Climate change and elevational range shifts: evidence from insects in Sierra Nevada and Alps

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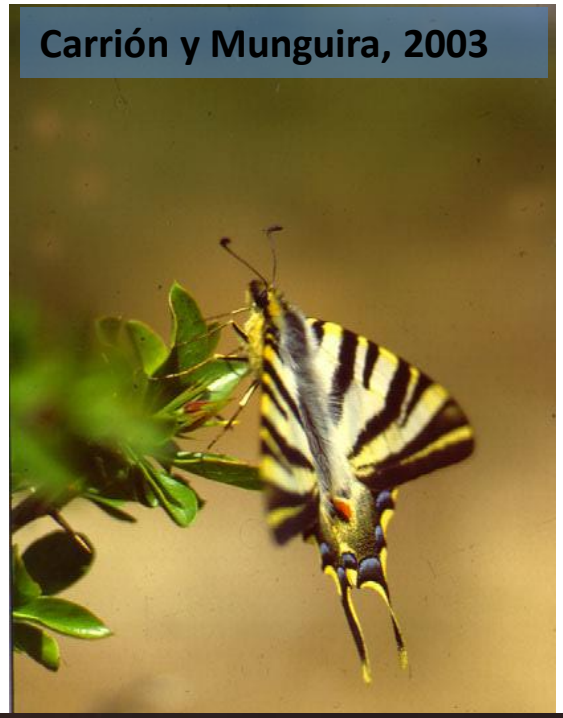
INSECTS OF SIERRA NEVADA

KNOWN SPECIES: 3,663

ENDEMIC SPECIES: 280

Ruano, Tierno Figueroa and Tinaut, 2013

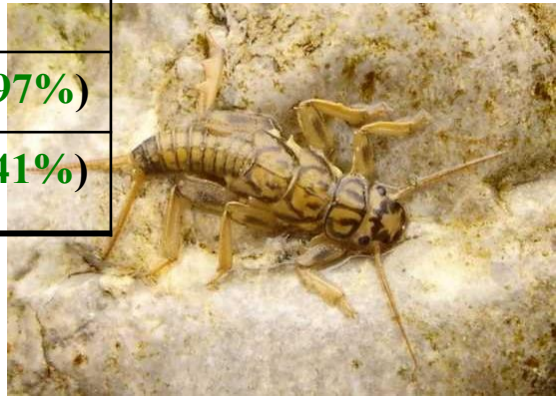
INSECTS OF SIERRA NEVADA



INSECTS OF SIERRA NEVADA

Sierra Nevada species represent 53% of the Andalucian species and 33% of the Spanish species

ORDEN	IBERIAN PENINSULA	ANDALUCIA	SIERRA NEVADA
Efemeroptera	**146**	**76 (52%)**	**42 (28%; 55%)**
Odonata	**78**	**65 (83%)**	**23 (29%; 35%)**
Dermaptera	**30**	**13 (43%)**	**8 (27%; 61%)**
Ortoptera	**329**	**180 (55%)**	**71 (22%; 39%)**
Plecoptera	**139**	**52 (37%)**	**22 (16%; 42%)**
Mantodea	**14**	**9 (64%)**	**??**
Neuroptera	**169**	**100 (59%)**	**97 (57%; 97%)**
Tricoptera	**389**	**103 (27%)**	**42 (11%; 41%)**



INSECTS OF SIERRA NEVADA

Known species

35,987 species in the Iberian Peninsula (Ortuño and Martínez-Pérez, 2011)

18,630 insect species in Andalucia (Tinaut and Pascual, 2004-2006)

