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Potential effects of climate change on first-feeding brown trout growth and metabolism

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Annual Meeting
7 – 10 March 2017
Shaftesbury – UK



Potential effects of climate change on first-feeding brown trout growth and metabolism

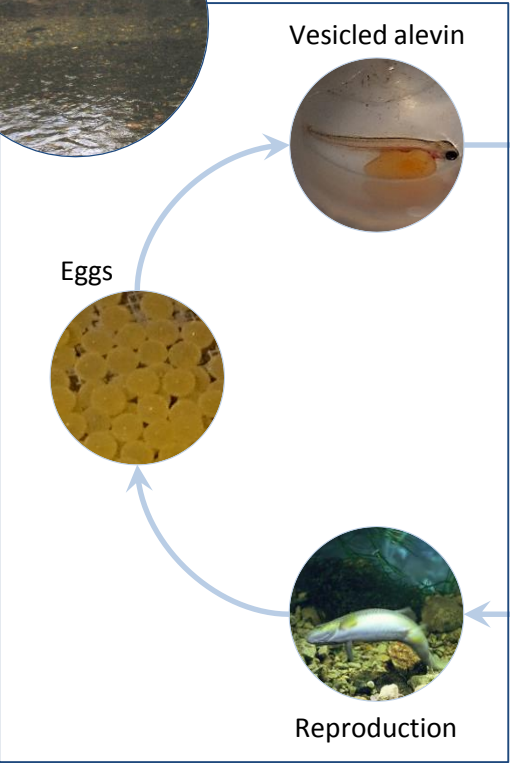
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Technical support from: **GLISE Stéphane, GUERAUD François, HUCHET Emmanuel,
LANGE Frédéric, PLAGNES-JUAN Elisabeth, RIVES Jacques**





Undergravel stages



Vesicled alevin



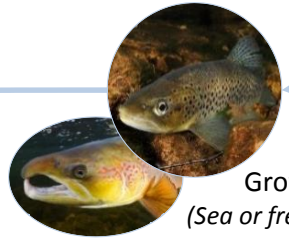
Emerged alevin



Juvenile



Growth
(Sea or freshwater)



