Effect of altitude on parasitoids and their host insects: a meta-analysis

Marc Kenis, Christelle Péré and Hervé Jactel

CABI Europe-Switzerland
INRA - Bordeaux

Project carried out in the framework of BACCARA

Climate change is known to affect the abundance and distribution of forest insects and their impact on forest productivity and ecosystems

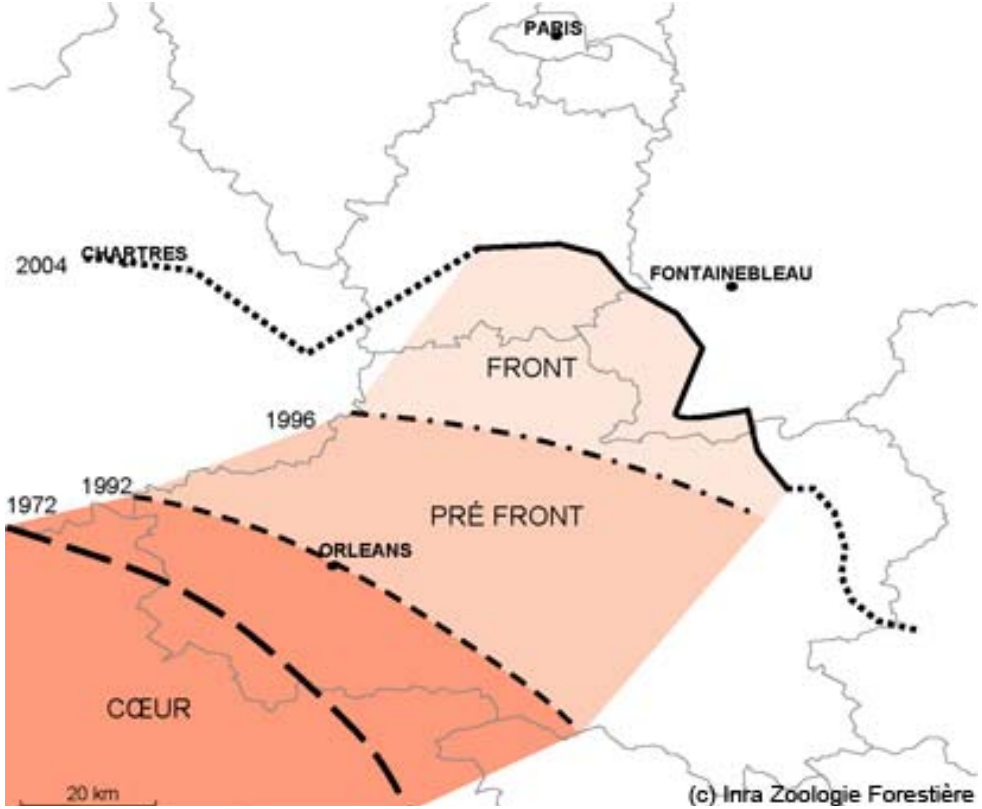
Photo: Hustvedt

Photo: USDA

These effects may be:

<u>Direct</u>, i.e. effects on the pest itself

Robinet et al. (this congress)



These effects may be:

Indirect, through effects on their host plants or their natural enemies, or disturbance of trophic interactions

Photo: Wermelinger

Photo: Svdmolen

Photo_Lindsey

Two major issues when studying the effect of climate change on insects and their natural enemies:

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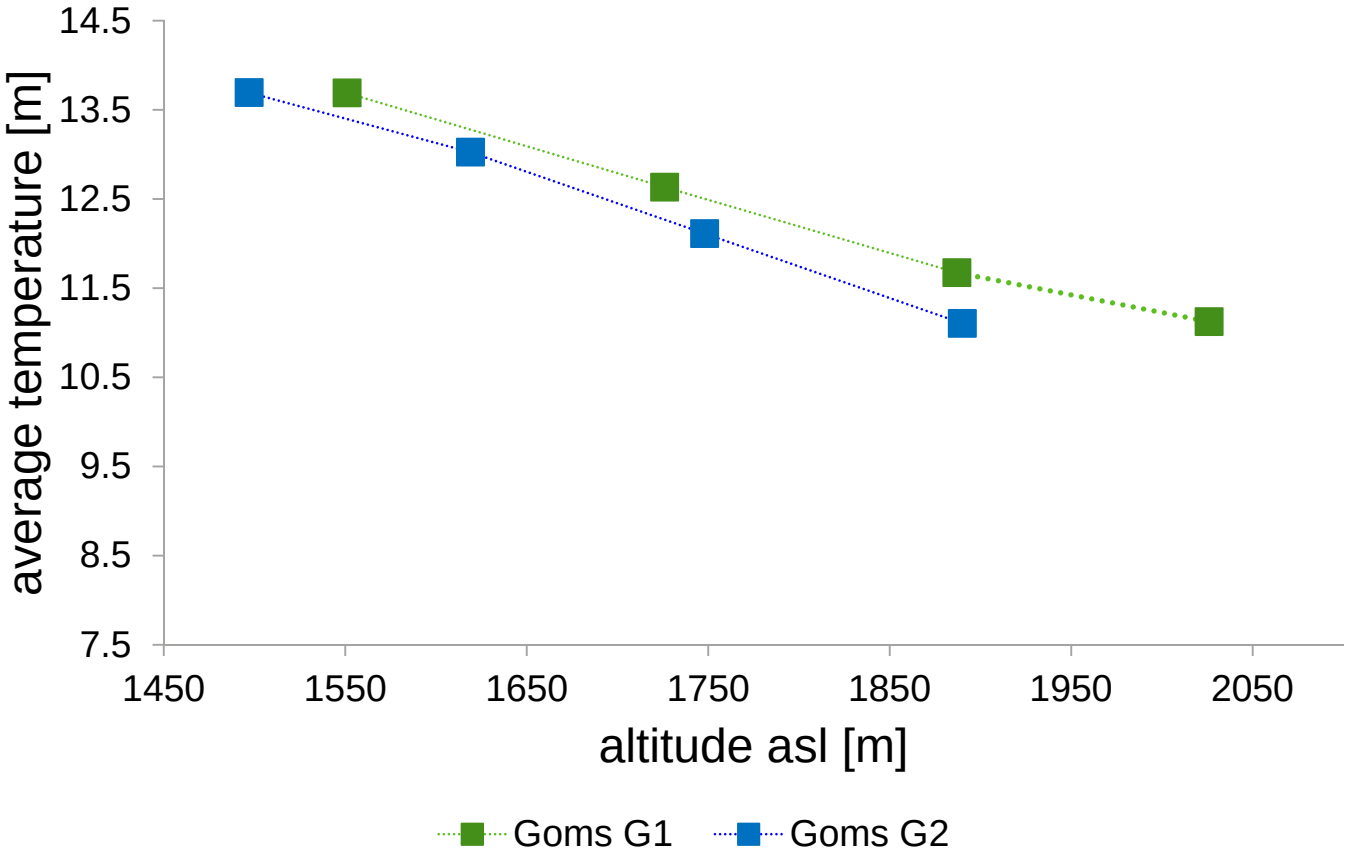
- Use the concept of functional groups
- Use altitudinal gradients as analogues of global warming



“Responses of insect species to the changing environments experienced along altitudinal gradients are diverse and widely dispersed. Such responses may serve as analogues for climate warming effects occurring at a particular fixed altitude”. (Hodkinson, Biol. Rev. 2005)

Variations of pest abundance/damage and natural enemies along altitudinal gradients in BACCARA

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- Observational and experimental studies along altitudinal gradients (Grodzki et al., Chinellato et al., Marini et al., Czwienczek et al, this congress)

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- Meta-analyses of published and unpublished data

Meta-analysis of published and unpublished studies on:

parasitism and parasitoid richness along altitudinal gradients


Photo: CABI


Photo: M. Storey

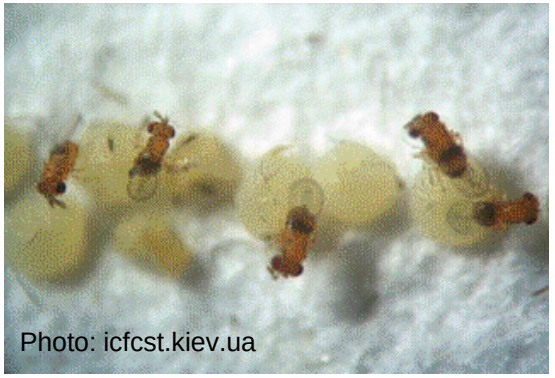
Photo: icfcst.kiev.ua


Photo: Hougardy

Photo: CABI


Photo: CABI

Meta-analysis of published and unpublished studies on:

parasitism and parasitoid richness along altitudinal gradients

Principle:

- Searching for data on parasitism rates and parasitoid richness of any insect along altitudinal gradients, in any region (at least 4 altitudes)
- Testing the effect of a gradient: r and b

$$z = \frac{1}{2}\ln\left(\frac{1+r}{1-r}\right) \quad v_z = \frac{1}{n-3}$$

$$b = \frac{\sum_{i=1}^{k} w_i b_i}{\sum_{i=1}^{k} w_i}$$

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Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Two datasets:

- Parasitism rates per parasitoid species along altitudinal gradients
  - + 150 gradients but…
  - 120 gradients with native parasitoids and hosts and natural/semi-natural ecosystems

- Parasitoid richness along altitudinal gradients
  - Same criteria, and range of species richness > 1
  - 27 gradients

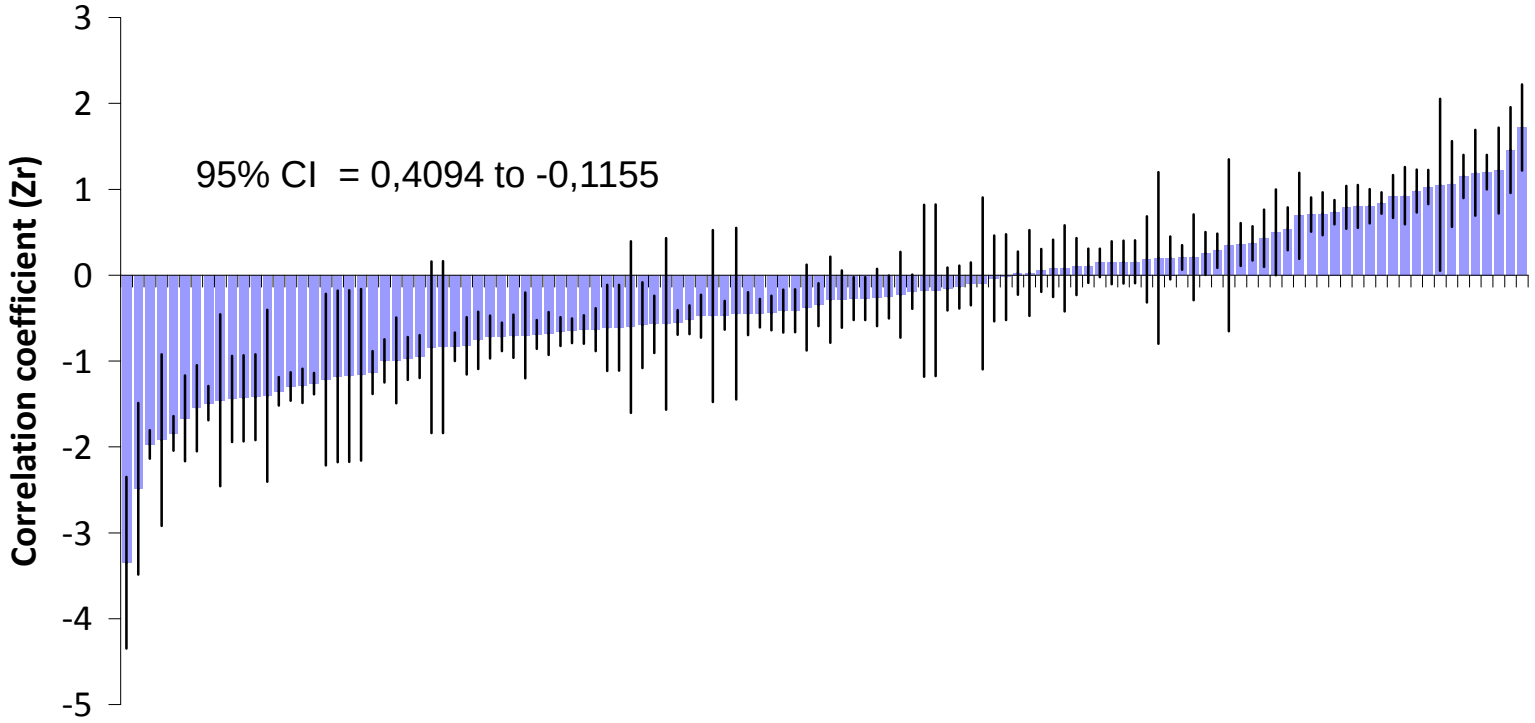
Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Covariates:

- **Host traits**: endo- vs exophagous, *feeding niches, order*
- **Parasitoid traits**: endo- vs ectoparasitoids, *specificity, taxonomy, host stage attacked, host stage killed, ….*
- **Environment**: gradient length; *temperate vs Ttopical*

Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Significant decrease of parasitism with altitude (both for r and b)



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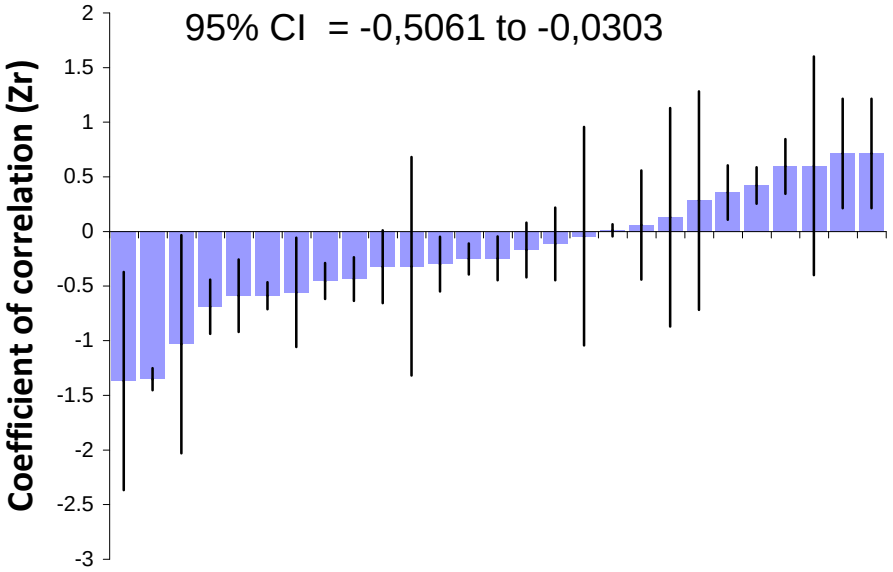


Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

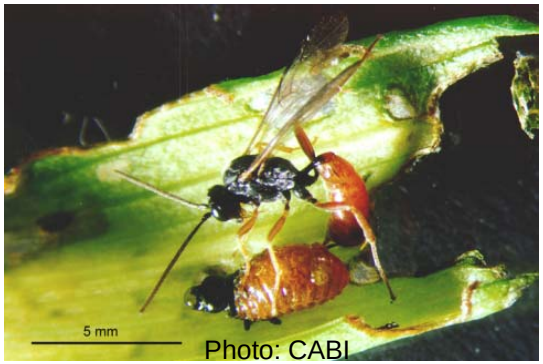
Covariate: endo- vs exophagous host

•Same significant response to altitude for parasitoids of internal vs external hosts (but r 2x higher for ectophagous)

r = - 0.19 [-0.37; -0.02]