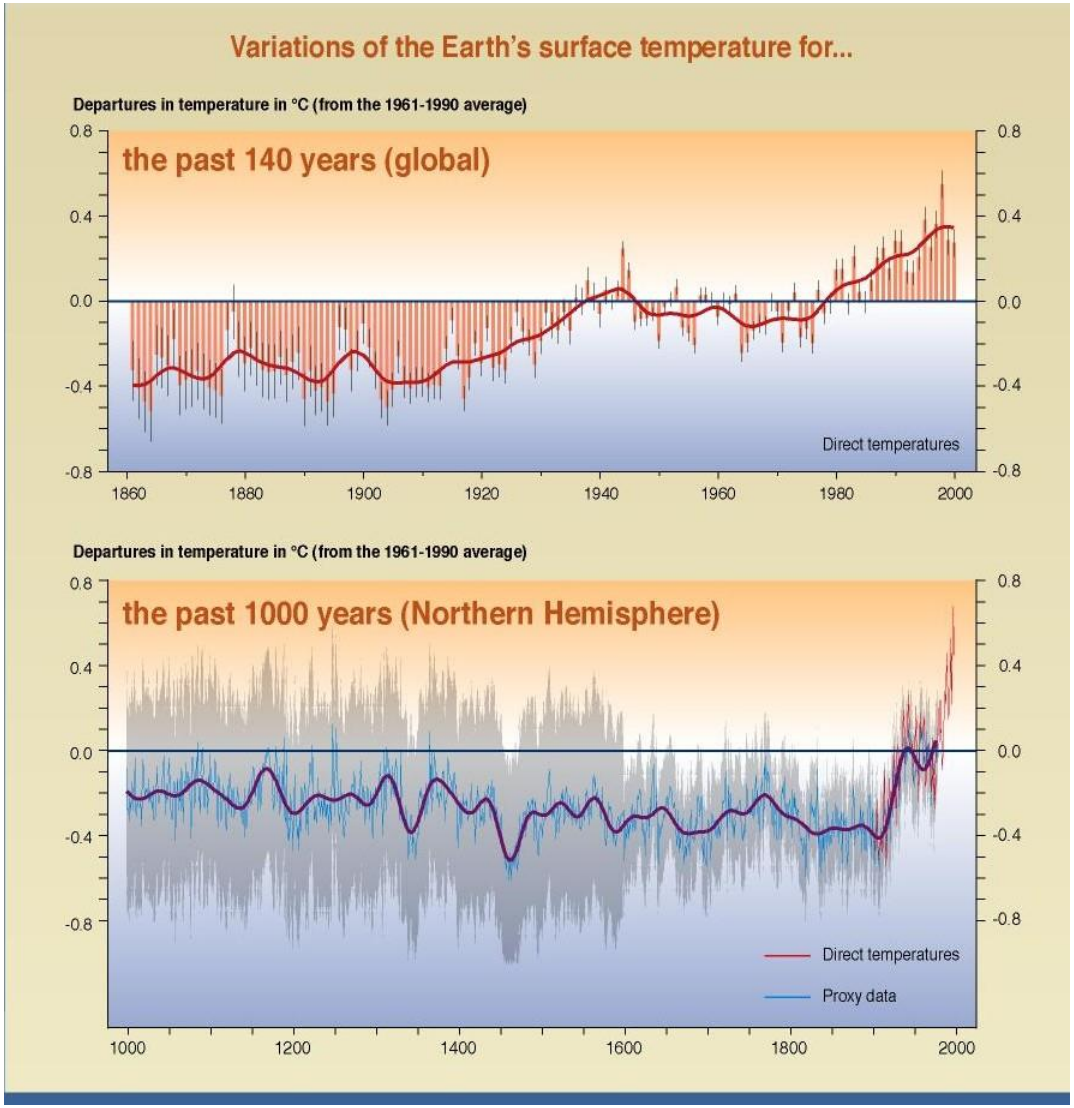
IN SIERRA NEVADA:

KNOWN SPECIES: 3,663

ENDEMIC SPECIES: 280

11,875 potential insect species
In Sierra Nevada

The Earth is heating up

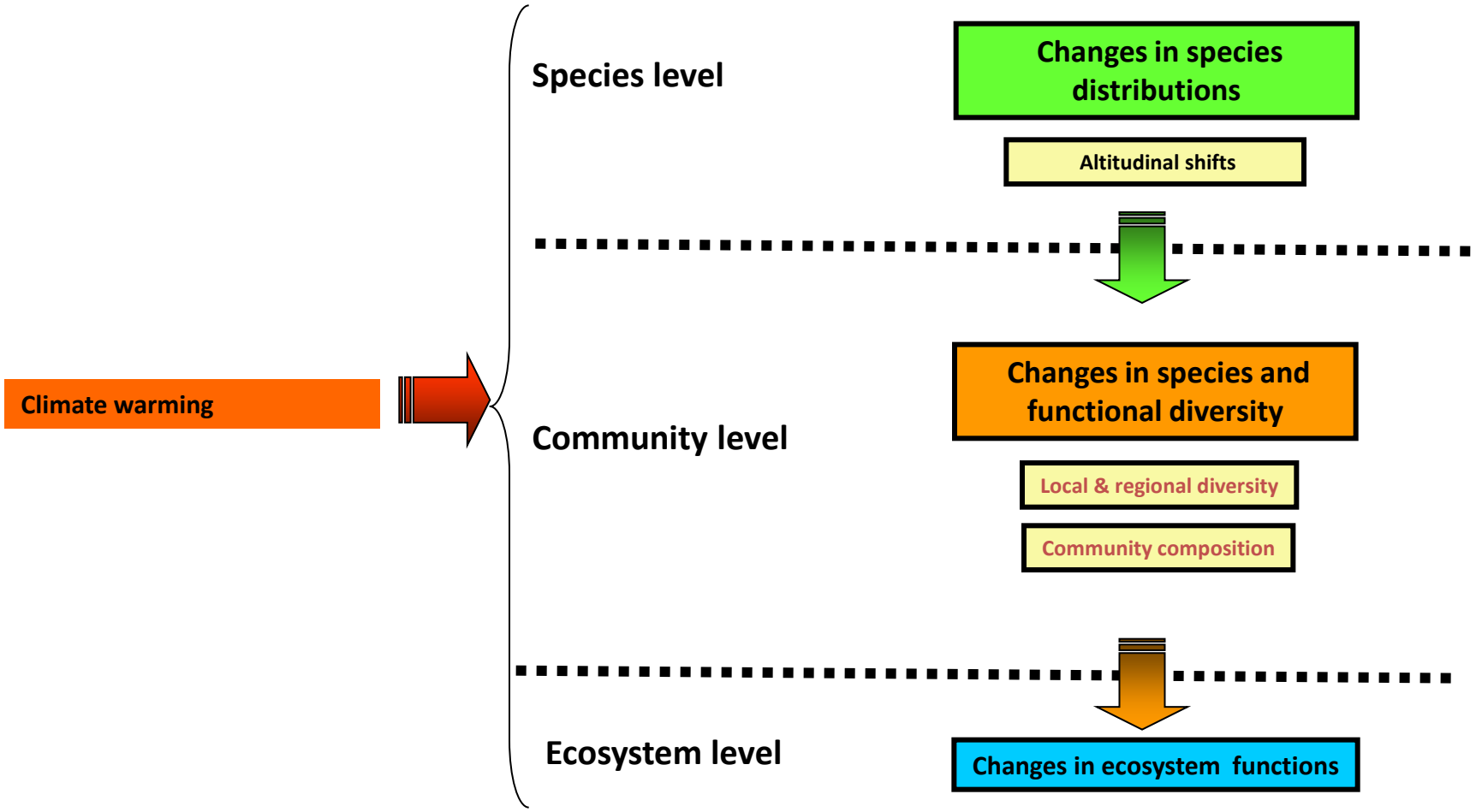


Global average surface temperature has increased by 0.6 ºC during the past century.

The rate and magnitude of warming during the 20th century has been the largest of the millennium.

IPCC 2001

Understanding the effect of climate change on biological systems: from the species to the ecosystem level.

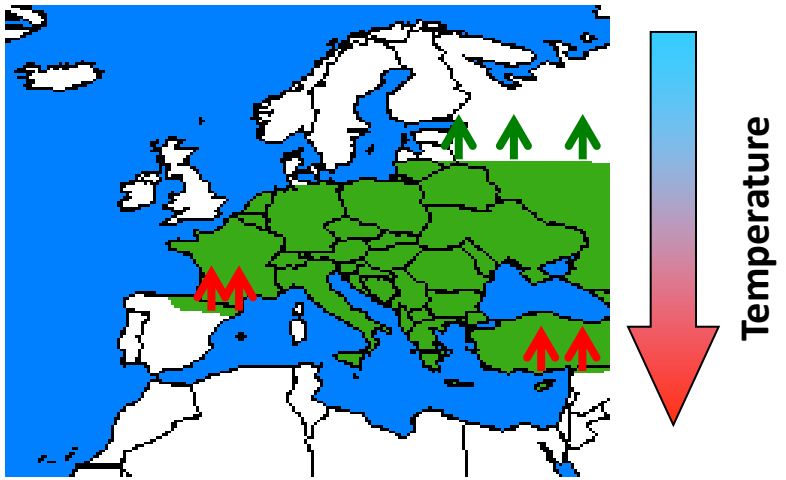


Distributional changes: predictions

Geographic range

Expansions towards poles

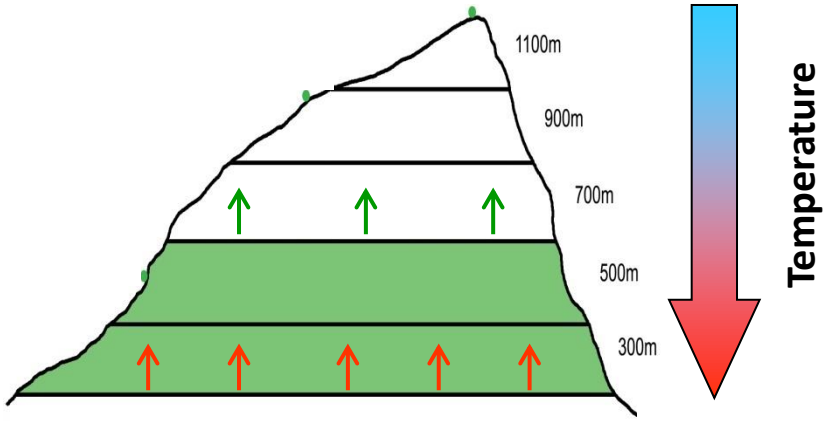
Contractions at the warm limit



Altitudinal range

Expansions towards higher elevations

Contractions at lower elevations



Why study dung beetle?

- Diverse group and easy to survey.
- Baseline information available from several mountain regions in Europe.
- