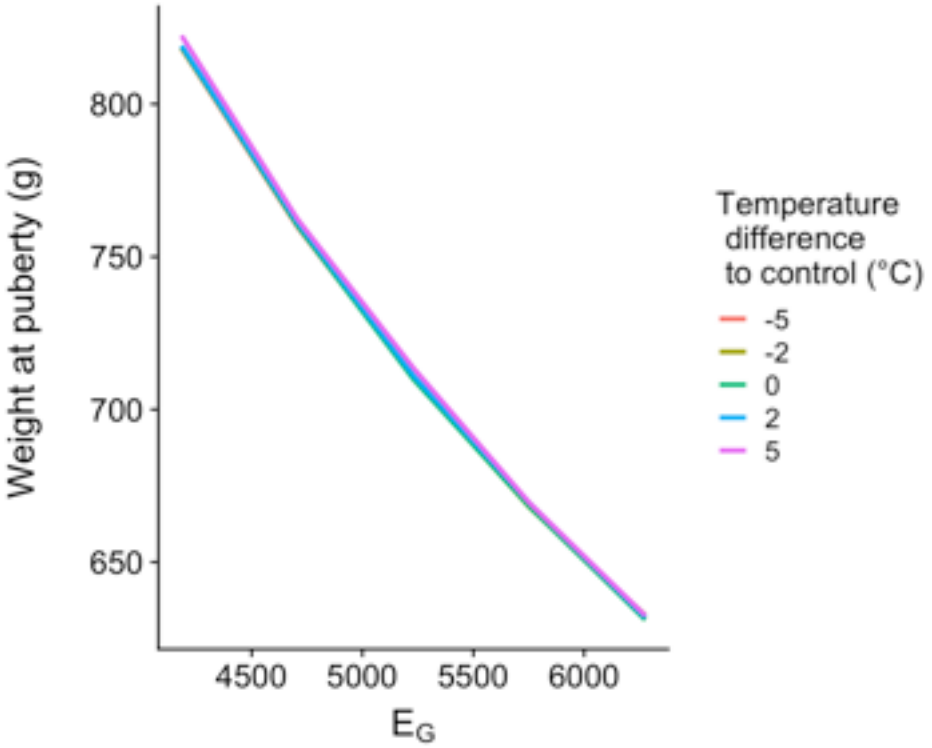
Classic DEB

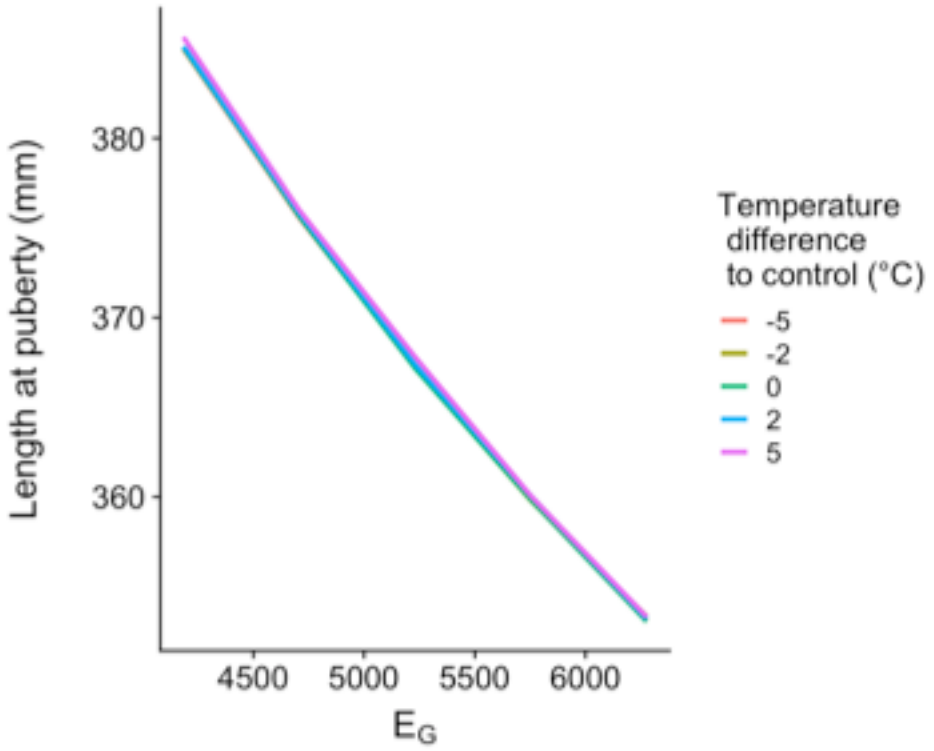
Variation of one parameter

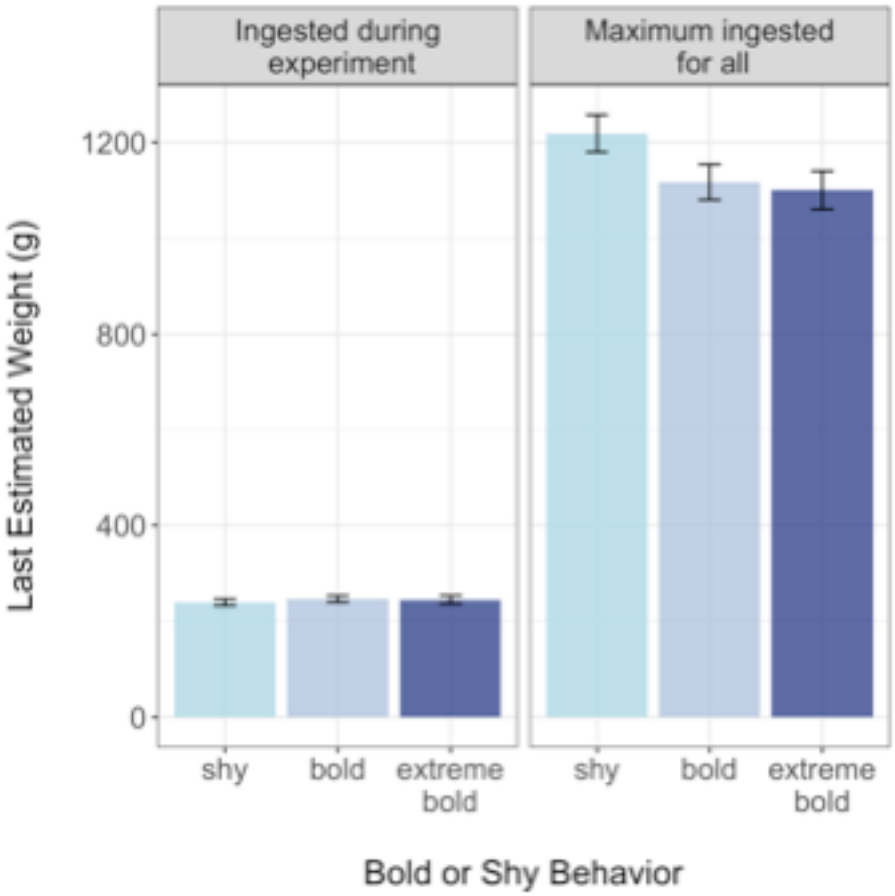
Individual DEB

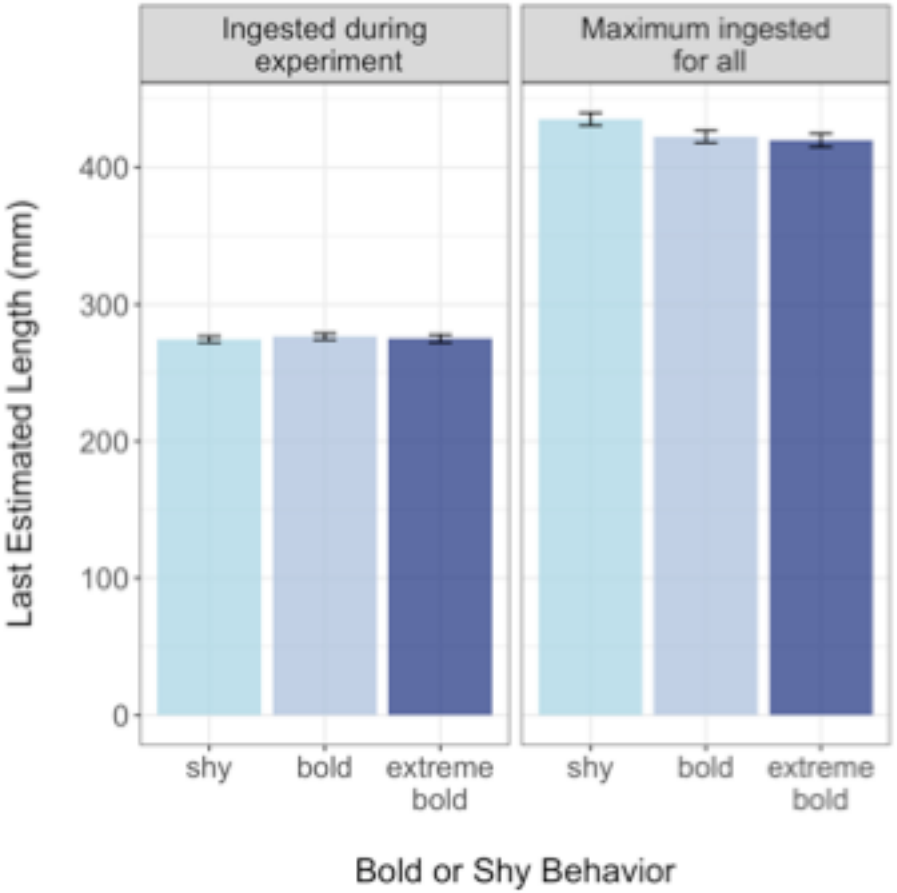


SIMULATIONS WITH IDENTICAL FEED INTAKE

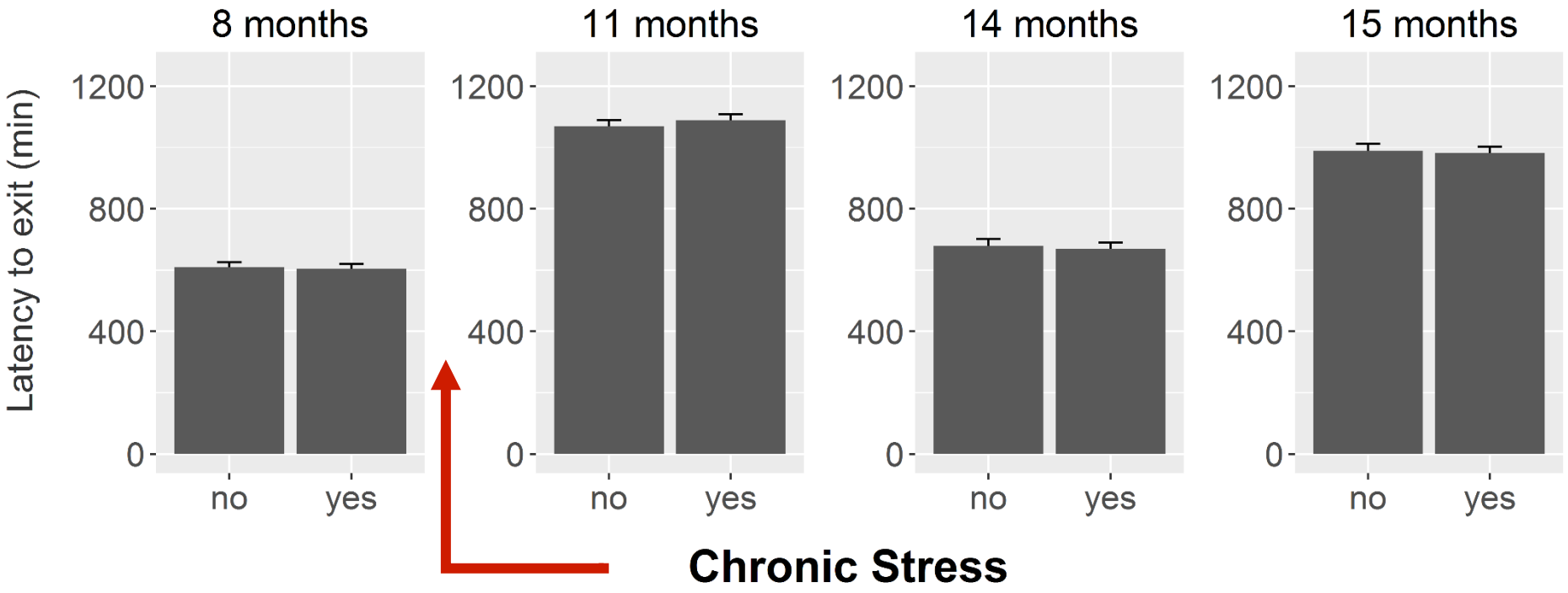





Ingested during experiment
Maximum ingested for all
Last Estimated Weight (g)
1200
800
400
0
shy
bold
extreme bold
Bold or Shy Behavior

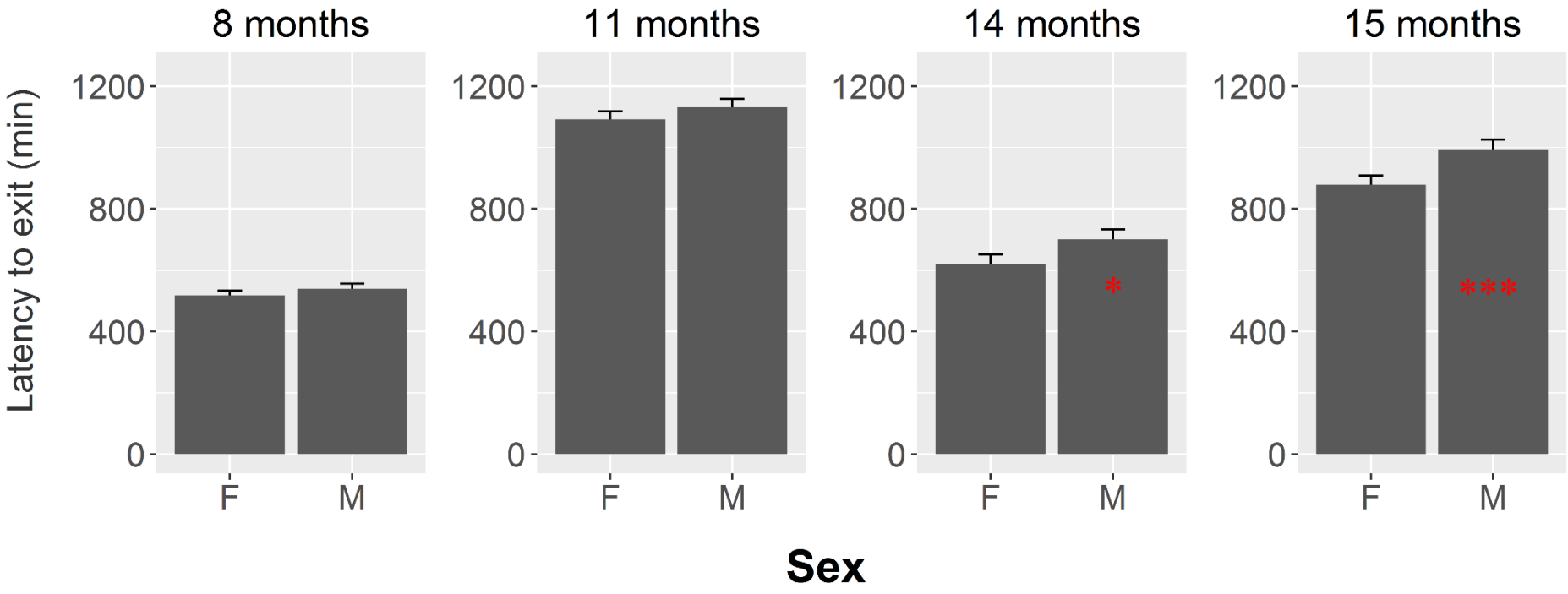

Ingested during experiment
Maximum ingested for all
Last Estimated Length (mm)
400
300
200
100
0
shy
bold
extreme bold
Bold or Shy Behavior

Effect of stress, results



- Chronic stress has no effect on future risk taking behavior

Effect of sex maturation, results



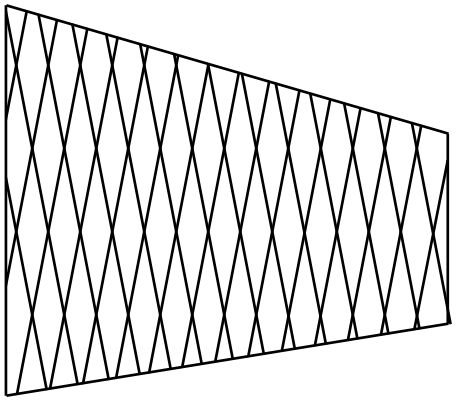
- Risk taking behavior is not different at early life stages between sexes
- Risk taking behavior is different between males and females

Test de prise de risque

Bold-shy continuum

Shy — Bold

Tendance à subir la pression de pêche



→ Importance halieutique

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Risk-taking behaviour variation over time in sea bass *Dicentrarchus labrax*: effects of day–night alternation, fish phenotypic characteristics and selection for growth

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PNAS

Oyster reprodu
polystyrene mic

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Prediction of long-term variation in offspring metabolism due to BPA in eggs in rainbow trout using the DEB model

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