Coping with climate change.

Implications of the Yellow-Bellied Marmot's (*Marmota flavivientris*) body mass evolution in the last half-century.

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2024-12-02

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Introduction

Climate change (C.C.)

- The importance of C.C. and its impact in the near future is no longer in doubt (Intergovernmental Panel On Climate Change (Ipcc) 2023)
- Broadly, C.C. is [...] (Polar melting, etc.
- Which even impact human society (e.g., winter in Ottawa isn't the same anymore: Rideau Canal ice skating future is in jeopardy, the number of days with under -20°C is expected to severly decrease in the near future, etc. (!!! + FACT CHECK everything!))
- Main/Precise impacts of C.C. in natural environments
  - **Raising T°**: Explain + study case (!!!)
  - **Changing season length**: Explain + study case (try to find something at RMBL !!!)
  - **Environmental predictibility**: Explain + study case (!!!)
  - **Drought events**: Explain + study case (!!!)
  - **Extreme weather events**: Explain + study case (!!!)
  - etc.

Ok, so, now, how does C.C. and these precise perturbations impacts concretely natural population? *Study cases* (!!!)

universal C.C. responses (C.C.)

Body size as a Life-History Traits (LHT) and expected effect of global warming

C.C. is expected to impact life history traits (LHT, i.e., traits impacting directly survival and reproduction, so individual's fitness Roff 1992).

Body mass is a LHT as in many species it has direct impact on survival and reproduction (explain + !!!)

(Daufresne et al. 2009), (Gardner et al. 2011), (Guillemain et al. 2010), (Sheridan and Bickford 2011), (Yom-Tov et al. 2008), (Ozgul et al. 2010)

And some authors argue that a decreasing body size could be one the universal C.C. response (!!!)

Because Bergmann's rules, which state that smaller body size should be expected in warmer environment as it raises the surface to volume ratio, thus favoring heat dissipation (Bergmann, C 1847).

Thus, a general shriking body size is expected with global warming. However opposite results at higher latitude yield objections of this theory and raise the need of more general study about that. Furthermore, these opposite results (i.e., increasing body mass at higher latitudes) can also been explain as C.C. is synonym to milder conditions in those latitudes. This change Allows individuals to forage more and thus gain mass.

Q.G. and animal models

(Kruuk 2004) (Charmantier et al. 2014)

LHT coevolution

Traits can't evolve alone Gould & Lewontin (1979)

Need to show that with multivariate animal model, but no one has enough power for the models (Teplitsky et al. 2014)

POLS

(Dammhahn et al. 2018)

Phenotypic plasticity vs microevolution

I * E, G * E (individual variation in their plasticity)

(Nussey et al. 2007)

Link with body mass, individual can vary in their growing speed

I * A and G * A

Species and study site

Phenological mismatch??

Chapter 1 - Mechanisms

Marmot's Biology: What mechanisms are behind the body mass increase?

Growth? Baseline? Both?

Double random (Intercept, Slope)

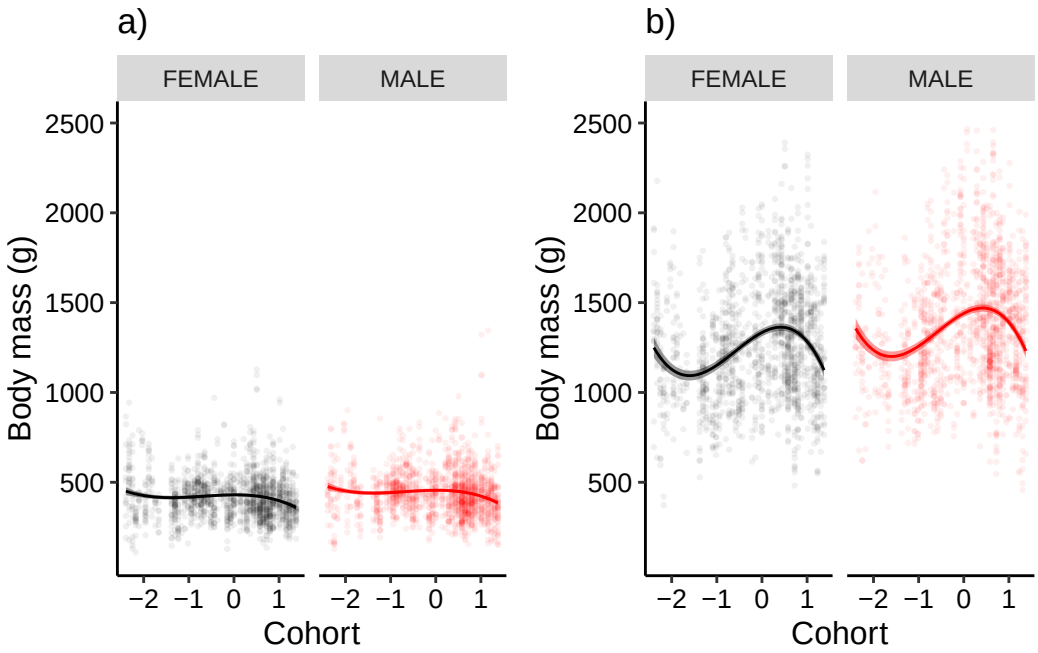

Figure 1: Body mass trend over time cohort for females (black) and males (red) juveniles compared between a) the beginning of the active season (birth weight) and b) the end of the season (mass on August 15th).

Chapter 2 - Methodology

Methodology: $I * E$ detection with double random mixed models

(Nussey et al. 2007) –> double random

So we're doing something different –> examining the residuals of the model (if I * E, still a lot of residual variance ?)

**Look at this one: (Westneat et al. 2015)

Chapter 3 - Triggers

Marmot's Biology: Which environemntal factors have triggered the phenotypic shift?

E1 - E10 (T°, Precipitation, …), Seasonal Gradient

Predators, Diet?

Chapter 4 - Implications

Marmot's Biology: What could be the implications of that for the population's future?

Manuscript models Body Mass/active season with survival

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