Reproduction

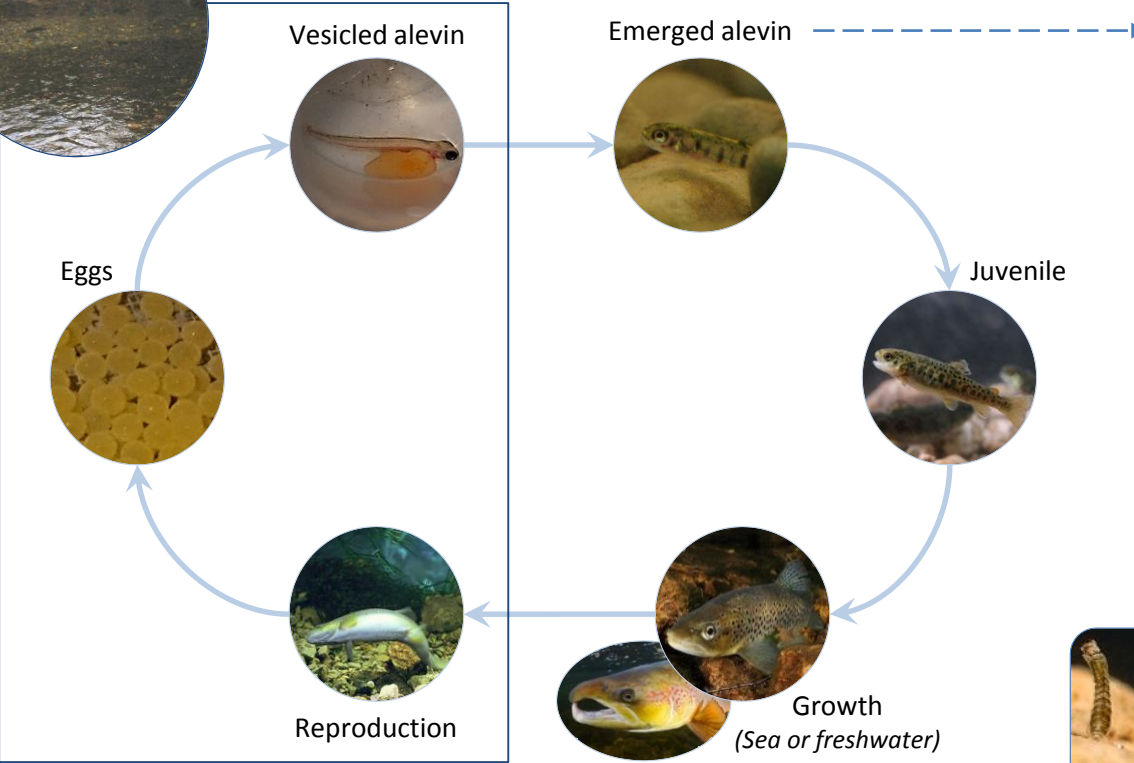


Eggs





Undergravel stages



EMERGENCE
a critical stage
 ~ March/April

Skoglund & Barlaup, 2006

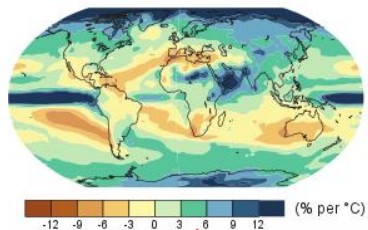
Physiological and behavioural changes

- Endogenous → exogenous feeding
- Competition for territory
- Predator vulnerability

Harsh conditions could induce huge mortality
i.e. reduced prey availability (macroinvertebrate larvae)



In the Atlantic coast of Europe ...



CLIMATE CHANGE

↘ abundance of
macroinvertebrate larvae

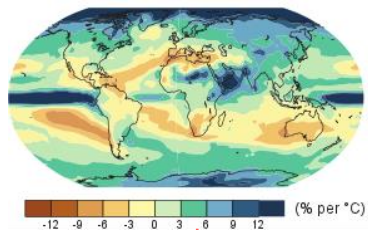
Robinson et al. 2004

↗ Rainfall *in winter & spring*
↗ Flood intensity and
frequency

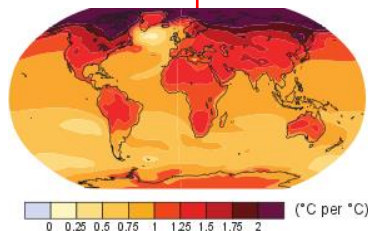
↘ Prey availability

IPCC, 2014

In the Atlantic coast of Europe ...



CLIMATE CHANGE



IPCC, 2014

↗ Rainfall *in winter & spring*
↗ Flood intensity and frequency

↘ abundance of macroinvertebrate larvae

Robinson et al. 2004

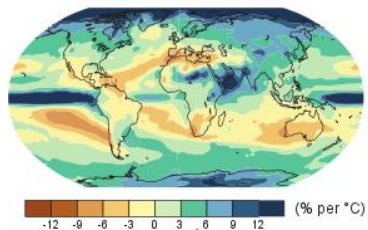
↘ Prey availability

↗ Temperature

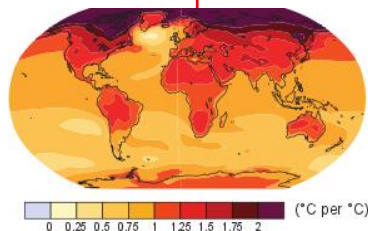
Leigh et al. 2015

↗ Metabolism

In the Atlantic coast of Europe ...



CLIMATE CHANGE



IPCC, 2014

↗ Rainfall *in winter & spring*
↗ Flood intensity and frequency

↘ abundance of macroinvertebrate larvae

Robinson et al. 2004

↘ Prey availability

↘↘ growth and survival of emerged alevins



↗ Temperature

Leigh et al. 2015

↗ Metabolism

CLIMATE CHANGE

**Alevins facing period
of starvation**

**Maintenance of
vital functions**



CLIMATE CHANGE

Alevins facing period of starvation

Reserve mobilisation

Bar, 2014

1) Carbohydrates

Glycolysis

2) Fatty acids

β -oxydation

3) Proteins

Proteolysis (e.g. proteasome)

and last reserves

Autophagy (amino-acids, fatty acids, and carbohydrates)

*Alevins:
limited amount
of reserves*



Energy production

Krebs cycle & respiratory chain

Maintenance of vital functions

Objectives of the experiment



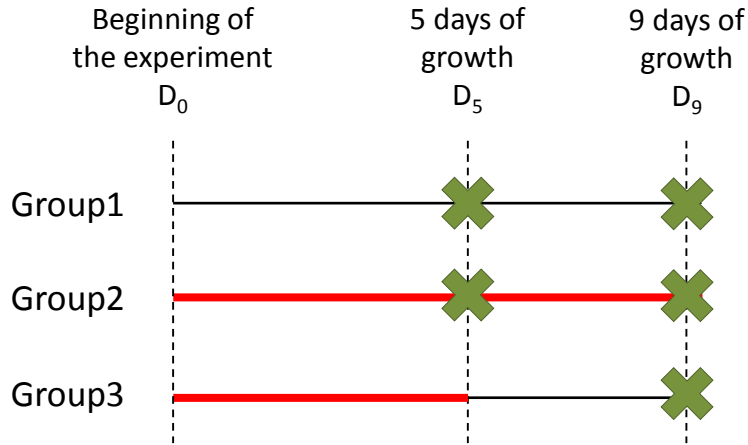
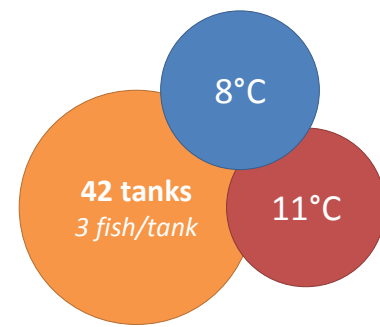
1) Understand the effects of **starvation** on alevins **nutritional** status