=

P: 0.270



r = - 0.36 [-0.55; -0.16]

Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Covariate: ecto- vs. endoparasitoid :

•Same significant response to altitude (but r 2 x higher for ecto parasitoids)

r = - 0.38 [-0.57; -0.14]

=

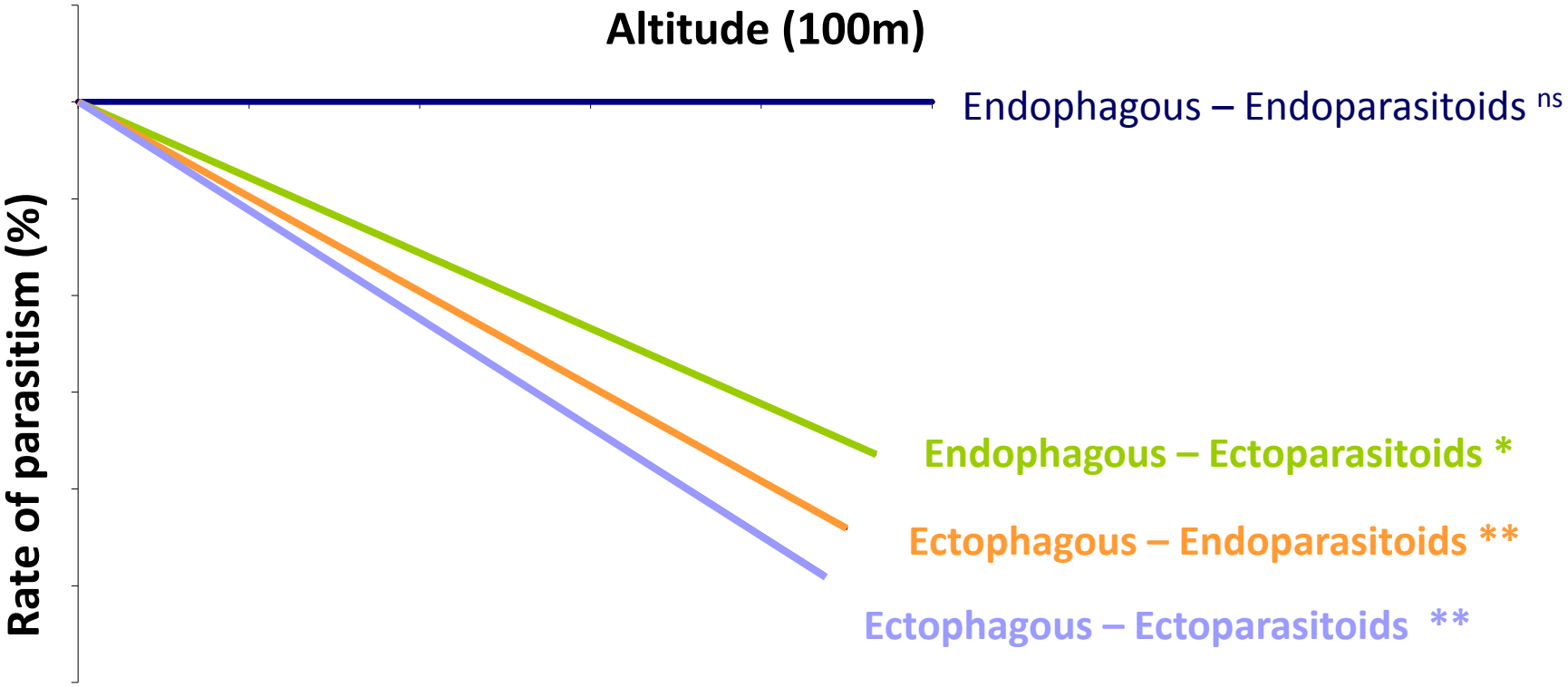
P: o.142

r = - 0.16 [-0.33; -0.01]

Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Endophagous – Endoparasitoid	r = + 0.03 [- 0.18; + 0.26]
Endophagous – Ectoparasitoid	r = - 0.33 [- 0.53; - 0.05]
Ectophagous – Endoparasitoid	r = - 0.30 [- 0.49; - 0.06]
Ectophagous – Ectoparasitoid	r = - 0.89 [- 0.99; - 0.57]

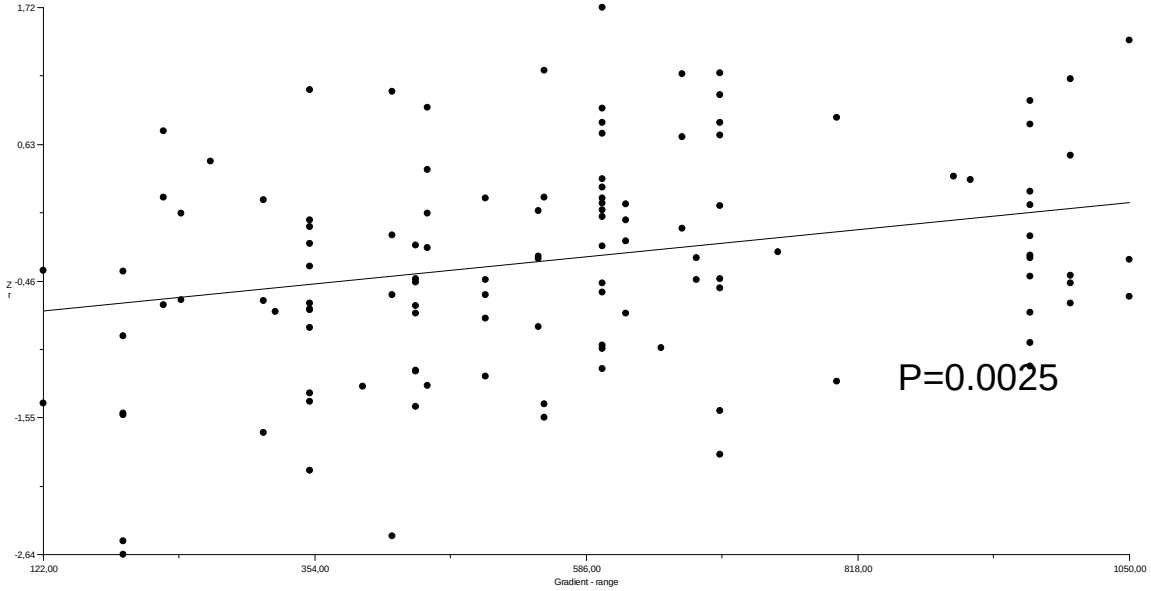
P= 0.027


Altitude (100m)
Rate of parasitism (%)
Endophagous – Endoparasitoids ns
Endophagous – Ectoparasitoids *
Ectophagous – Endoparasitoids **
Ectophagous – Ectoparasitoids **

Meta-analysis of published and unpublished studies on parasitism and parasitoid richness along altitudinal gradients

Covariate: Altitudinal gradient range:

- Shorter gradients have stronger responses to altitude



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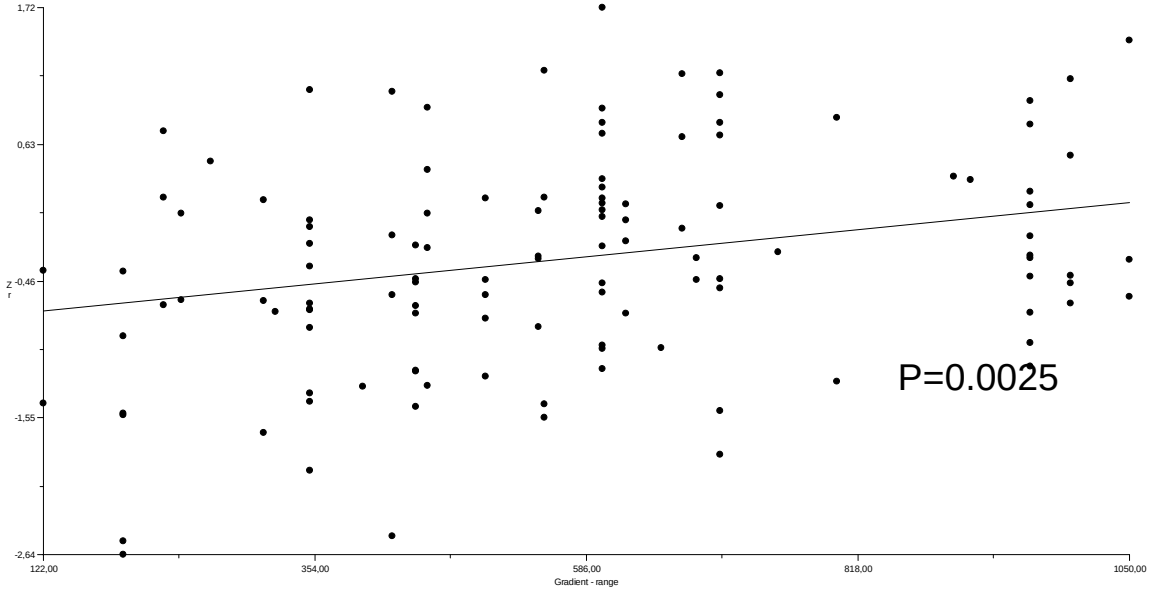

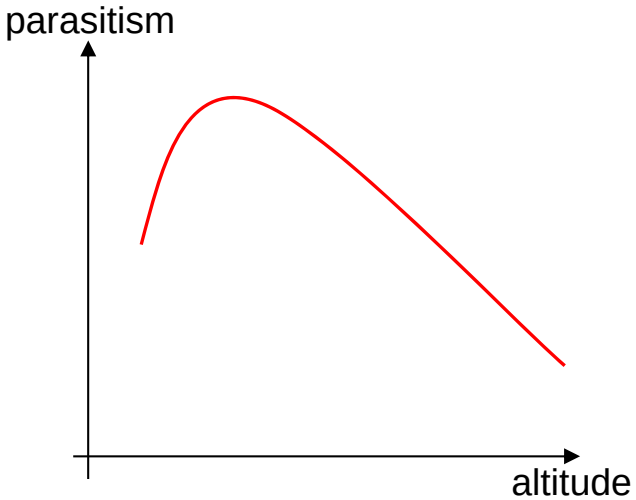

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To sum up:

- Parasitism and parasitoid richness decrease with altitude (and temperature?)

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- Due to variation in host abundance?
    - Density dependance?
    - Inverse density dependance?

Meta-analysis of published and unpublished studies on:

insect herbivore abundance/damage

Dataset:

Abundance/damage of insect herbivores along altitudinal gradients

- Data related to host plant only (no absolute data)
- Native herbivores on native plants
- Natural or semi-natural habitats
- 101 gradients
- Hypothesis: parasitism rates and parasitoid richness do not vary with altitude
- Effect size: Zr and slope

Meta-analysis of published and unpublished studies on insect herbivore abundance/damage

Covariates:

- **Host traits**: order, feeding niche, voltinism, specificity
- **Environment**: temperate/tropical; gradient length;

Meta-analysis of published and unpublished studies on insect herbivore abundance/damage

Results so far:

- **No significant effect of altitude on r or b**
- **No effect of covariates**
- **Results still preliminary**
- **Non-linear regressions**

Conclusions

- Parasitism and parasitoid richness decrease with altitude
- Decrease more important for ectophagous hosts and ectoparasitoids (Protection? Specificity?)
- Herbivory by insects does not vary with altitude (decrease of parasitism not due to density-dependence relationship)
- Implication for global warming?

Thank you for your attention

This work was supported by the EU project BACCARA