Physiological responses of cold acclimation in *Drosophila suzukii*

<u>Thomas ENRIQUEZ</u>

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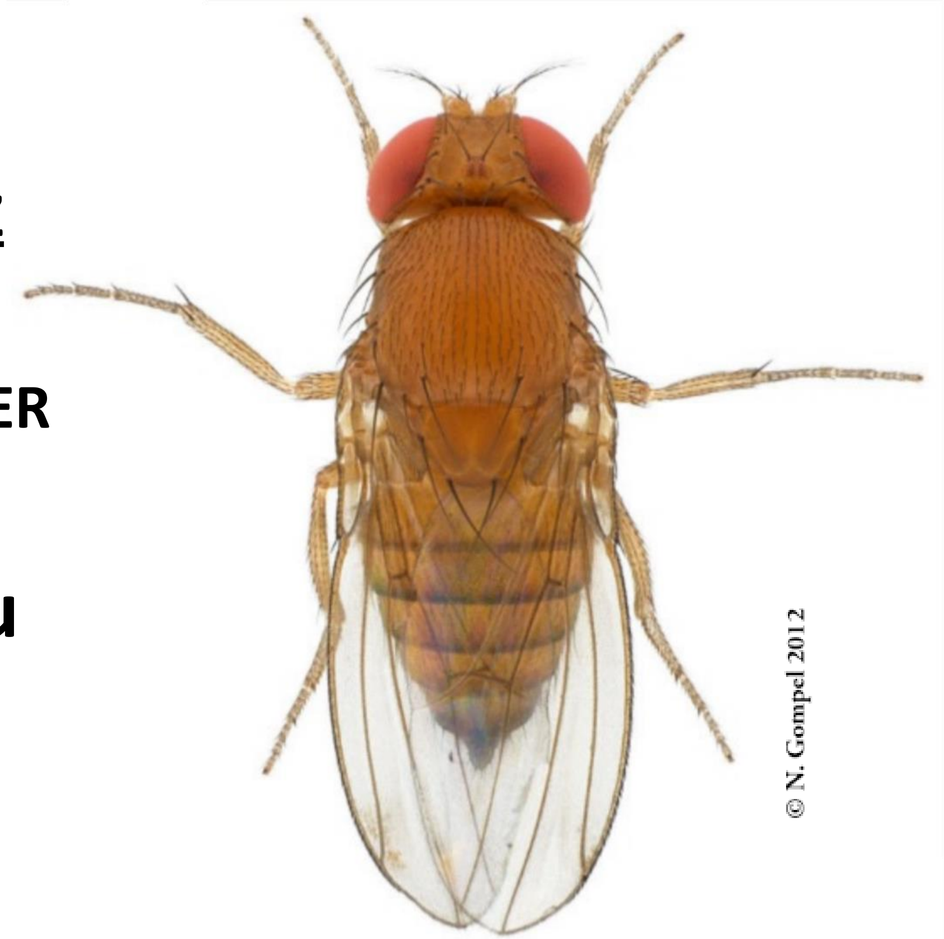
ISEPEP7 - Tartu



Context

- Temperature: **limiting factor** for ectotherms
  - ➢ Avoid
  - ➢ Adapt (evolution)
  - ➢ Acclimation (plasticity)

→ Thermal biology: Important to **predict pest invasion**

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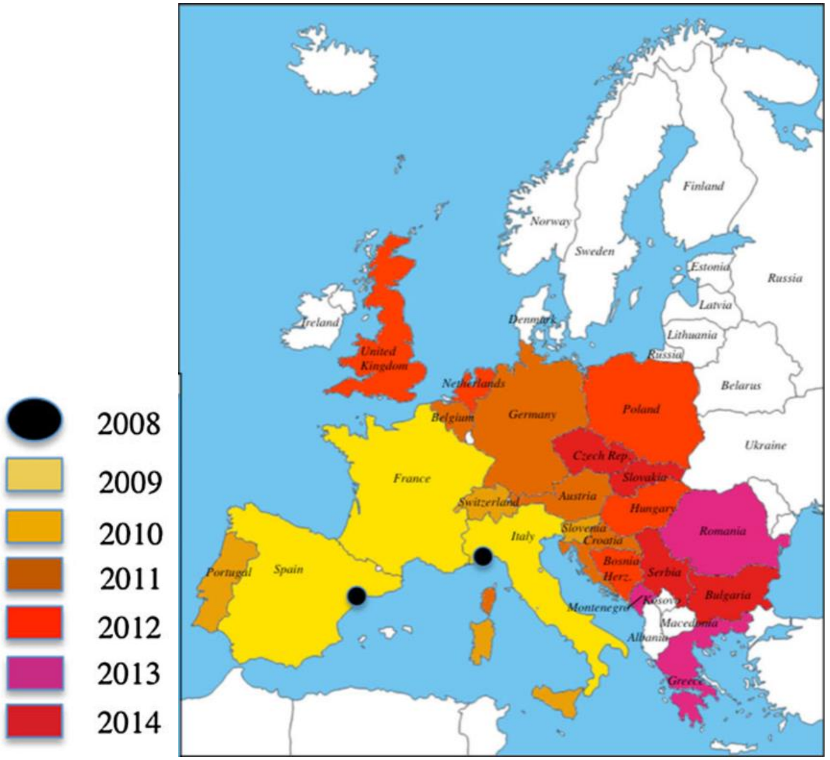
- *Drosophila suzukii* : **invasive pest**
  - ➢ Overwinter in cold regions



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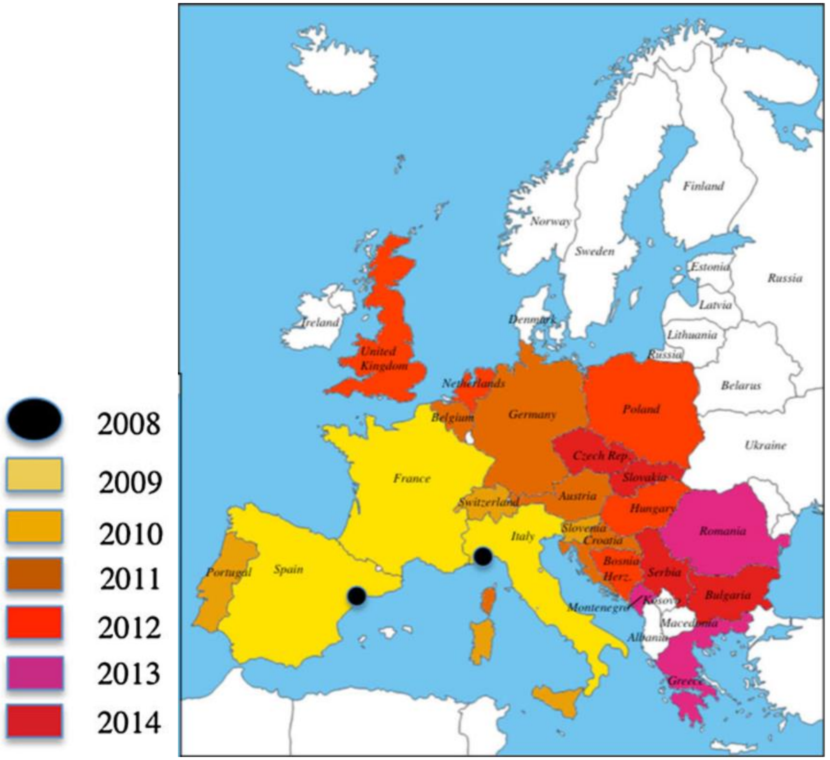
Data on *D. suzukii* thermal biology could help predict its invasion



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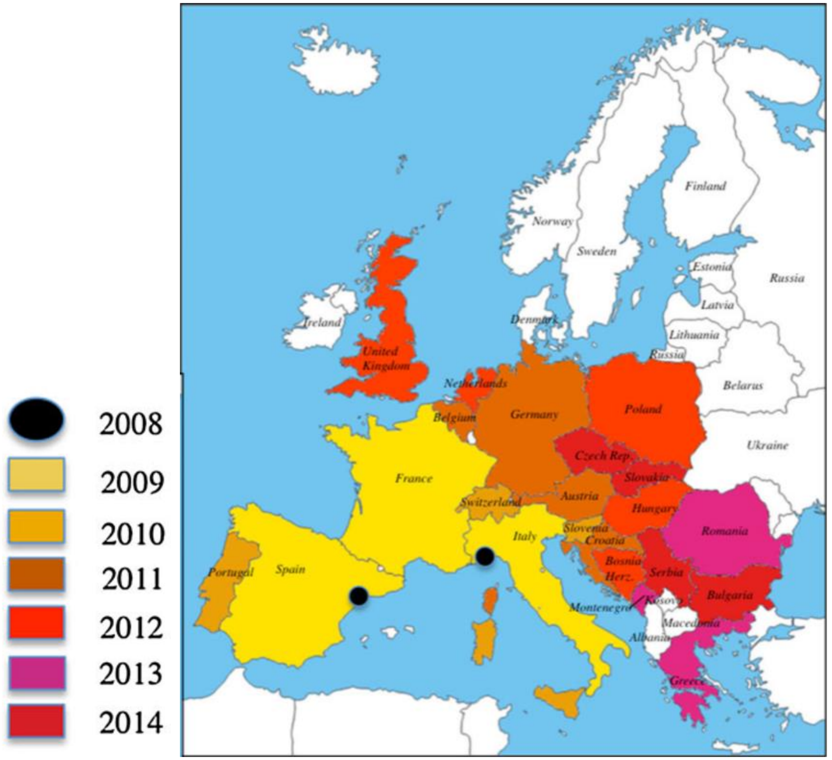

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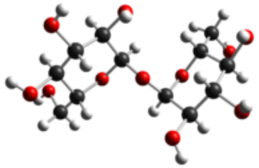
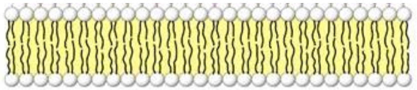
Phenotypic plasticity at different level

Changes in cold tolerance

Metabolic response



Lipidomic response

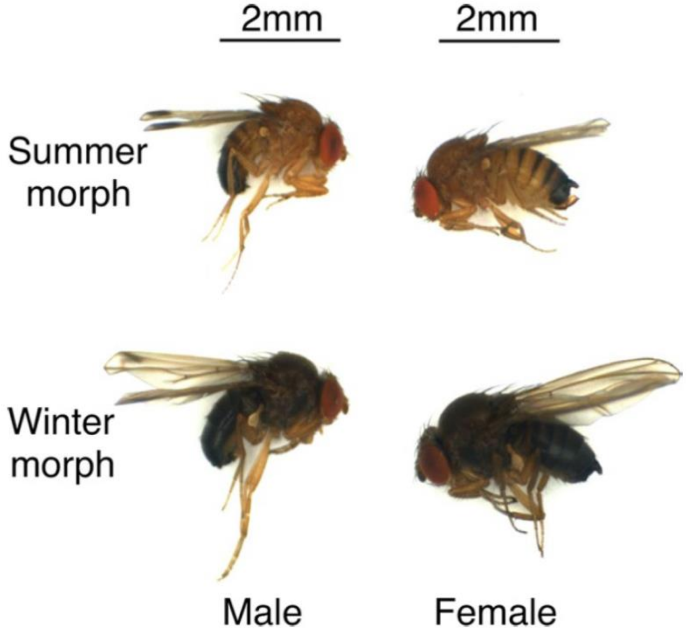


Phenotypic plasticity

- *D. suzukii* is chill susceptible
  (Jakobs et al., 2015)

- Winter morph: ↗ cold tolerance
  (Stephens et al., 2015; Toxopeus et al., 2016; Shearer et al., 2016; Wallingford & Loeb, 2016)

➡ **Plastic response**



Shearer et al., 2016

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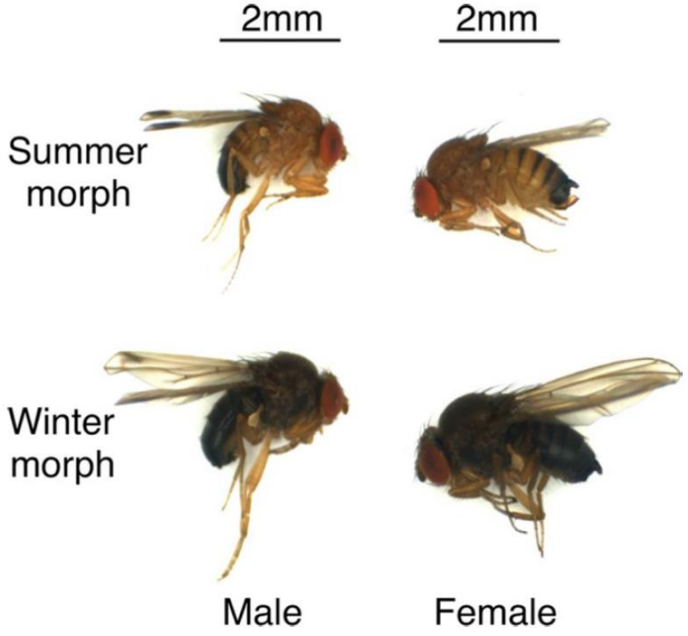

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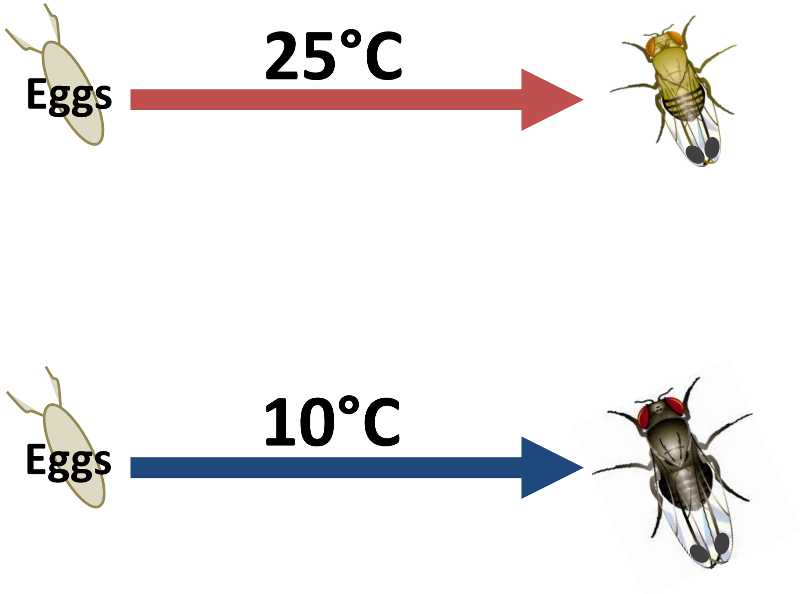
In which extent different types of acclimation increase cold tolerance?