2) Test the alevins ability to **recover** from a **delayed** first-feeding

3) Analyse the effect of **temperature** on these phenomena



Experimental set up

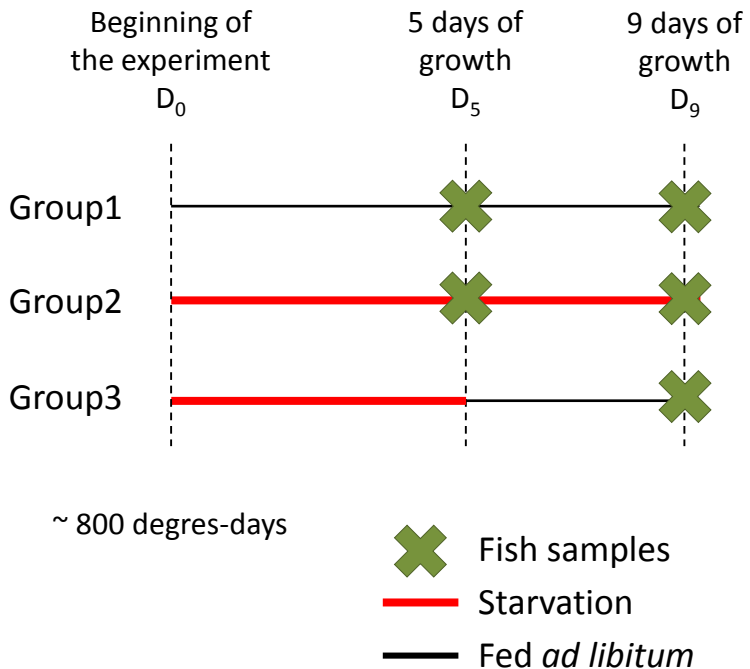


~ 800 degrees-days

- Fish samples
- Starvation
- Fed *ad libitum*

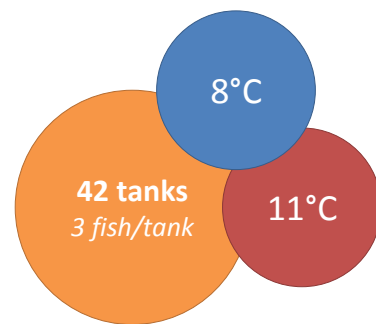


Experimental set up



At each endpoint

D_0 D_5 D_9



Biometric data

- Weight
- Size