Experimental design



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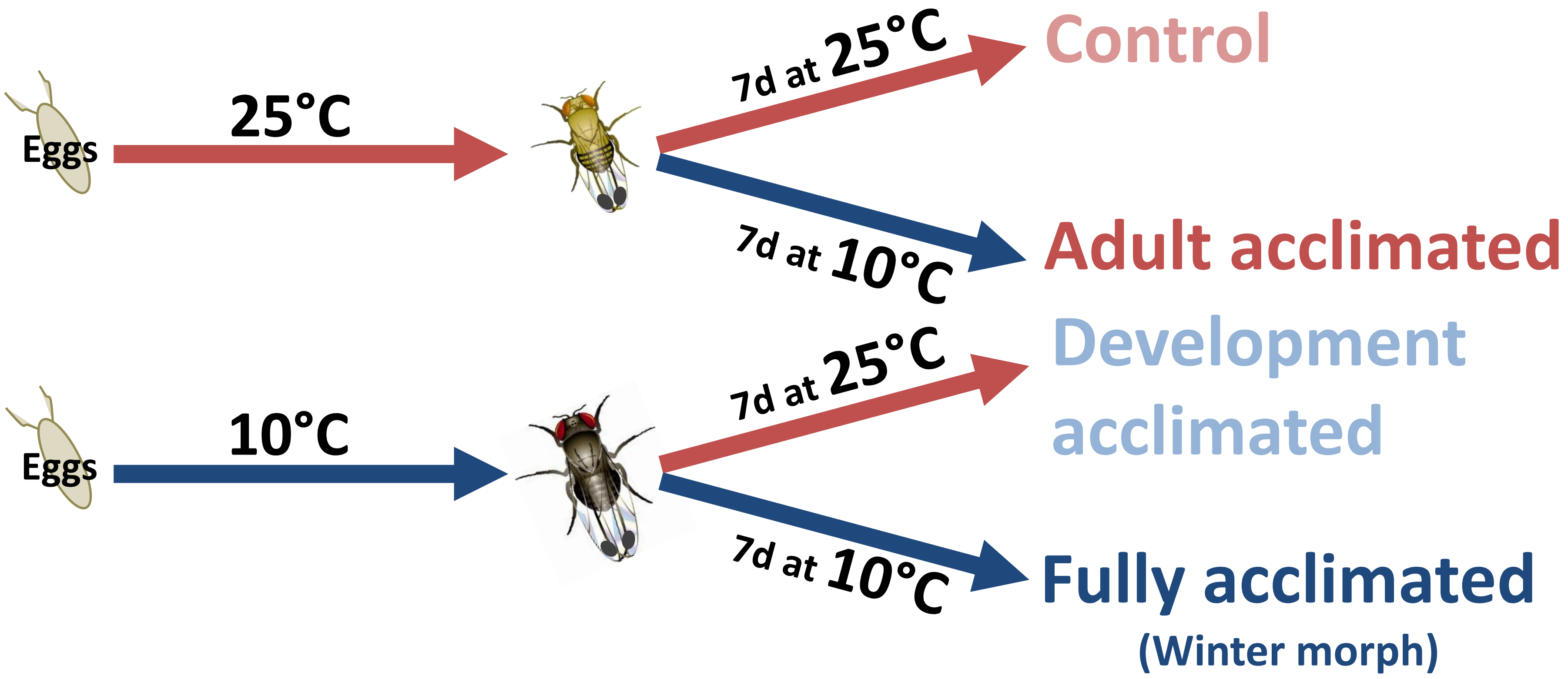

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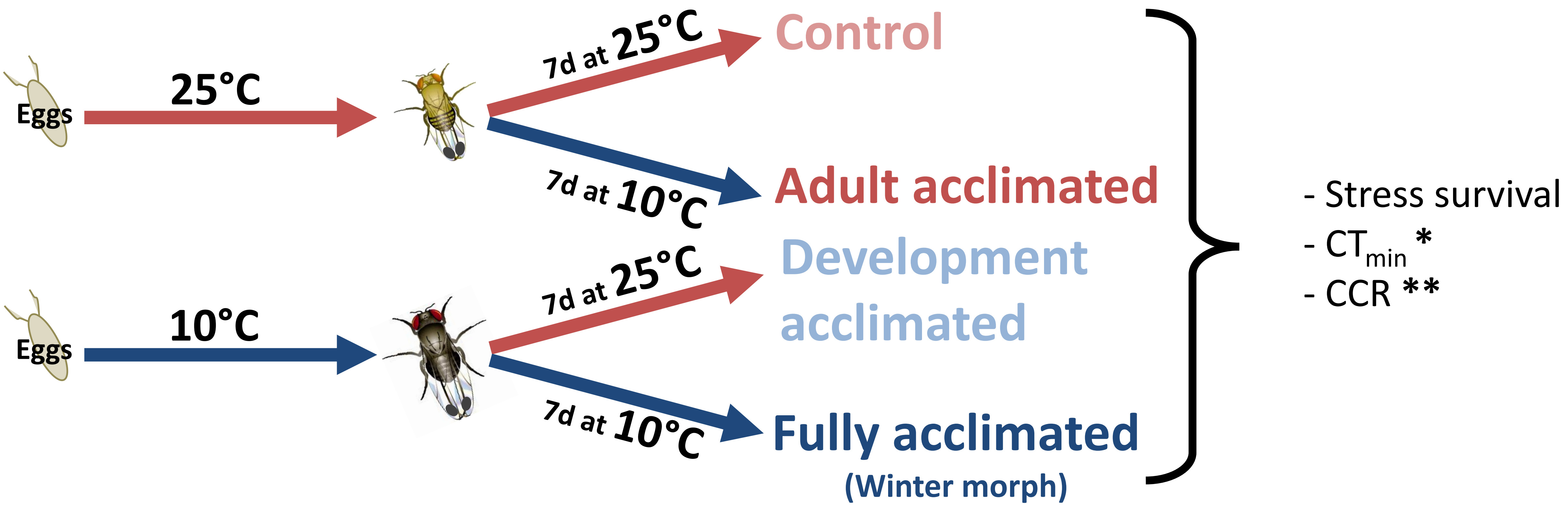
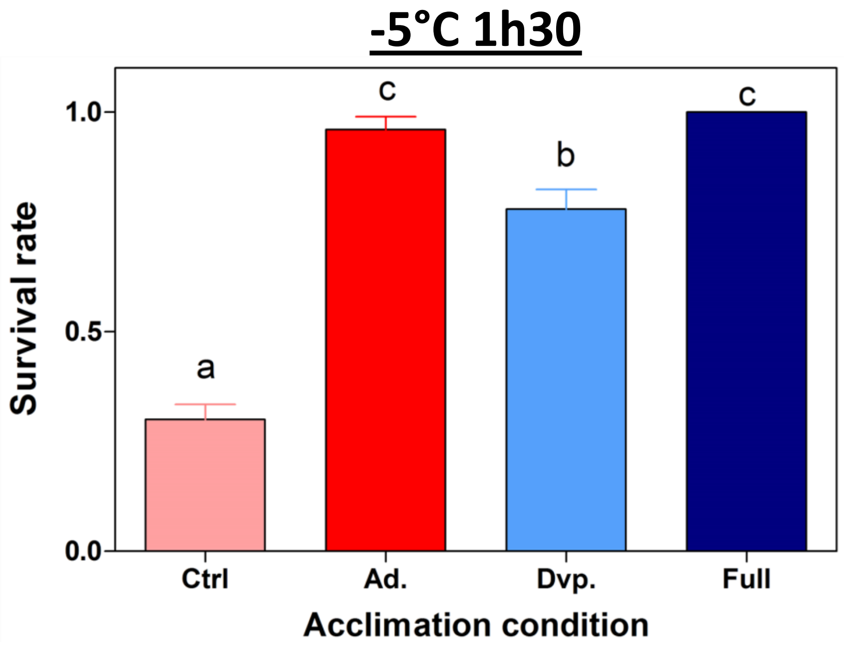


* CT_{min} **: Minimal Critical Temperature** → Temperature at which flies fall into coma

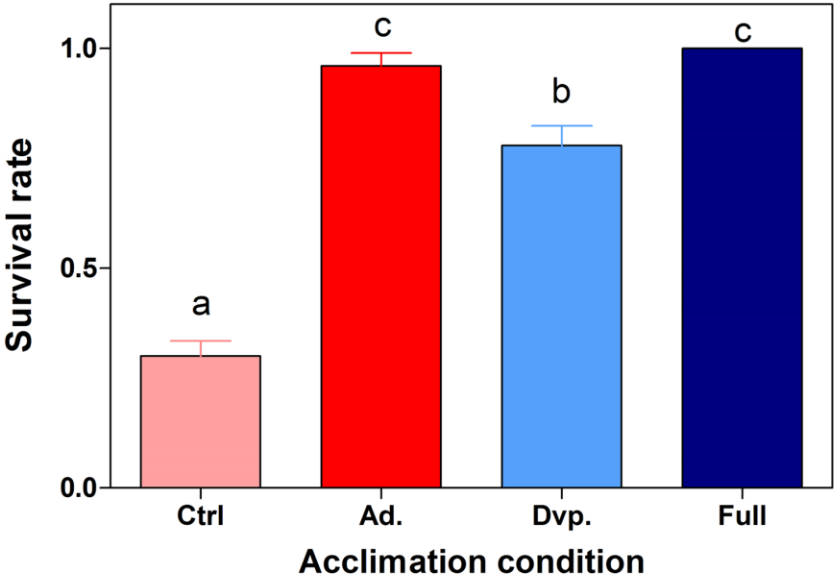
** **CCR: Chill Coma Recovery Time** → Time that flies take to recover from a chill coma

Results: cold tolerance

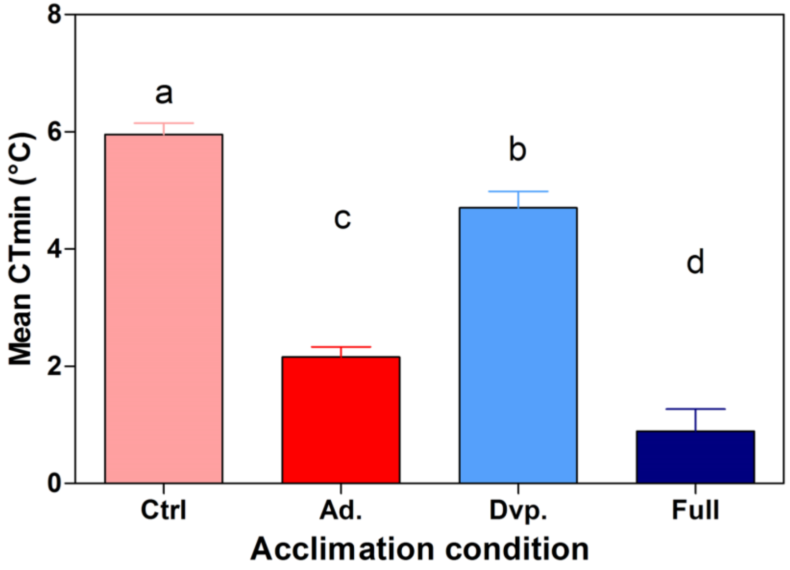


Results: cold tolerance

-5°C 1h30



CT_{min}



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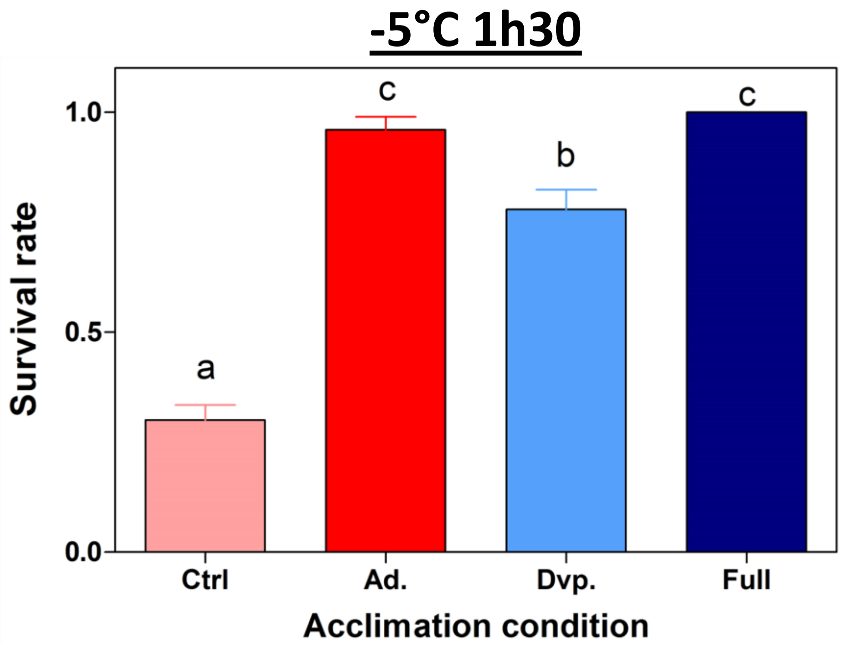

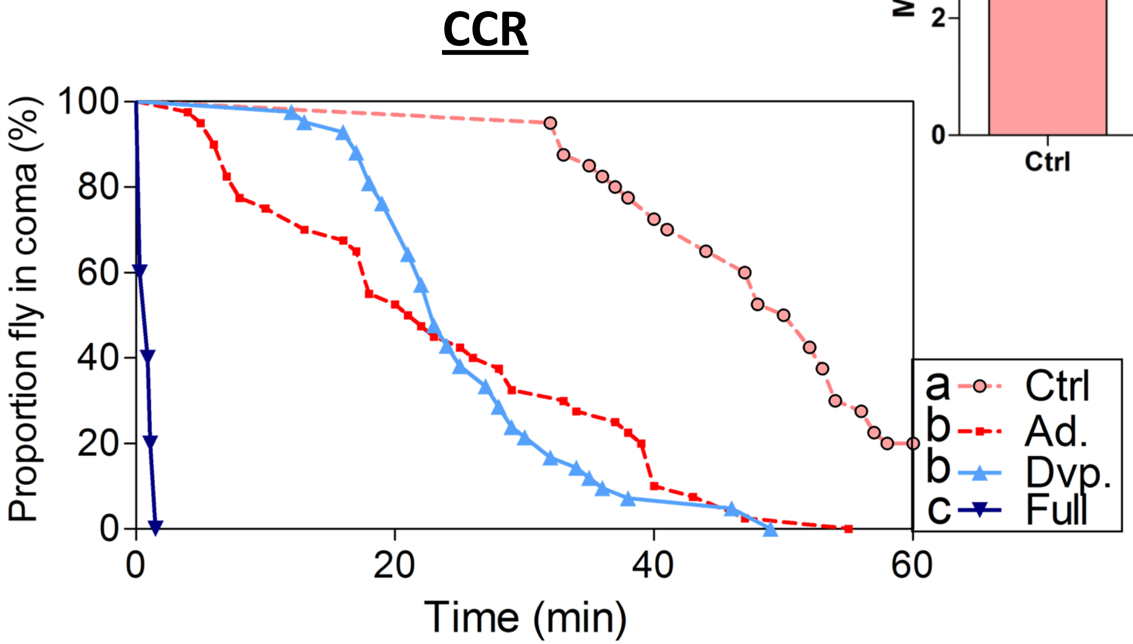

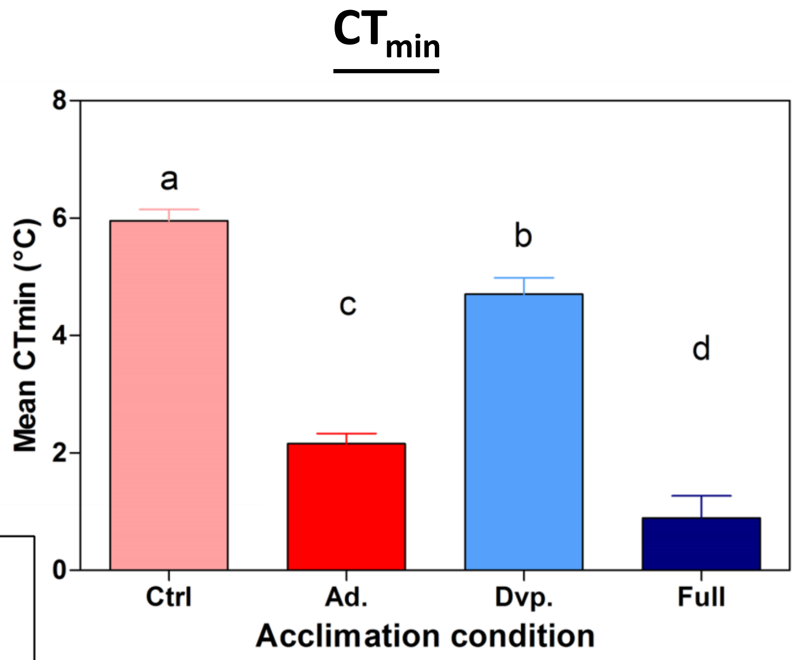

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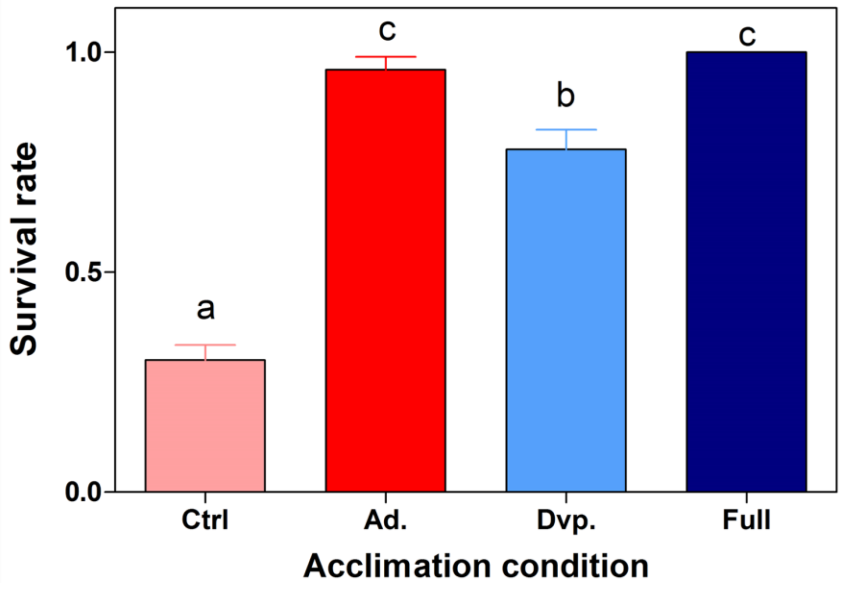

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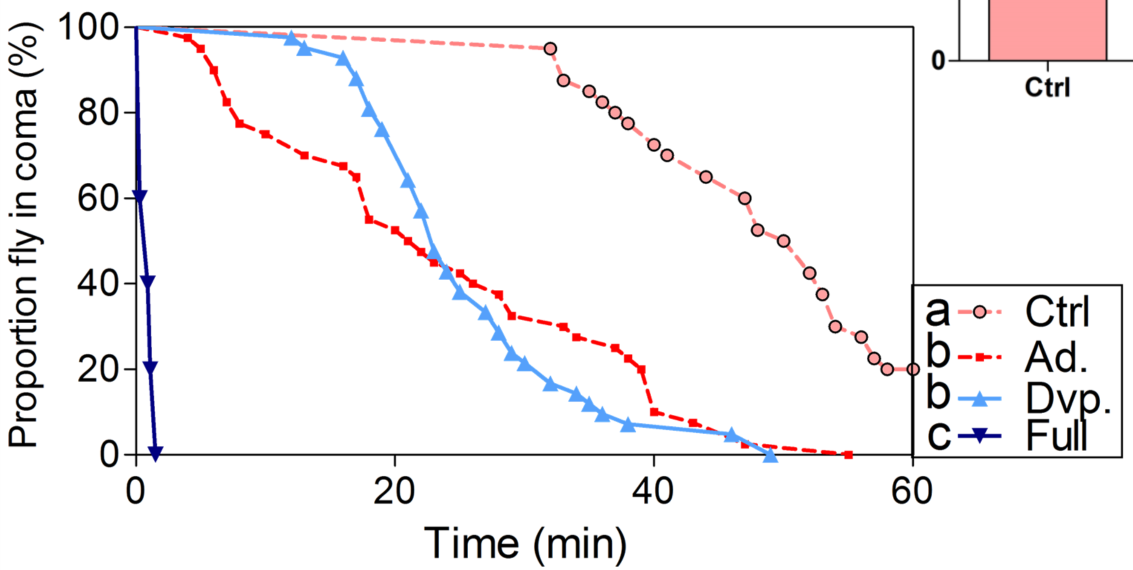
CCR



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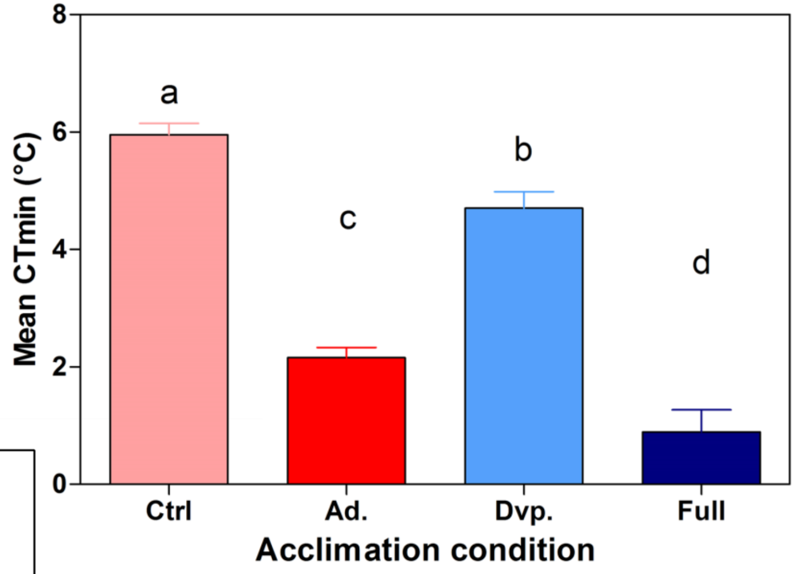

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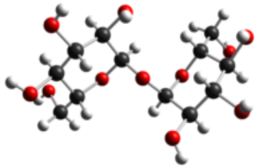

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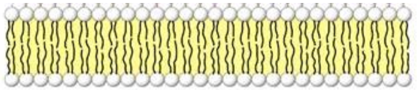
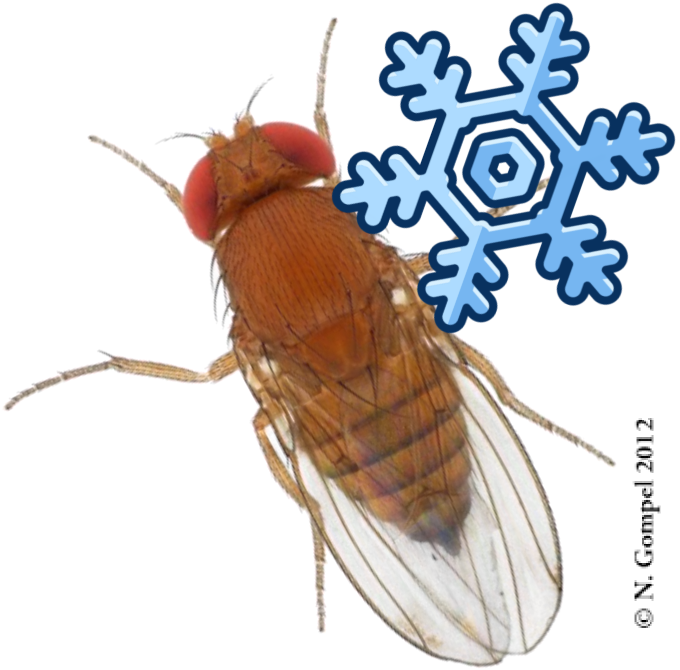


Cold effects on insect homeostasis

- **Cold stress**
  - Loss of ions & water homeostasis
    (Koštál *et al.*, 2004 ; Overgaard and MacMillan, 2017)
  - Loss of metabolic homeostasis
    (Overgaard *et al.,* 2007 ; Colinet *et al.,* 2012, Williams *et al.,* 2014)
- **Acclimation is associated with**
  - Maintenance of cellular homeostasis: ions, water and metabolites
    (Overgaard et al., 2007 ; Colinet et al., 2012, Williams et al., 2014)
  - Cryoprotectant accumulation (sugars, polyols…)
    (Michaud and Denlinger 2007; Overgaards et al 2007; Teets et al 2012)



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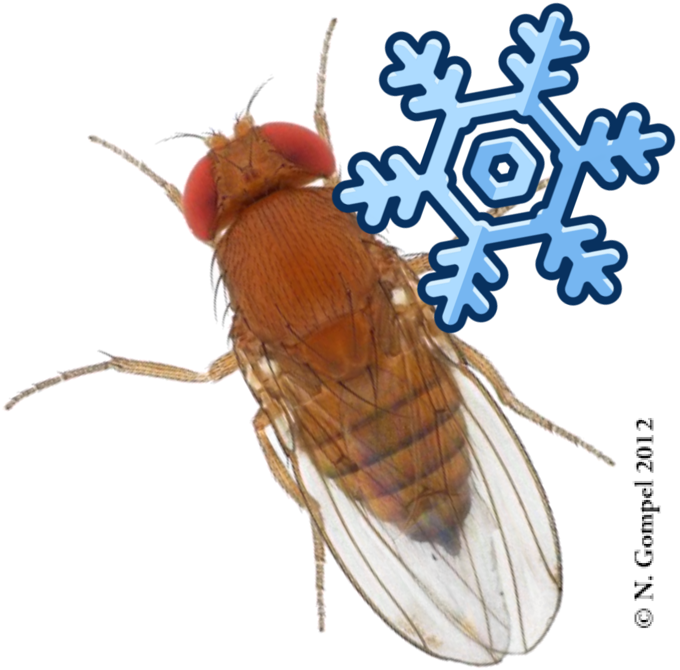

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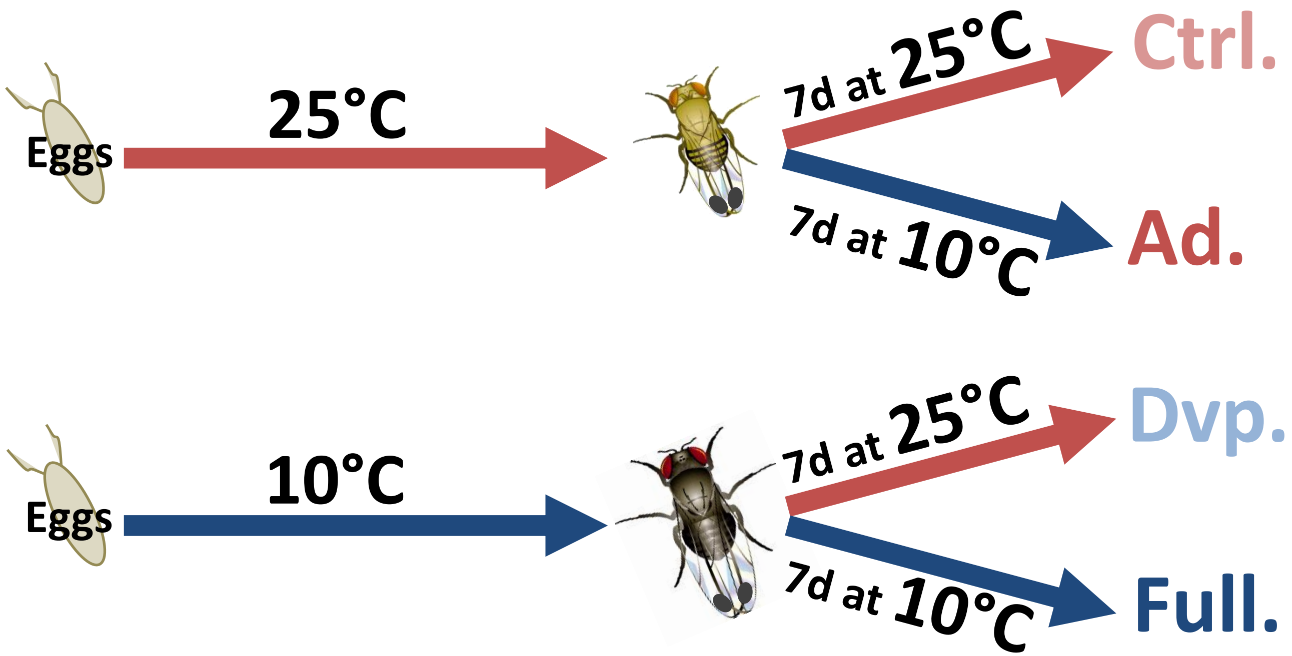
→ **Fully acclimated flies**

Metabolic response of acclimation

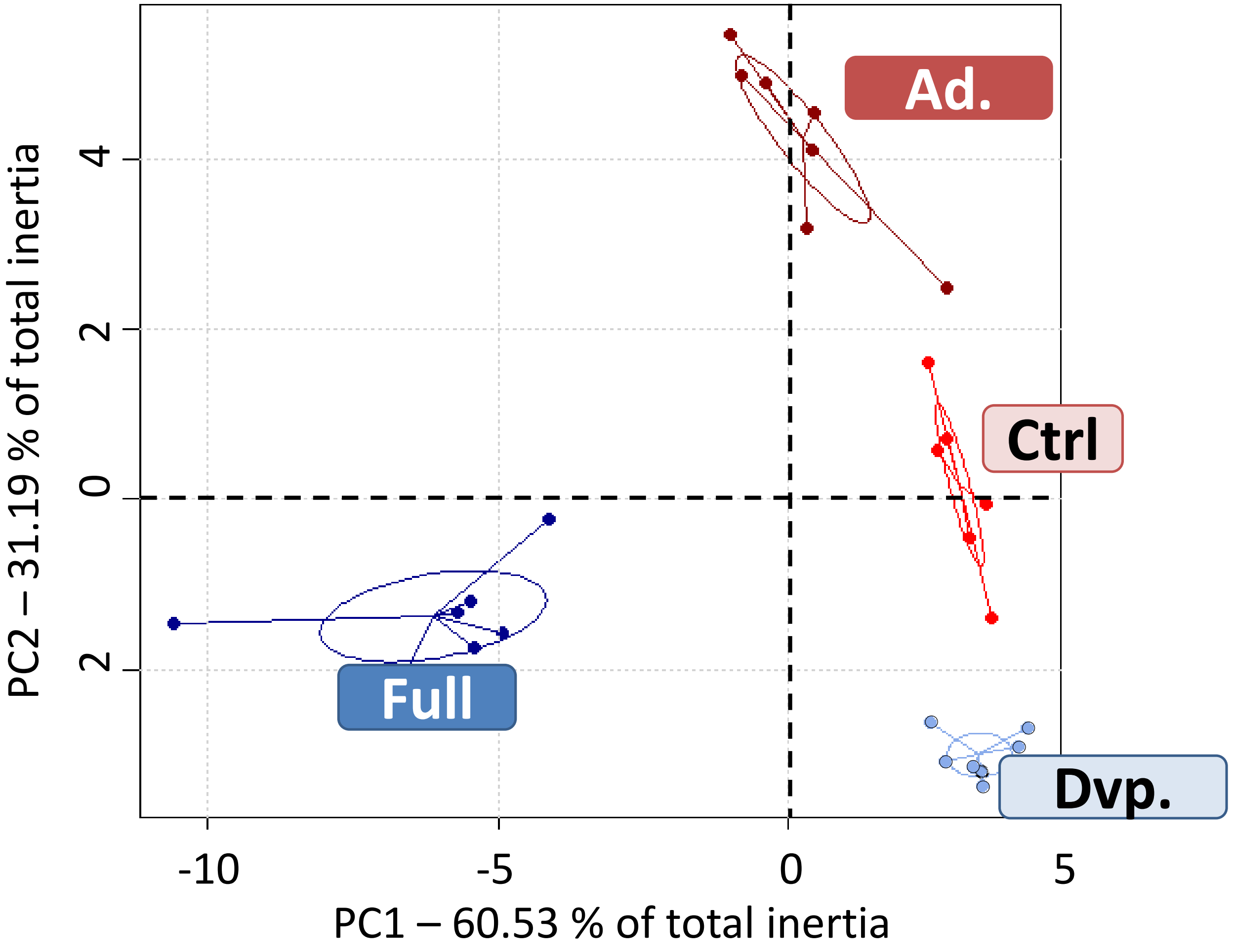


Comparative analysis of metabolites composition among the 4 acclimated phenotypes
→ **Cryoprotectant accumulation?**

GC-MS target analysis: 45 identified metabolites (absolute quantification)

Metabolic response after acclimation

Principal Component Analysis (PCA):



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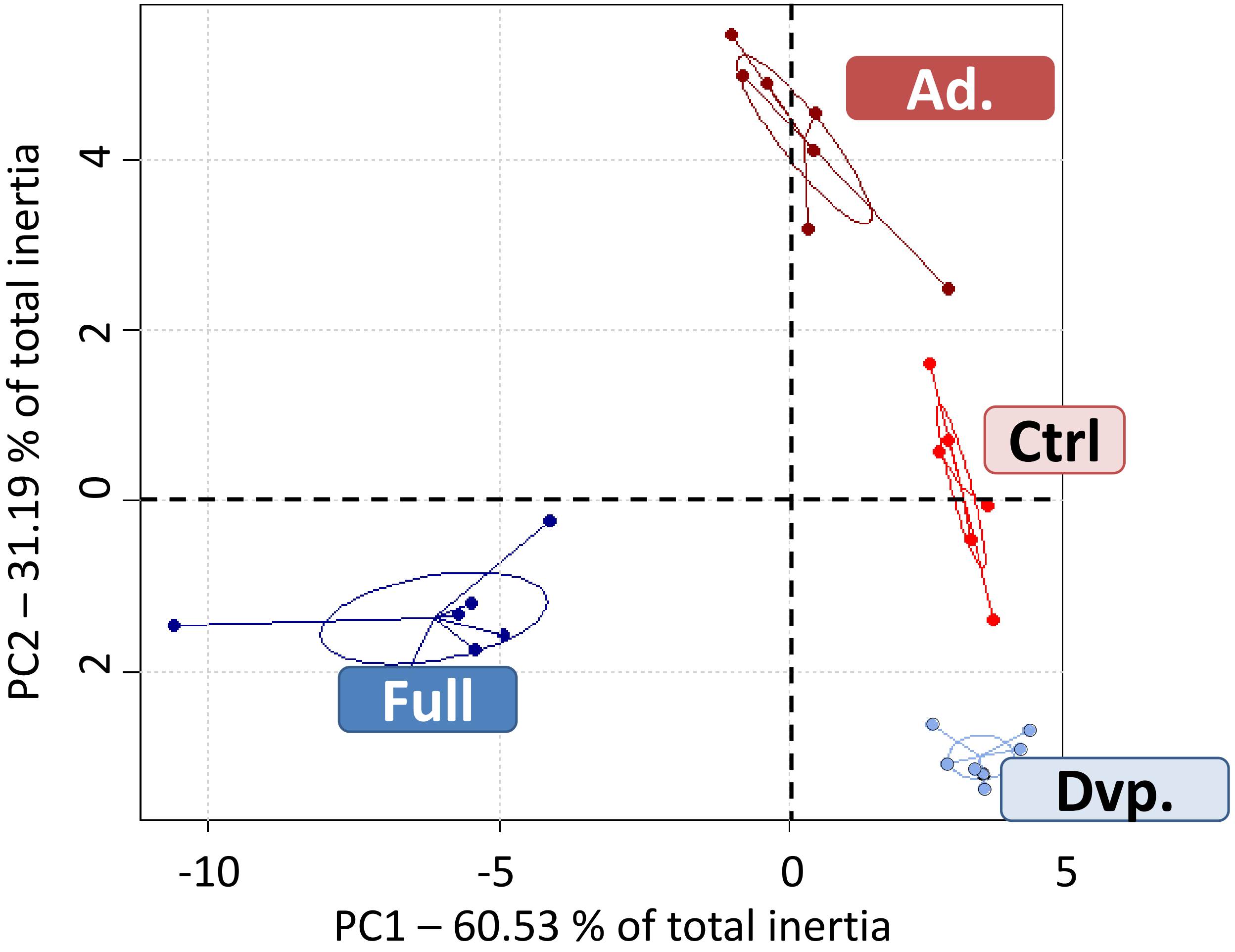
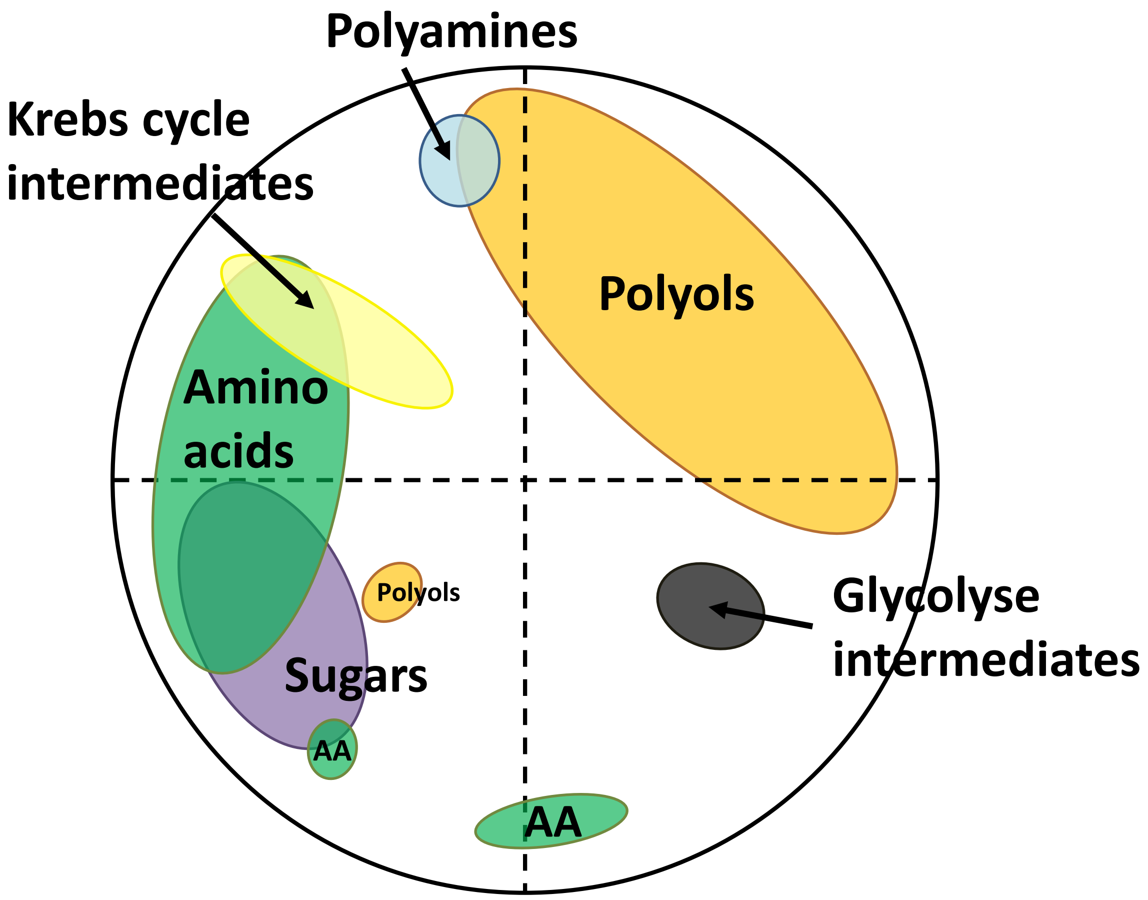
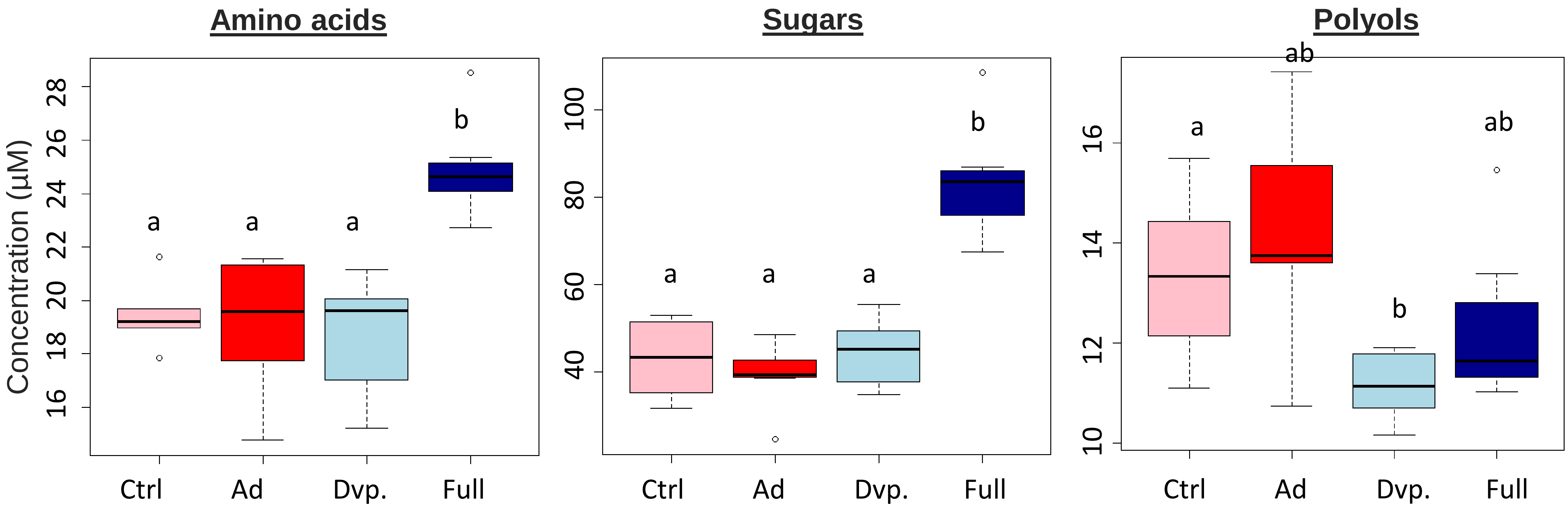


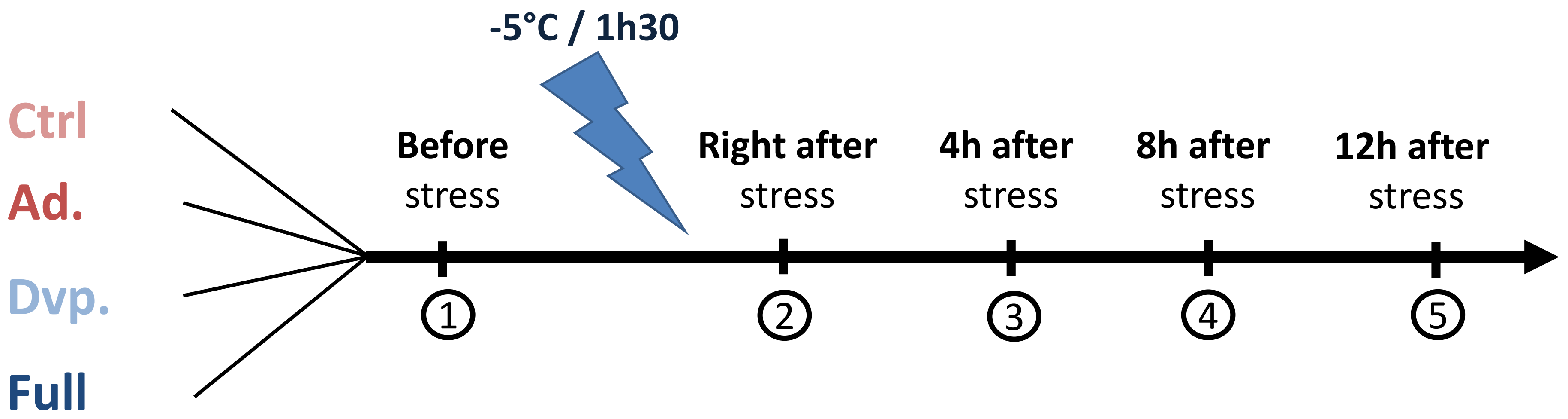


Metabolic response after acclimation

- Focus on cryoprotectant families:



Temporal robustness of metabotypes



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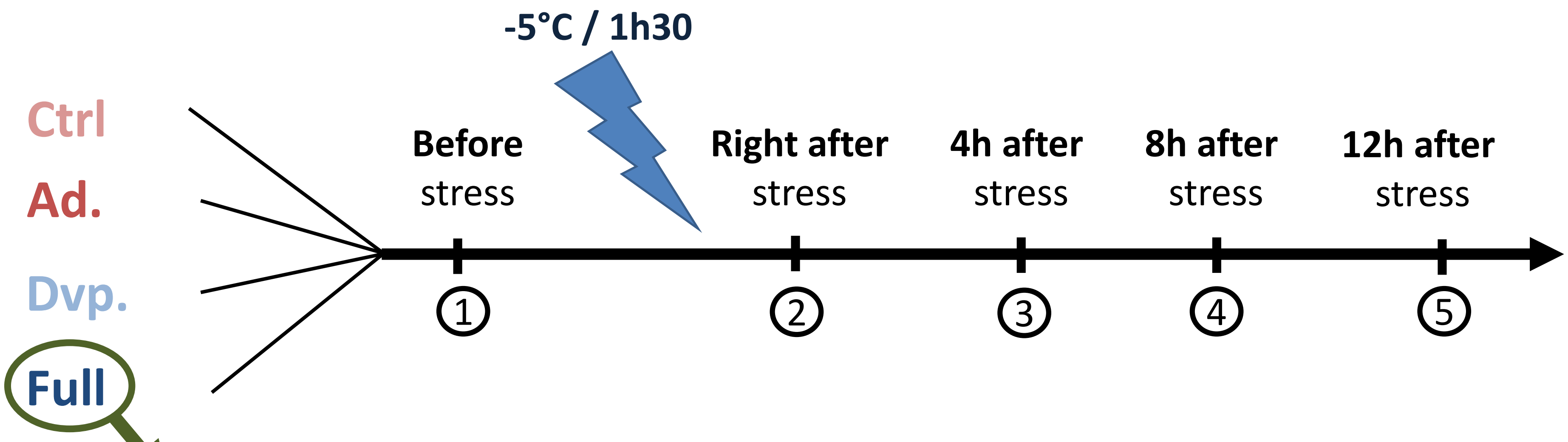
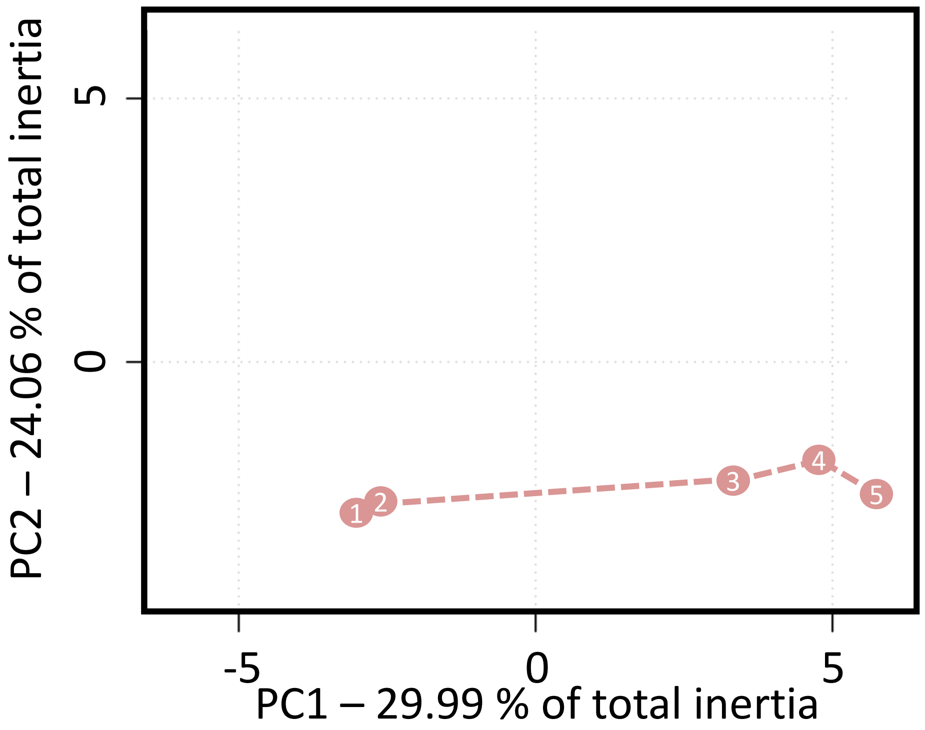


Signs of metabolic robustness?

GC-MS target analysis: 45 identified metabolites (absolute quantification)

Temporal robustness of Metabotypes

① **Before** stress
② **Right after** stress
③ **4h after** stress
④ **8h after** stress
⑤ **12h after** stress



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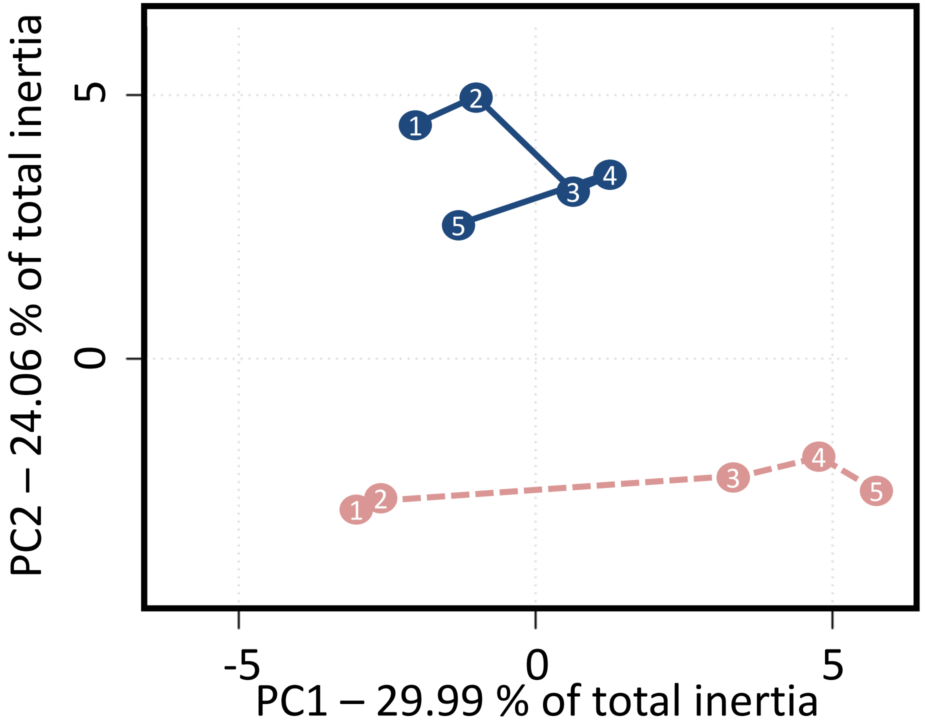

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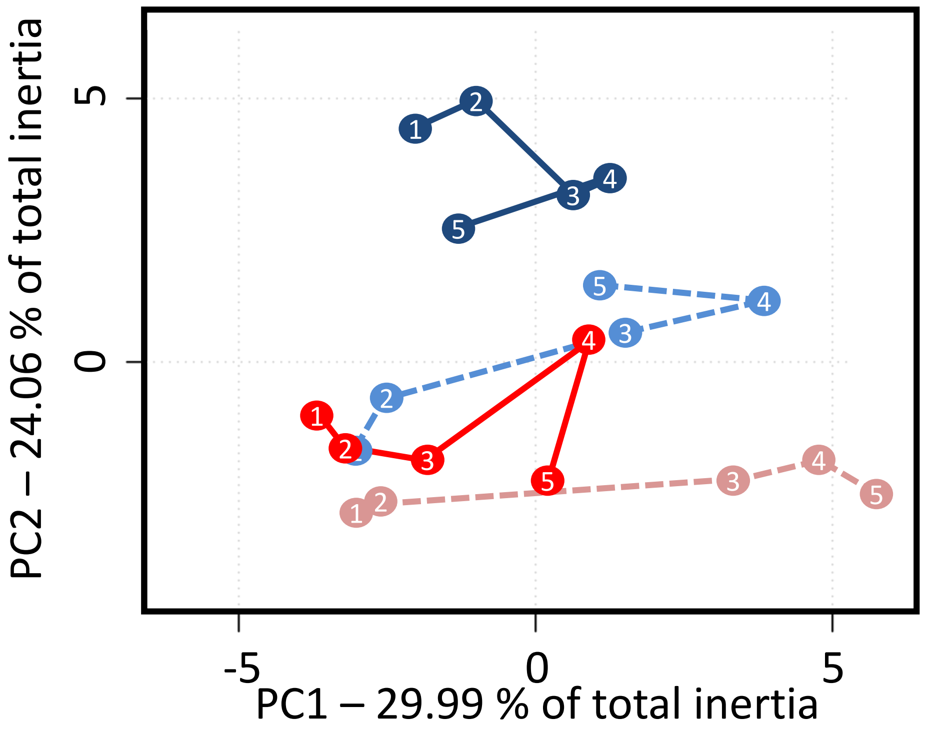

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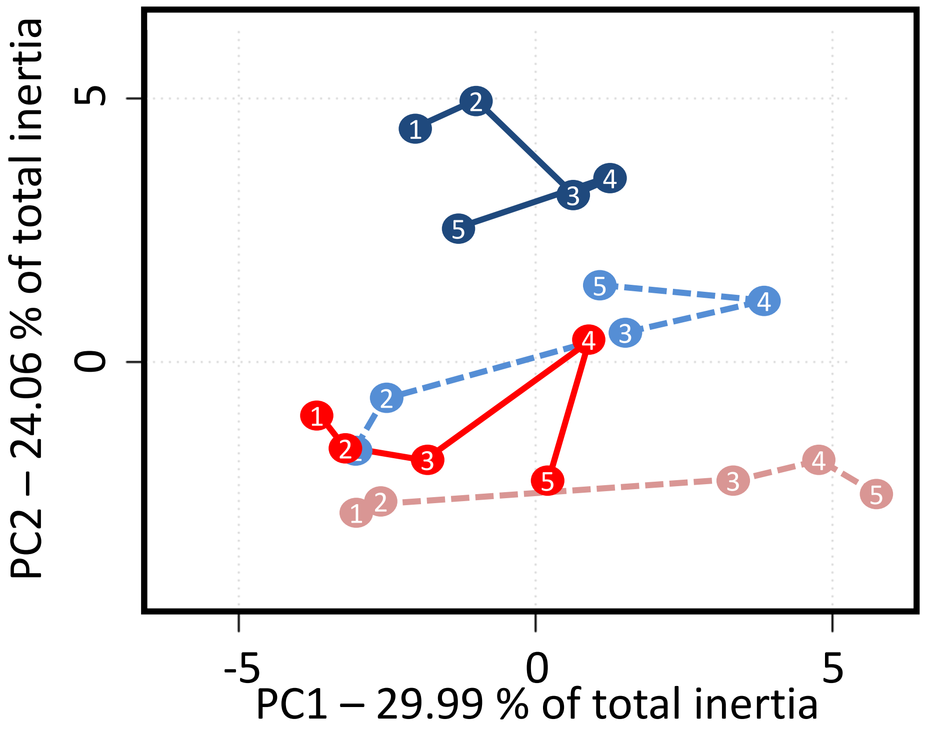
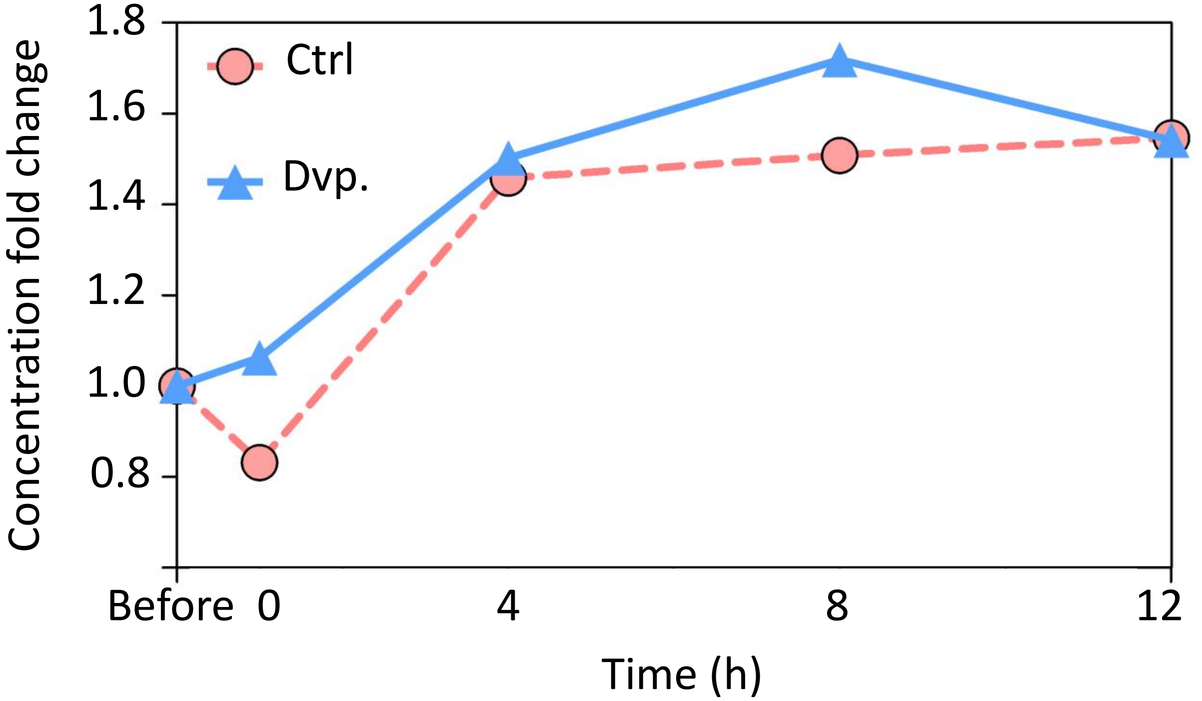


Amino acids



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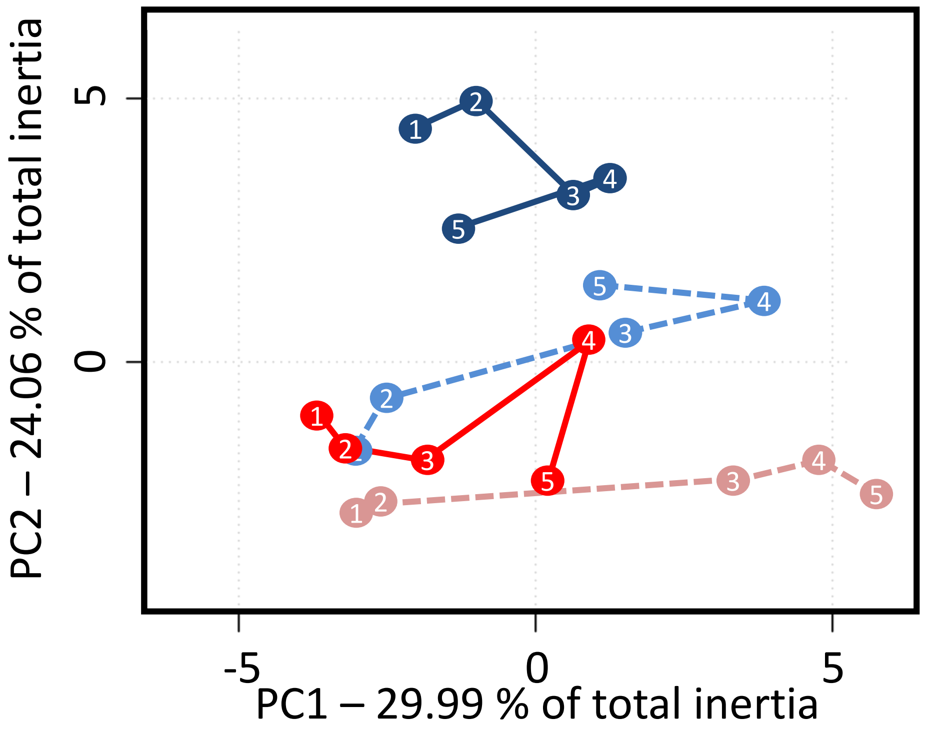

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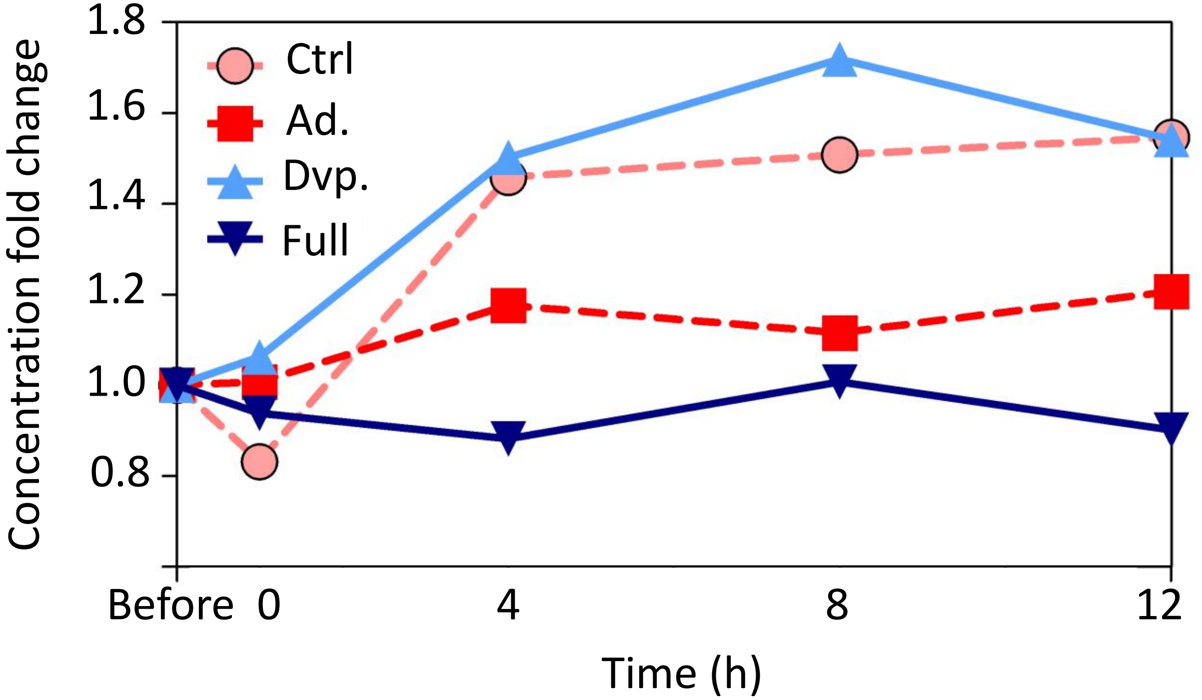

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Cold tolerance:

Full > Ad. ~ Dvp. > Ctrl

Metabolic homeostasis:

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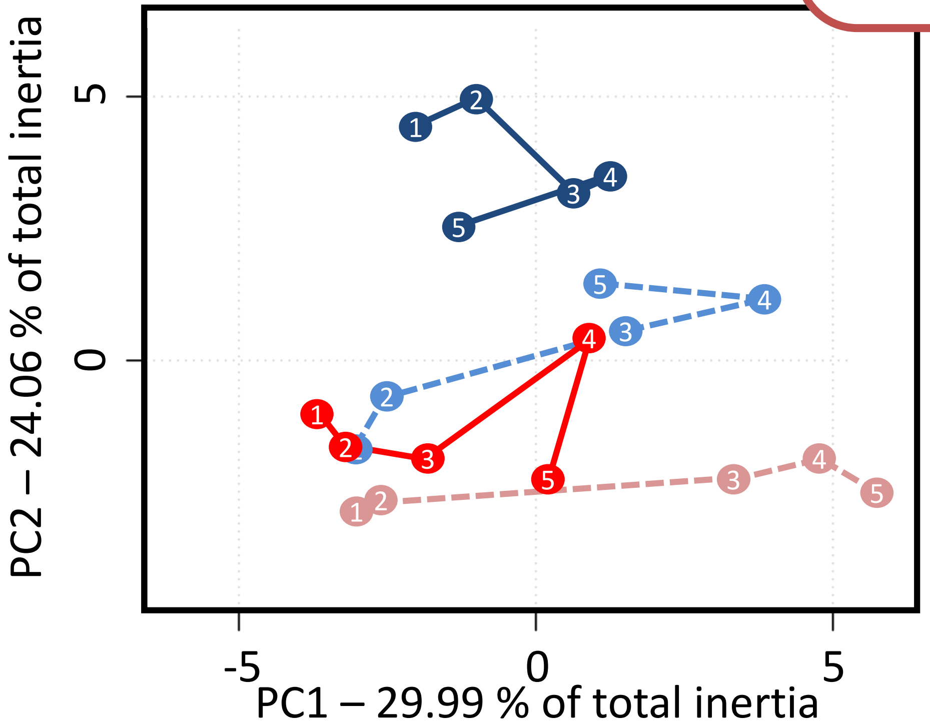

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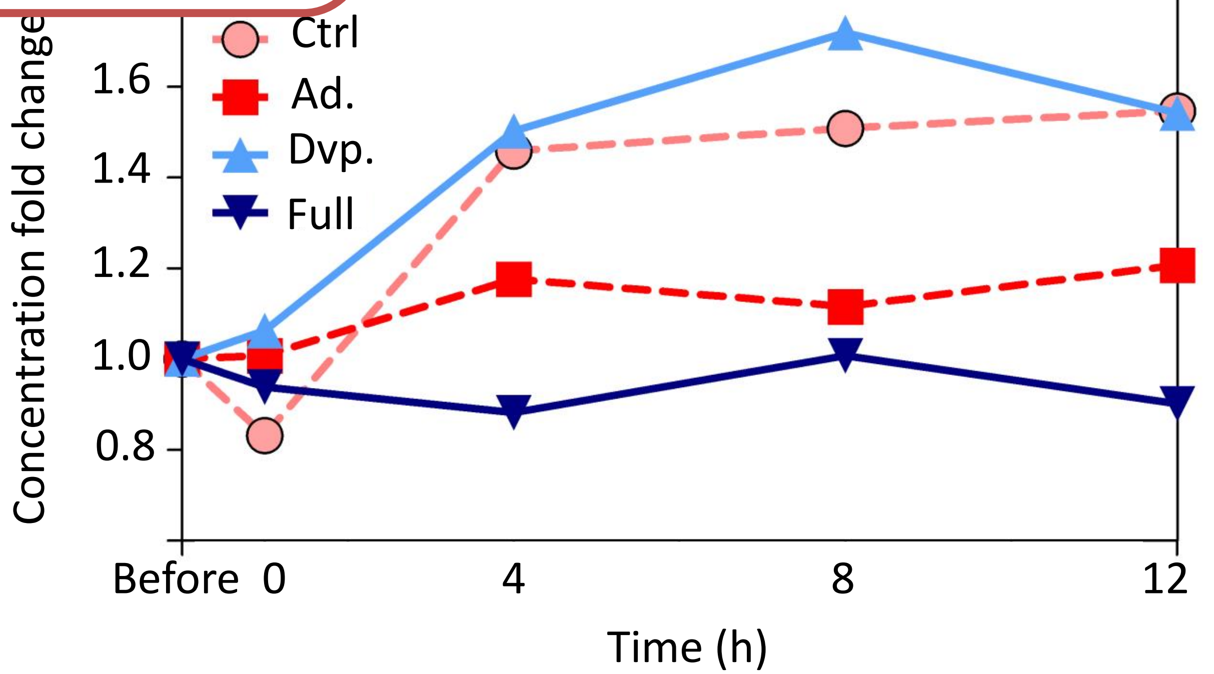

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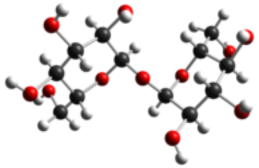

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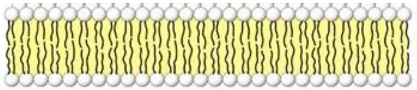
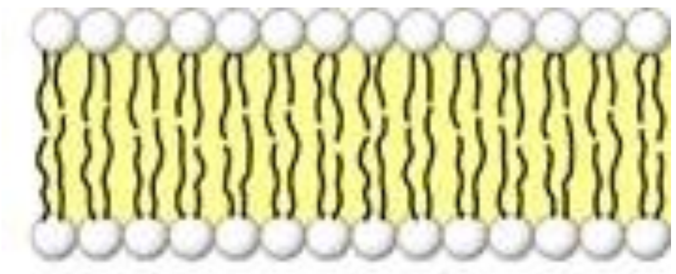


Cold effects on cell membranes

- Fluid to gel phase transition → Phospholipid bilayer separation → Chill injuries
- Phospholipids reajustment
  (Sinensky, 1974; Cossins, 1994; Koštál, 2010; Colinet et al., 2016)



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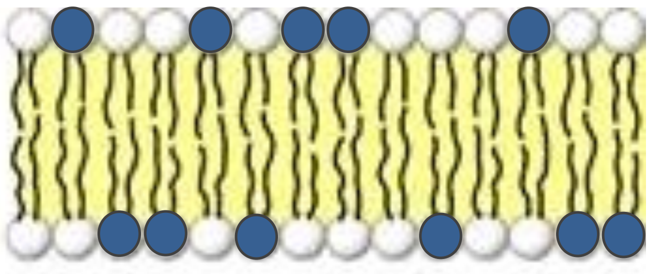

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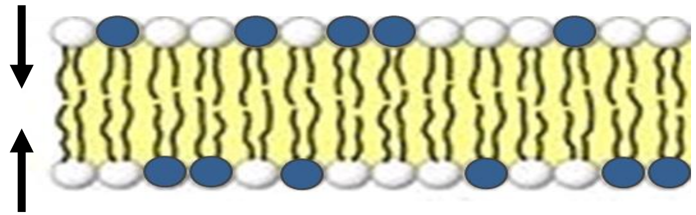

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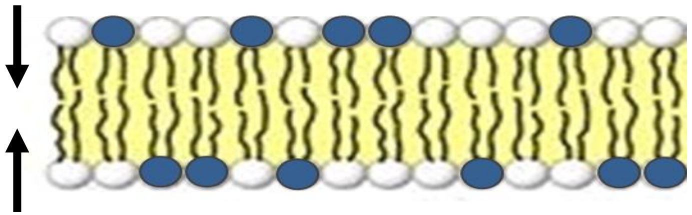
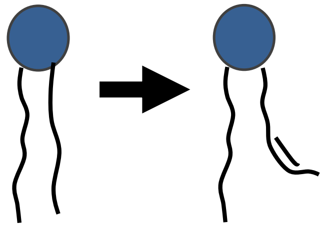
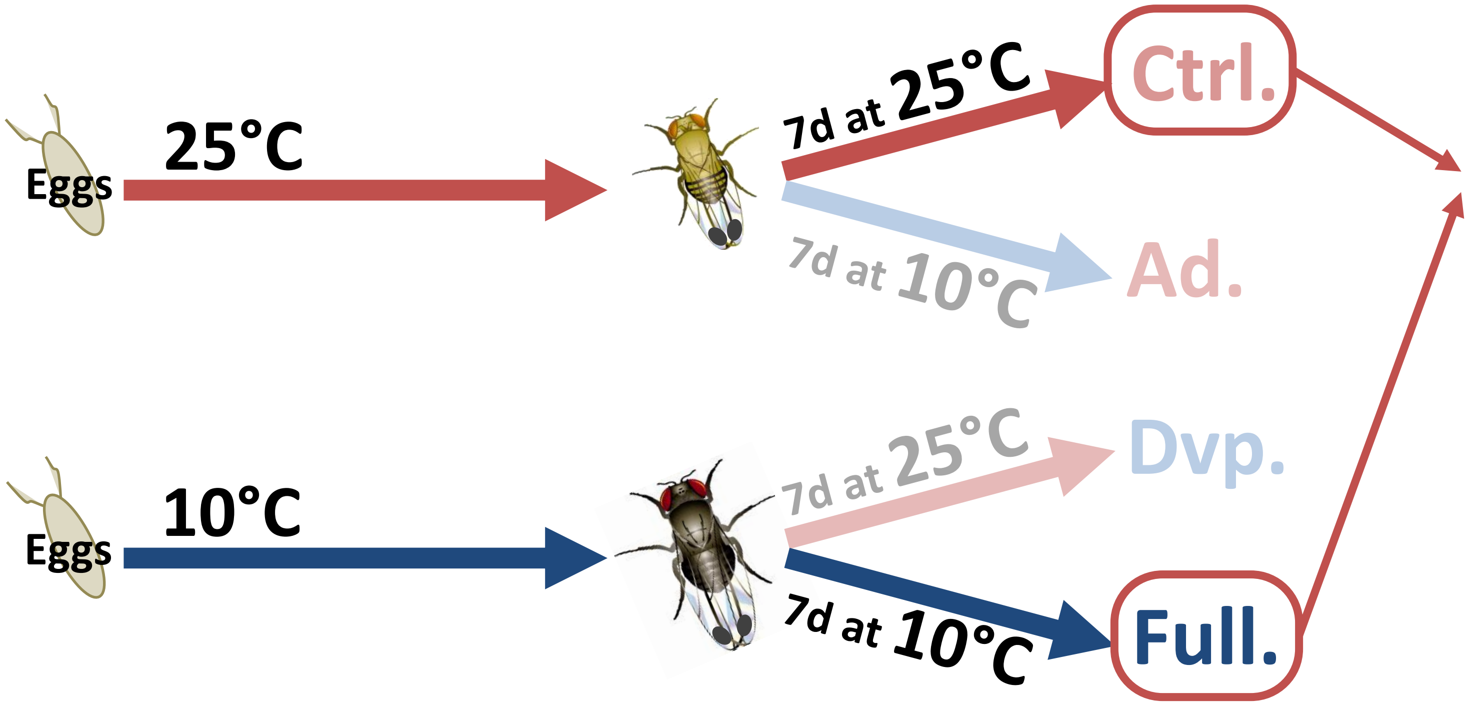




→ **Homeoviscous adaptation**

Focus on fully acclimated flies



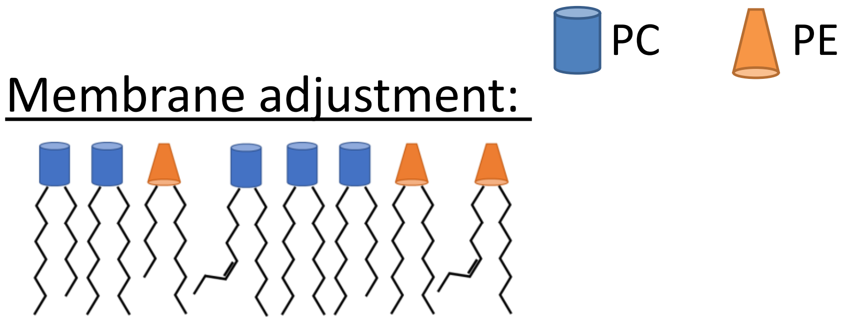
Methods:

- Profiling of complex lipids
  LC-QTOF

Lipidomic response

→ 275 annotated lipids from different families

Membrane adjustment:



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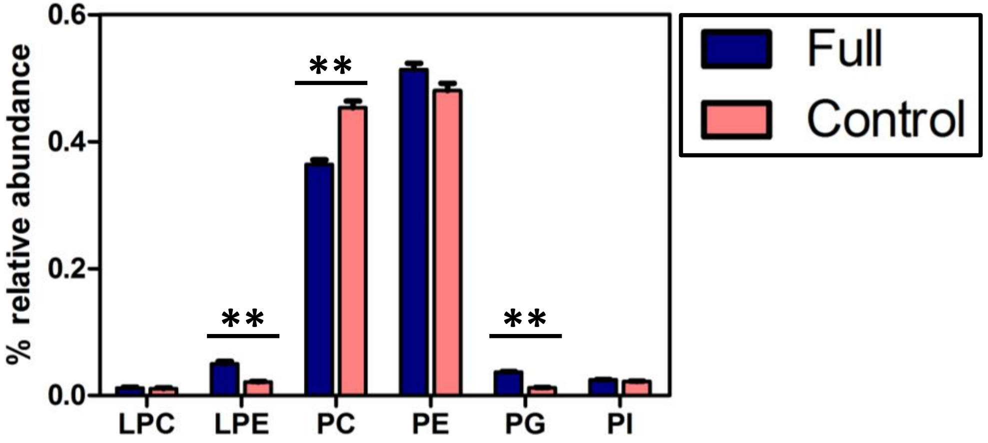

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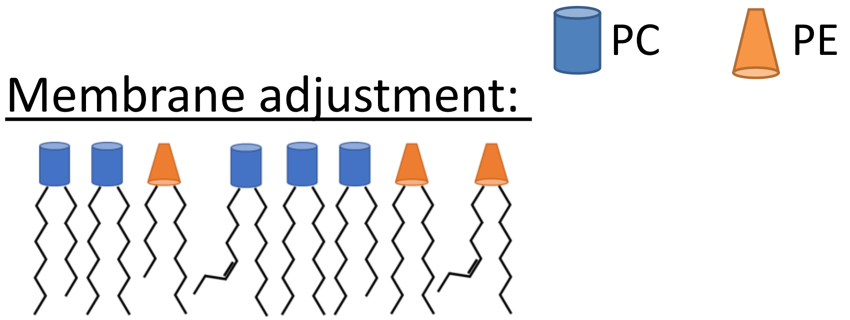

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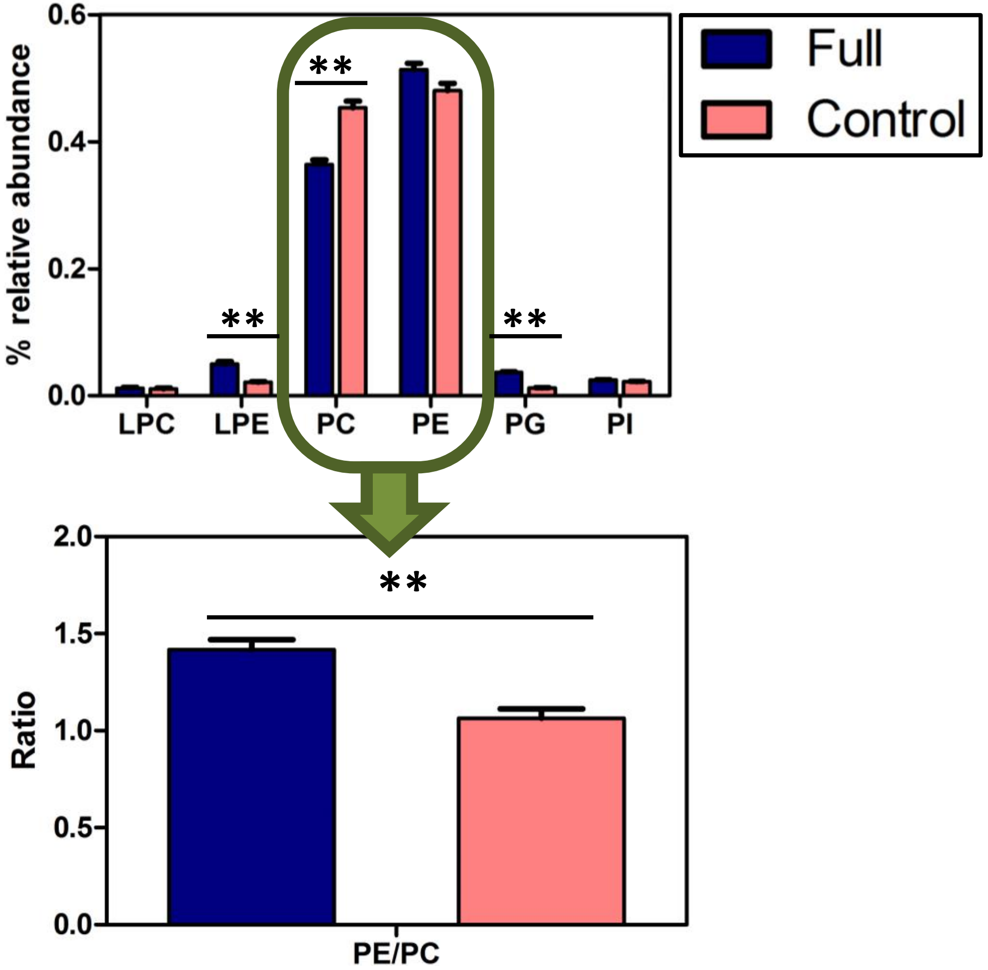

PC PE

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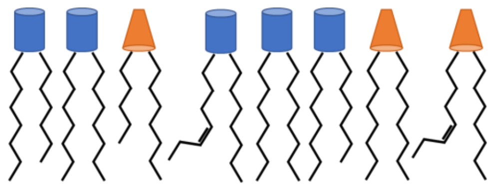

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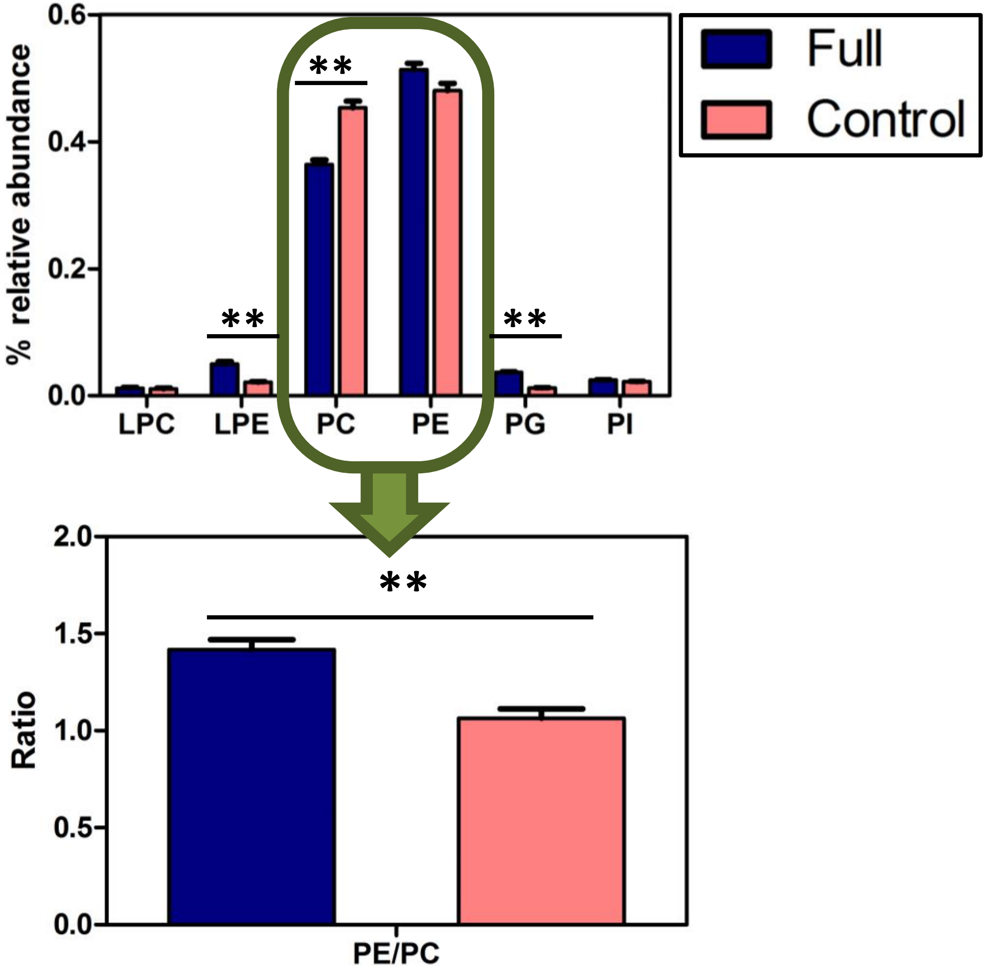

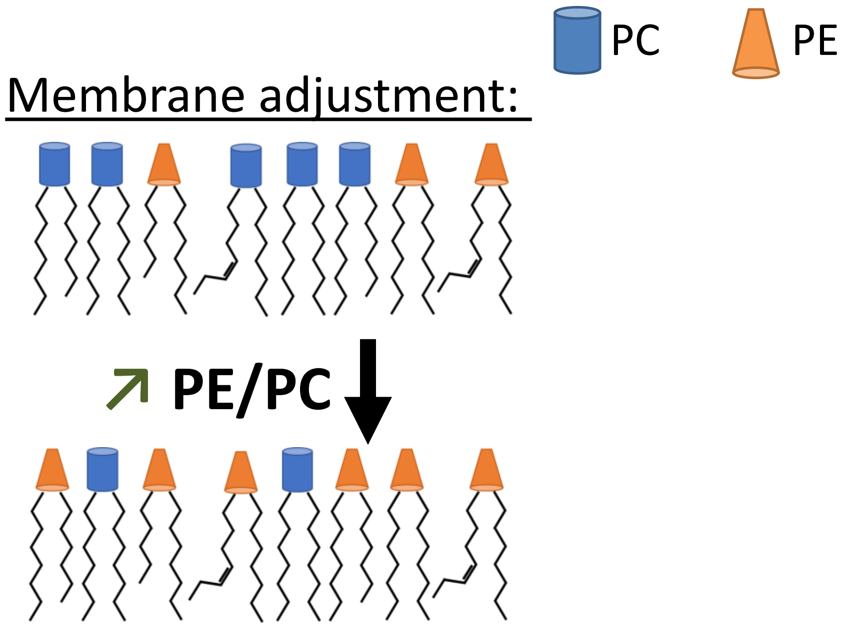

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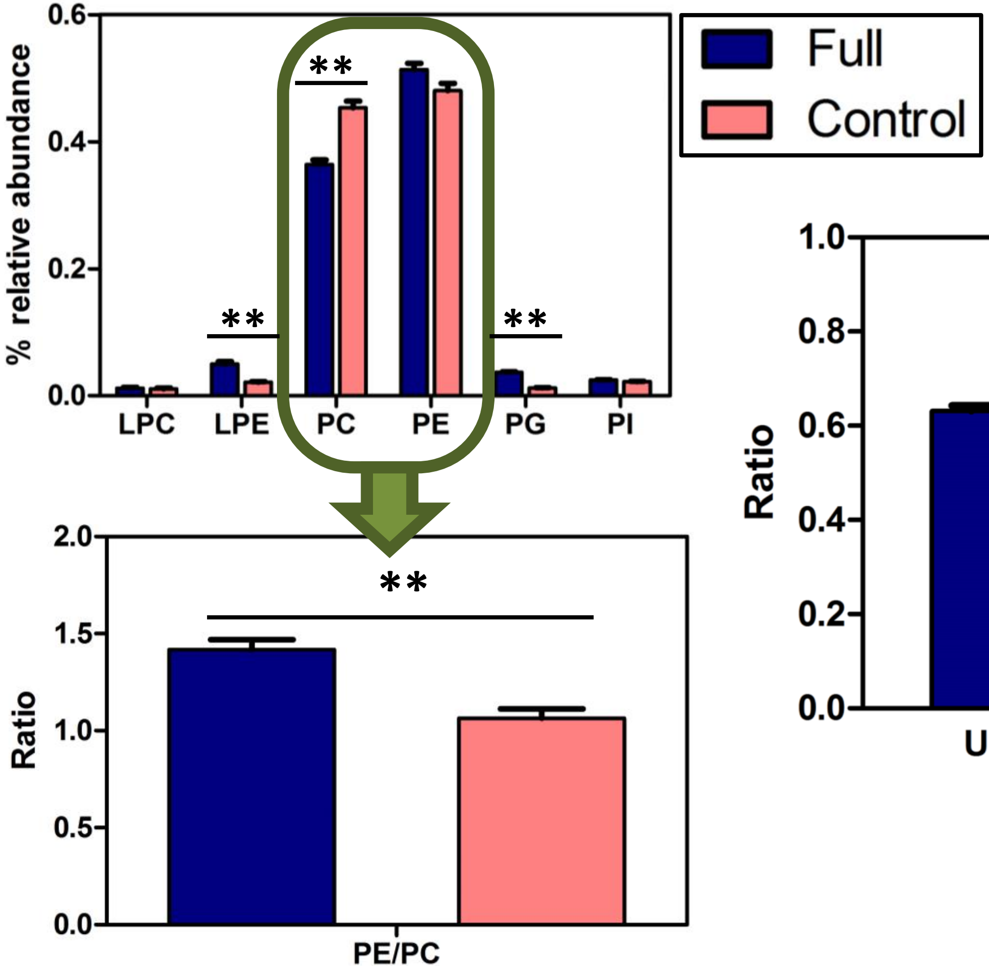
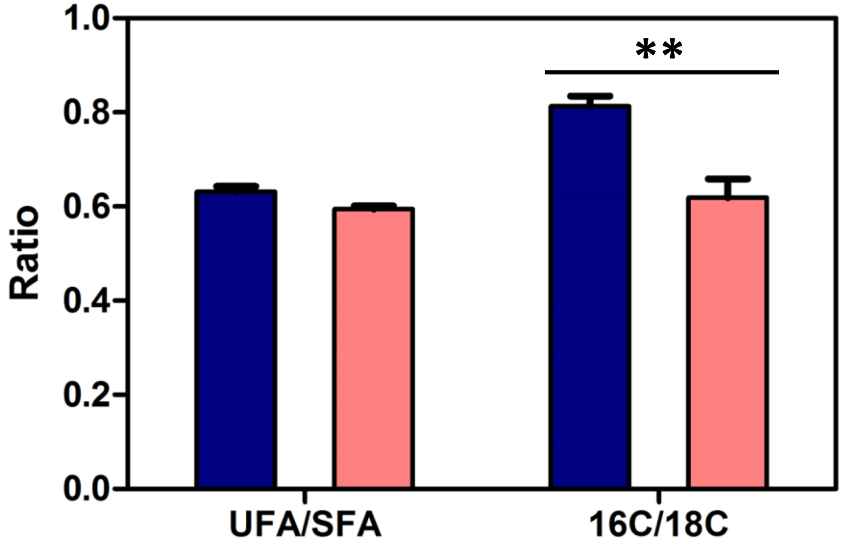
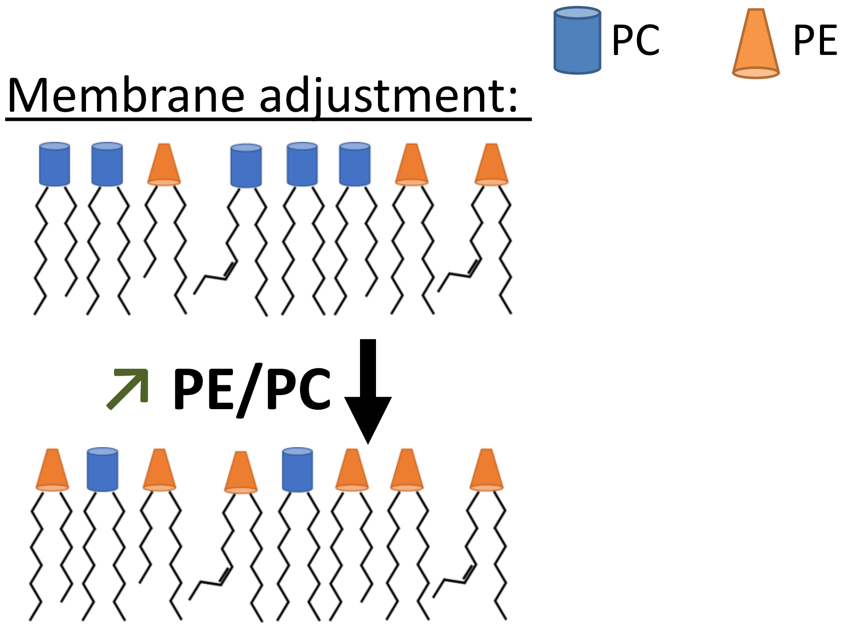
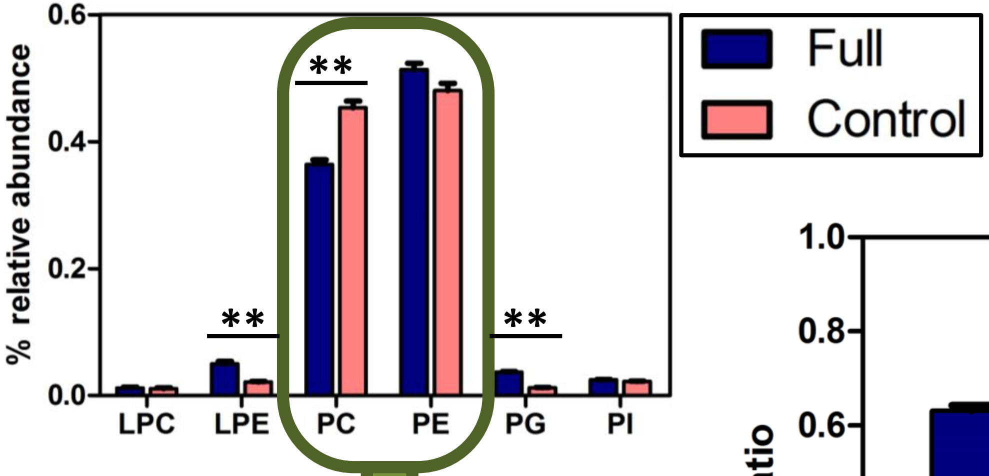


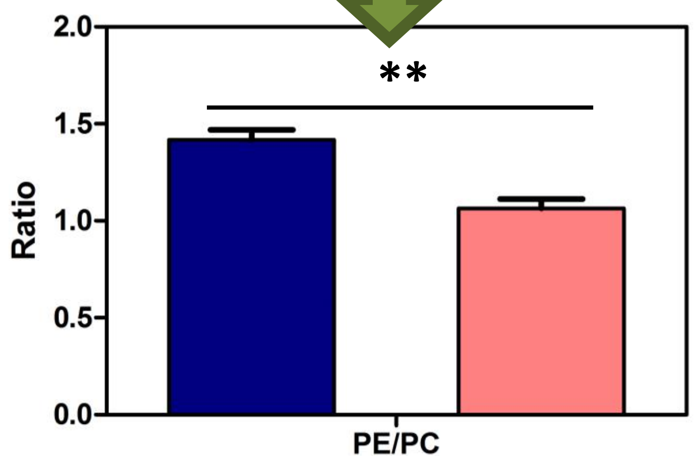


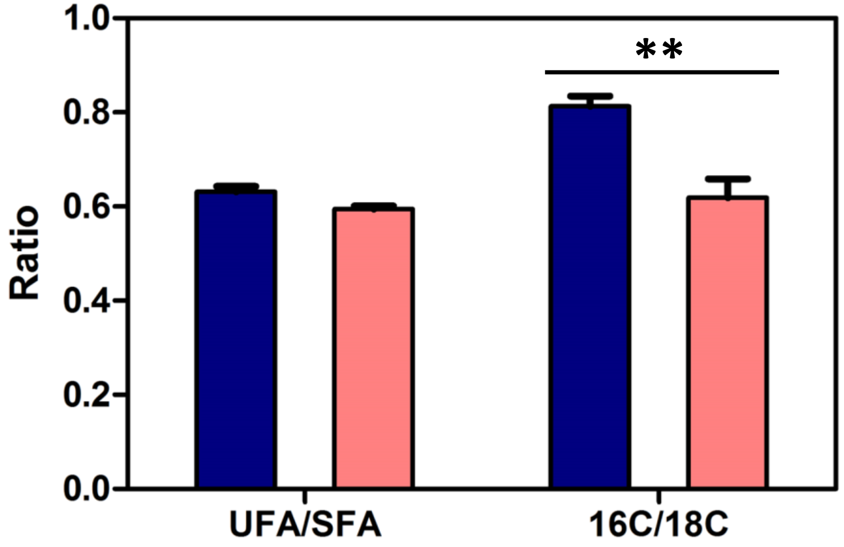


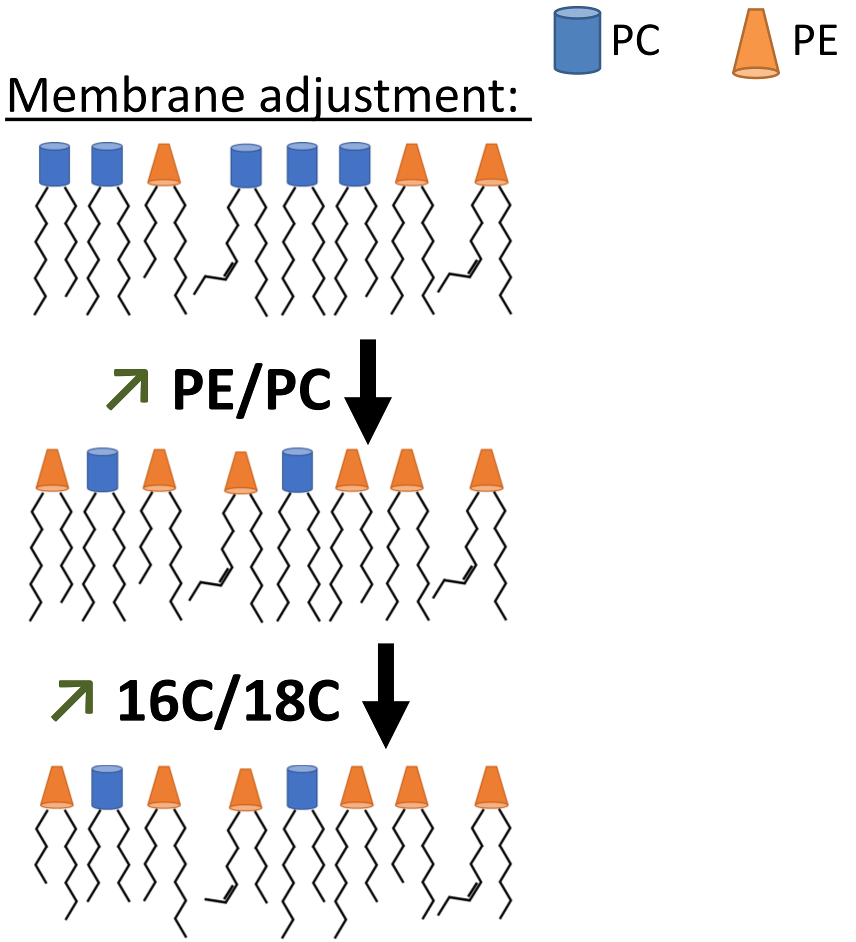
Lipidomic response

→ 275 annotated lipids from different families









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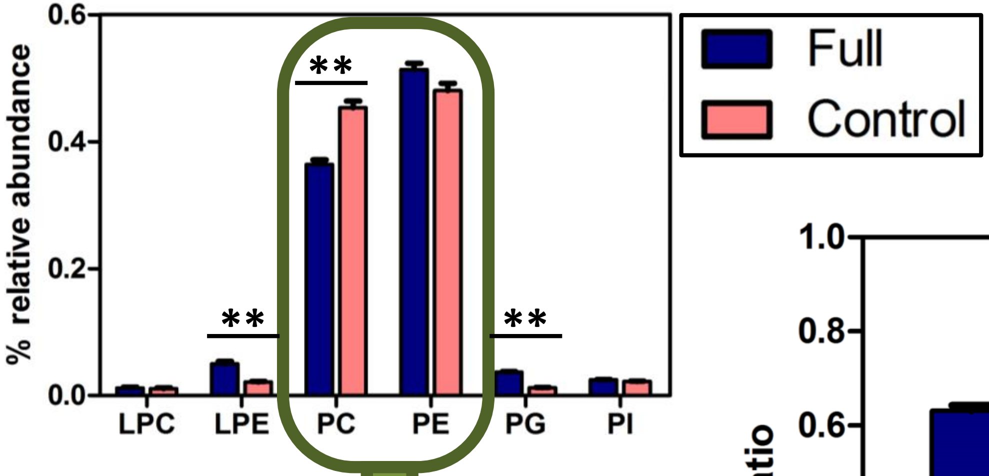
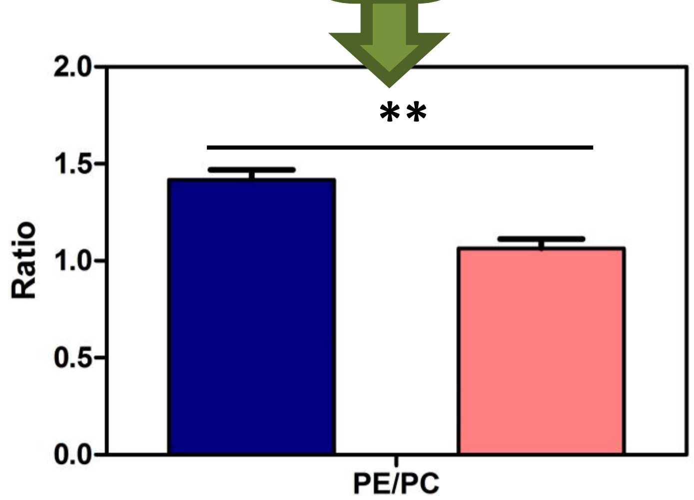
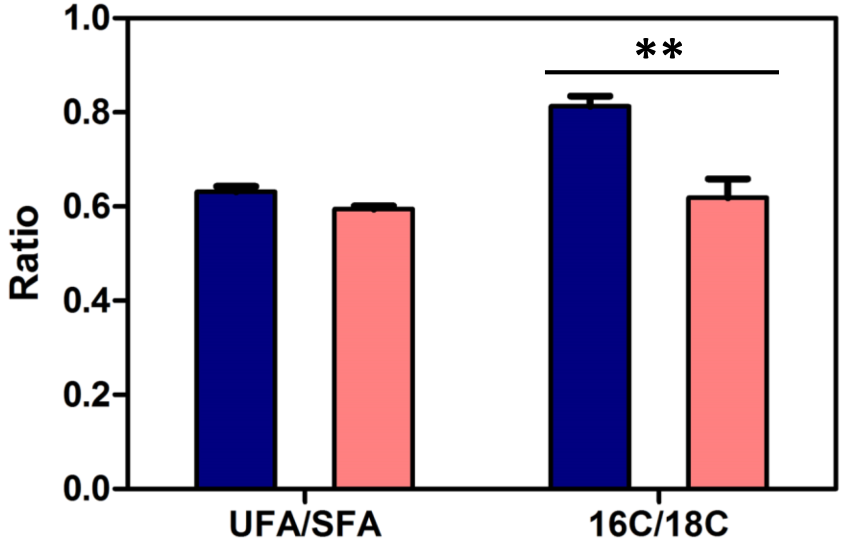
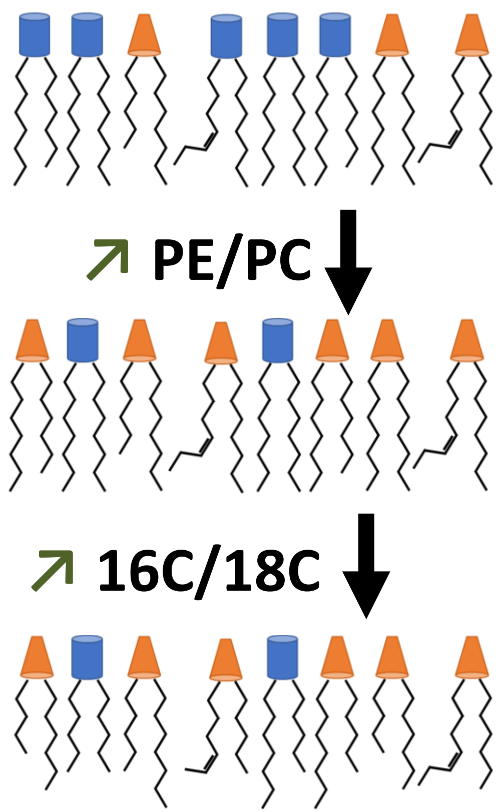






PC PE

Membrane adjustment:



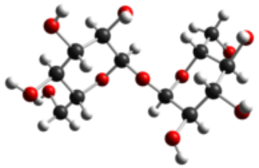
→ **Homeoviscous adaptation**

Conclusion

Changes in cold tolerance

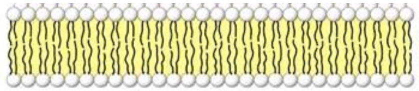
- Full acclimation ↗ cold tolerance

Metabolic response



- Sugars and amino acids accumulation
- Metabolic robustness

Lipidomic response



- Homeoviscous adaptation

Conclusion

Changes in cold tolerance

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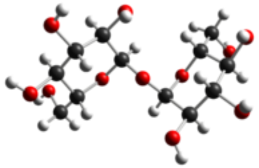

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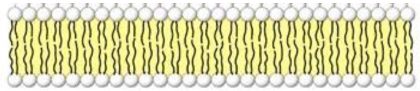
Lipidomic response



- Homeoviscous adaptation

Cold tolerance **very plastic**
Adaptive mechanisms to prevent chill effects

→ Help to explain *D. suzukii* **overwintering success**

Thank you for your attention!