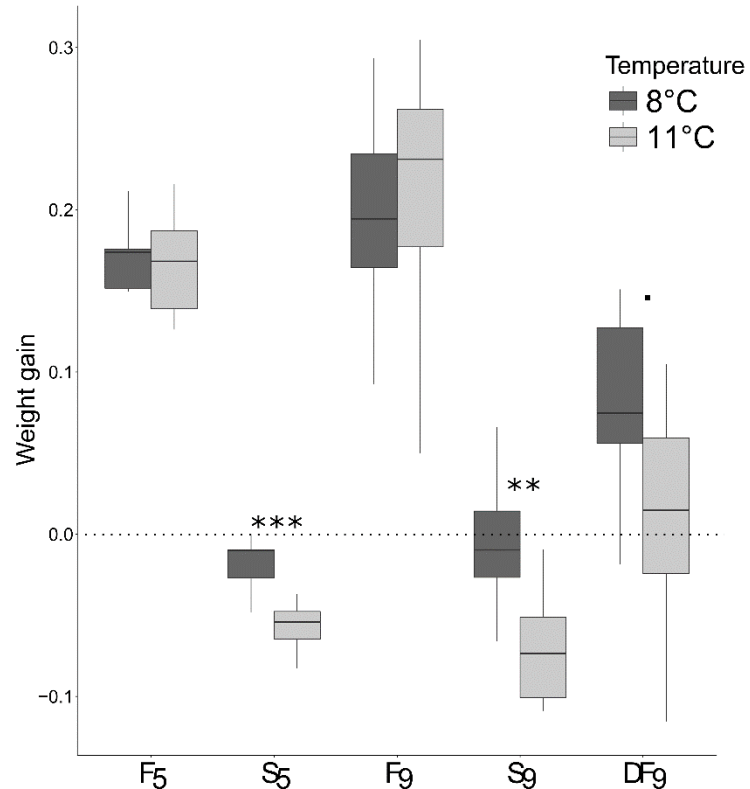
Wilcoxon-Mann-Whitney rank sum test

Biomolecular data

- Whole body
- RT-qPCR
- Expression of 19 genes
Lipid (3) & Amino-acid (6) catabolisms, Proteasome (5), Autophagy (5)
- Pfaffl method

Bayesian modelling





❖ F₅ & F₉: **Fed** fish **gained** weight

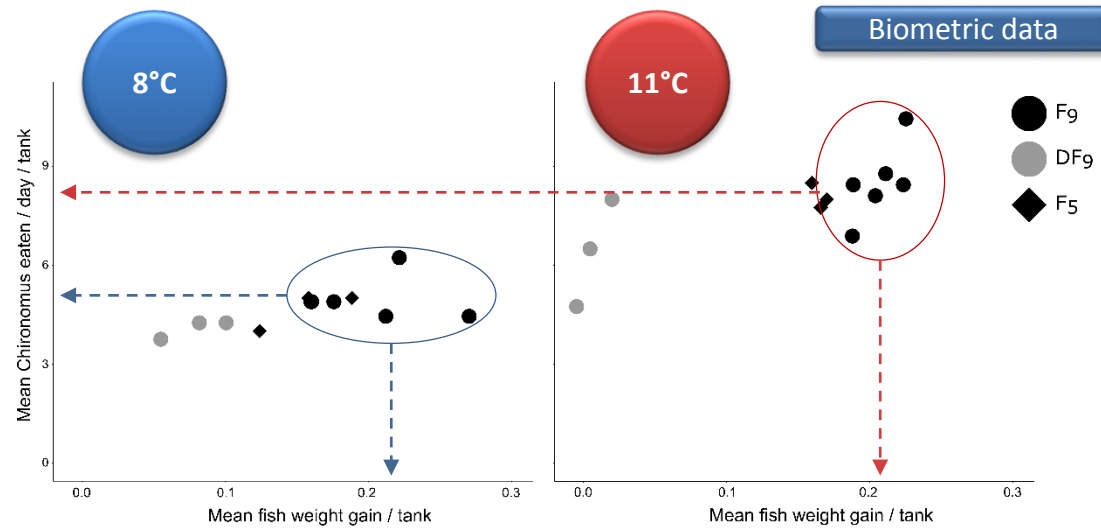
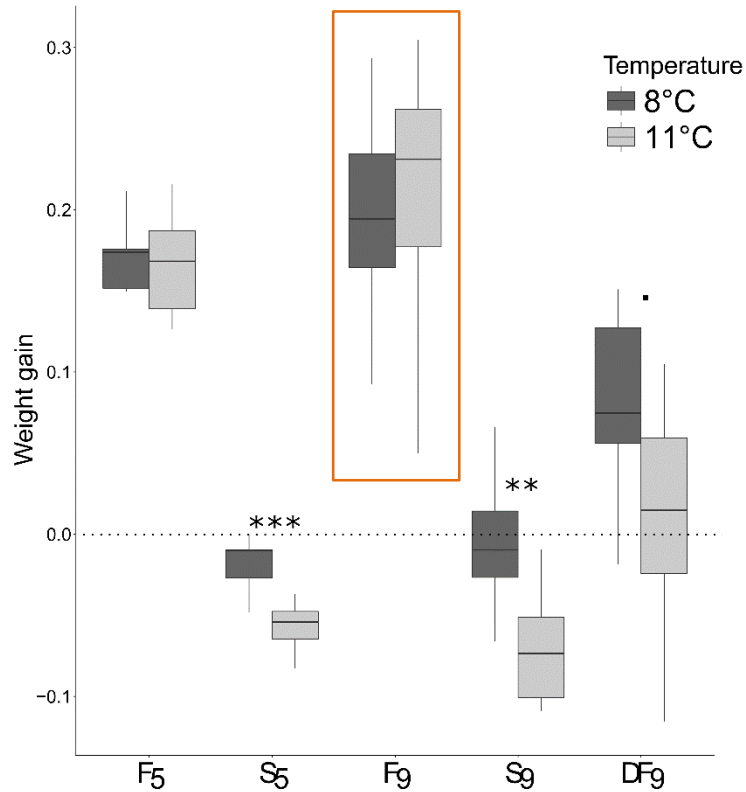
- No difference between 8°C and 11°C

❖ S₅ & S₉: **Starved** fish **lost** weight

- Fish leaner at 11°C

❖ DF₉: **Delayed first-fed** fish: intermediate state

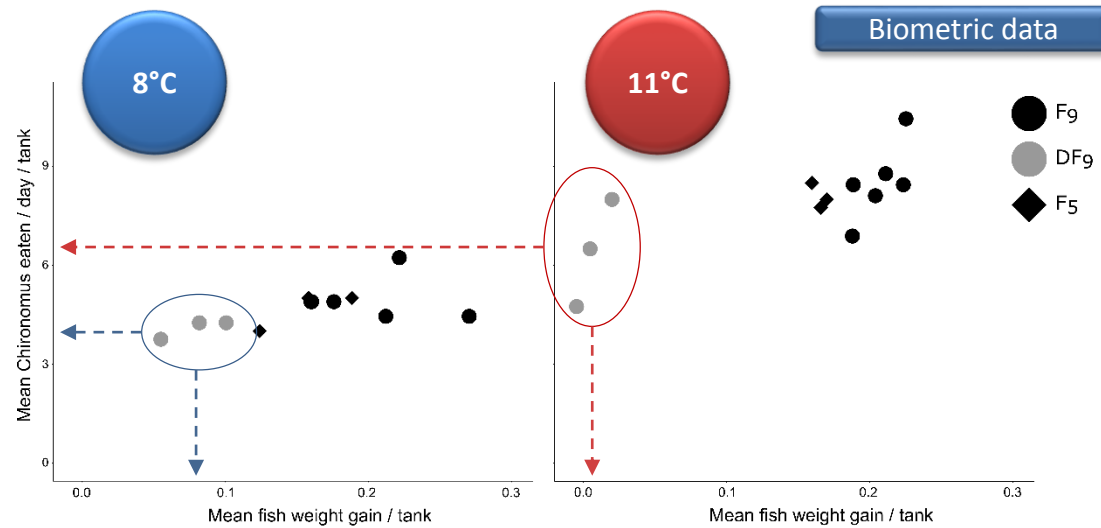
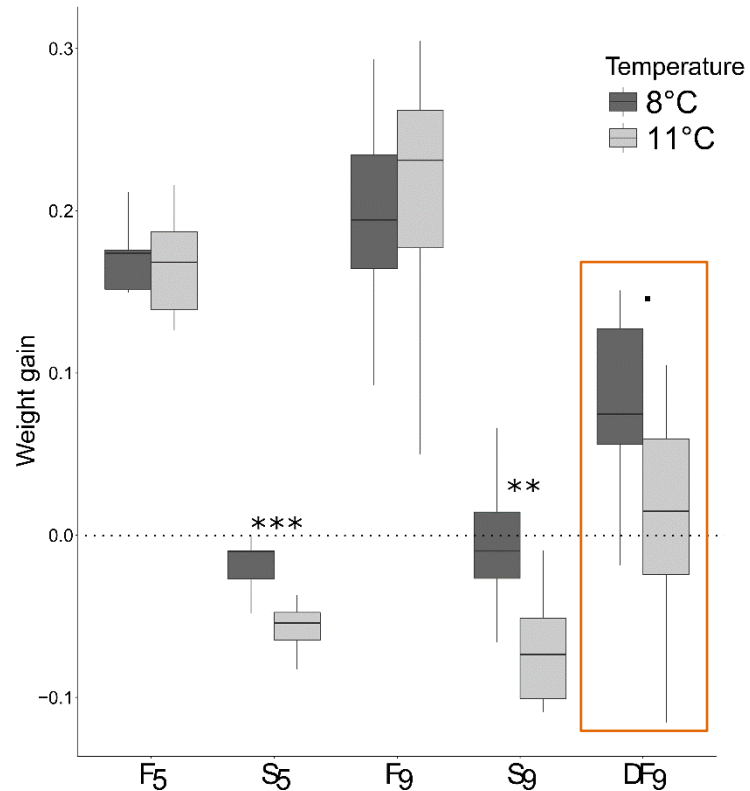
- Difference close to significance level
- *p-value = 0.059*



◆ F₉: 8 vs 11°C

- Similar growth
- But food intake higher at 11°C





❖ F₉: 8 vs 11°C

- Similar growth
- But food intake higher at 11°C

❖ DF₉: 8 vs 11°C

- Both able to start feeding
- Same food intake than fed fish
- A trend for a better growth at 8°C



1) Understand the effects of **starvation** on alevins **nutritional** status

↘ Growth

2) Test the alevins ability to **recover** from a **delayed** first-feeding

↗ Recovery



↘↘ Growth

Recovery → More contrasted

- Some alevins recovering
- Others at the same levels than starved fish



Fed fish

- Under other physiological mechanisms
- Carnivores: food → fatty acids and proteins

Rainuzzo et al. 1997
Palmer and Ryman, 1972

Food degradation

No/low induction

Carbohydrates

Fatty acids

Proteins

Autophagy & Proteasome

Starved fish

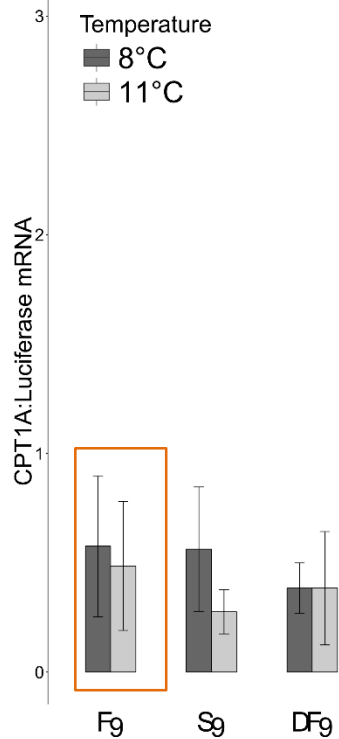
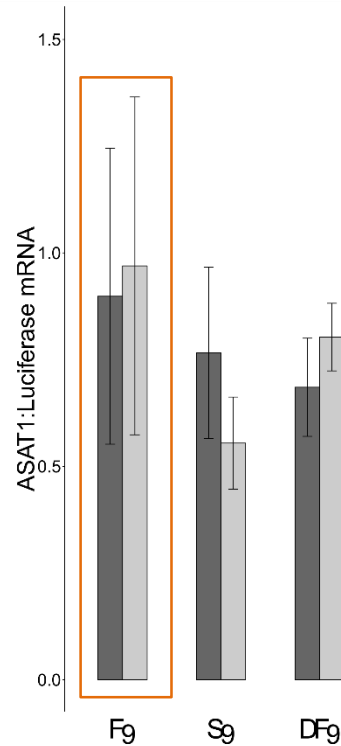
- Under other physiological mechanisms
- Limited: depletion in few hours

Body reserve uses

Last resort to
produce Energy
Seiliez et al. 2008

Data showed: D₉



Lipid catabolismAmino-Acid catabolism

Fed fish

8 ~ 11°C

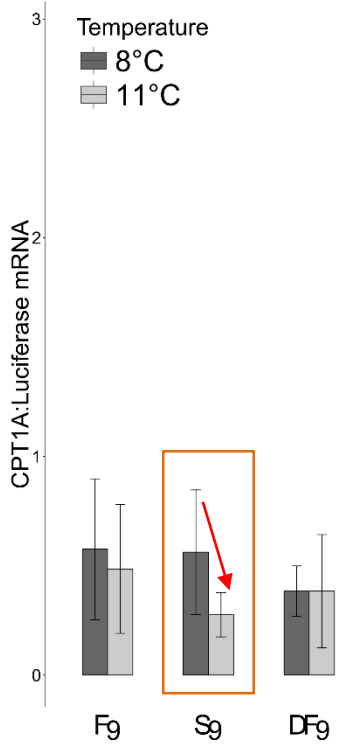
↗ food intake at
11°C

+

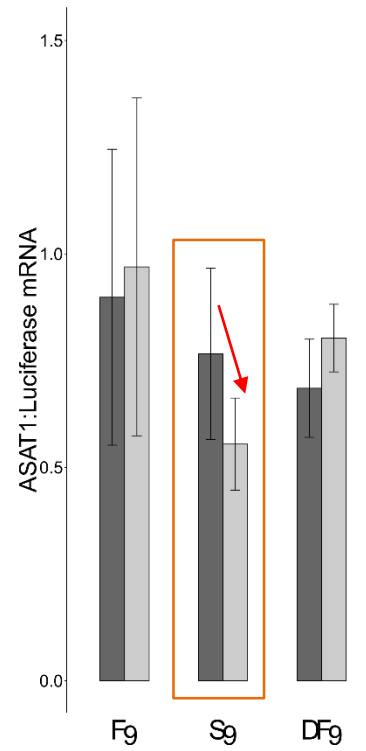
Similar growth &
catabolism

Better food
conversion
at 8°C?

Lipid catabolism



Amino-Acid catabolism



Fed fish

8 ~ 11°C

↗ food intake at 11°C

+
Similar growth & catabolism

Better food conversion at 8°C?

Starved fish

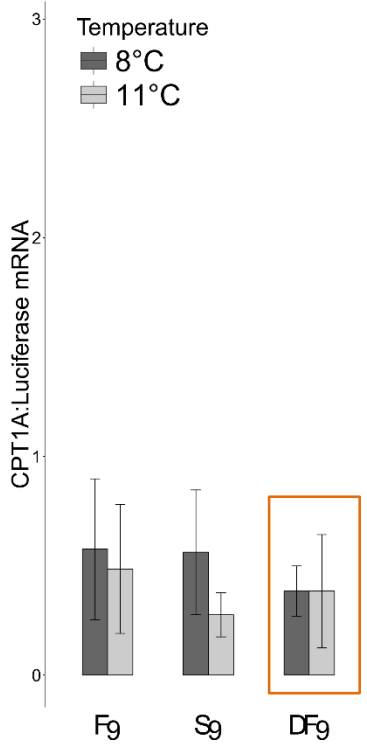
At 8°C = remaining reserves

At 11°C = lipid and AA catabolism ↘↘

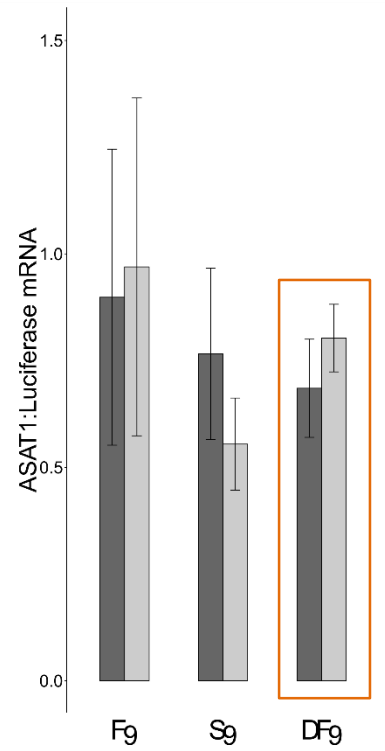
Hypometabolism?



Lipid catabolism



Amino-Acid catabolism



Fed fish

8 ~ 11°C

↗ food intake at 11°C

+
Similar growth & catabolism

Better food conversion at 8°C?

Starved fish

At 8°C = remaining reserves

At 11°C = lipid and AA catabolism ↘↘

Hypometabolism?

Delayed first-fed fish

8 ~ 11°C





1) Understand the effects of **starvation** on alevins **nutritional** status

↘ Growth

Still body reserves

2) Test the alevins ability to **recover** from a **delayed** first-feeding

↗ Recovery



↘↘ Growth

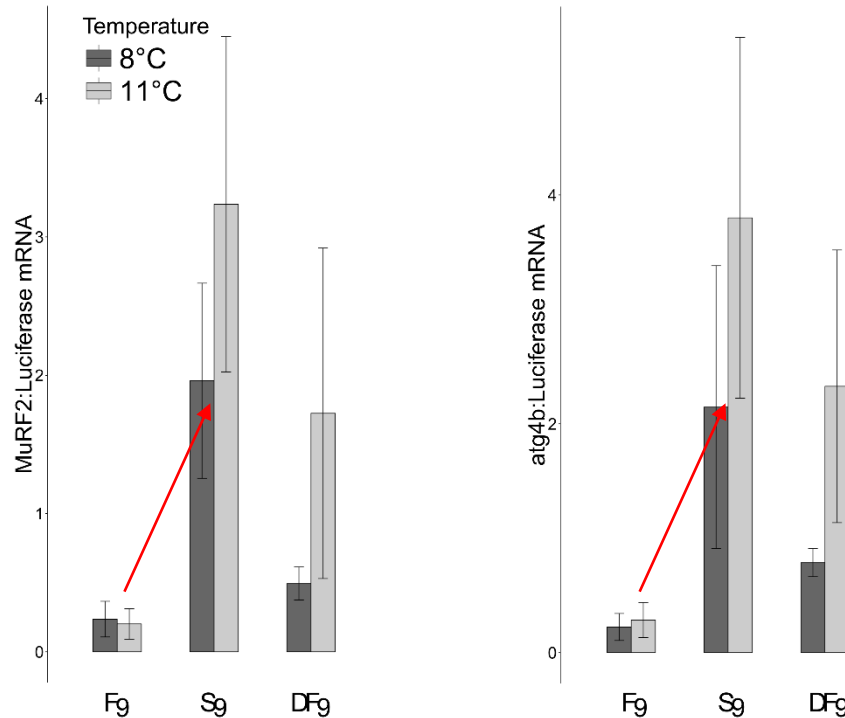
↘↘ gene expression
Reserves depleted?

Recovery → More contrasted



Proteasome:
skeletal-muscle protein + all the potential sources of energy
(amino acids, fatty acids, and carbohydrates) =

Energetic stress indicators



❖ Proteasome & Autophagy-related genes highly expressed during starvation

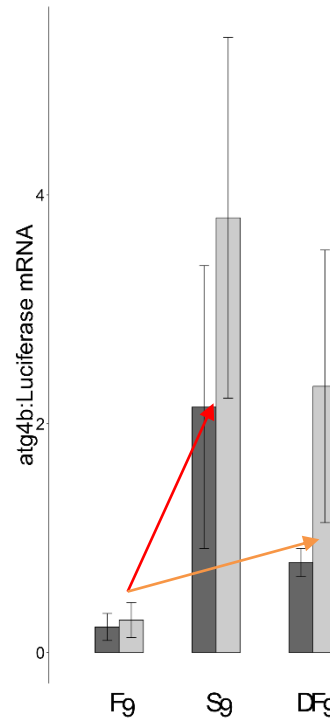
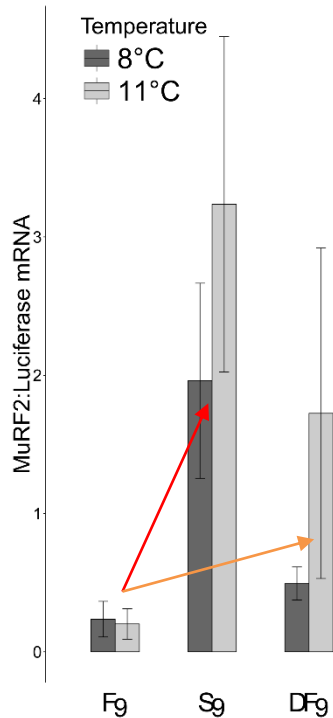
Proteasome:
skeletal-muscle protein

+

Autophagy:
all the potential sources of energy
(amino acids, fatty acids, and carbohydrates)

=

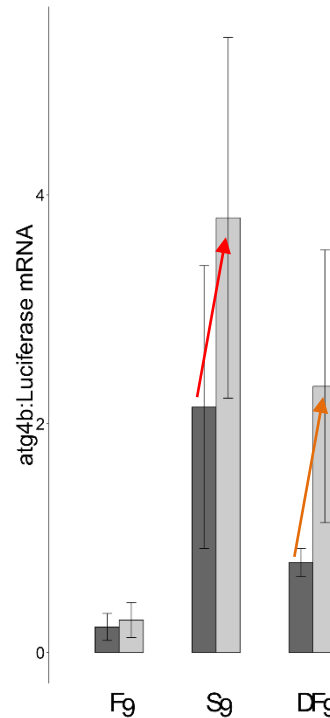
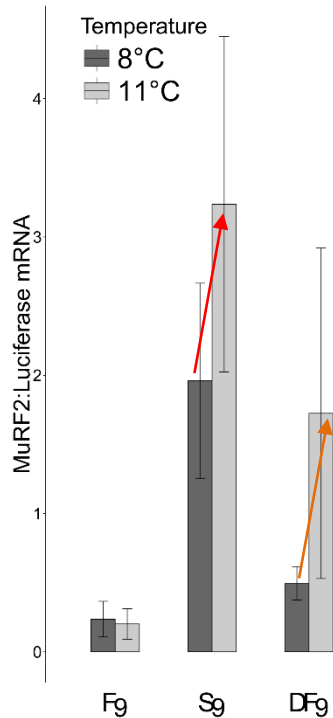
Energetic stress indicators



- ❖ Proteasome & Autophagy-related genes highly expressed during starvation
- ❖ Stress of starvation still noticeable in DF₉ fish

Proteasome:
skeletal-muscle protein + all the potential sources of energy
(amino acids, fatty acids, and carbohydrates) =

Energetic stress indicators



❖ Proteasome & Autophagy-related genes highly expressed during starvation

❖ Stress of starvation still noticeable in DF₉ fish

❖ Effect of temperature (S & DF)

■ 11°C >> 8°C



1) Understand the effects of **starvation** on alevins **nutritional** status

2) Test the alevins ability to **recover** from a **delayed** first-feeding

↘ Growth

↗ Recovery

Still body reserves

Autophagy & Proteasome induced



↘↘ Growth

Recovery → More contrasted

↘↘ gene expression
Reserves depleted?

Autophagy & Proteasome **highly** induced





- Food conversion is better at 8°C
- A **higher** temperature exacerbates the **metabolic distress** induced by **starvation**
- Despite 5 days of starvation, alevins are **able** to feed but recovery ...
 - Is not complete after 4 feeding days
 - Is more contrasted at 11°C

Thank you for your attention!
Any questions?



Photo credit: Stéphane GLISE (INRA) & www.arkive.org

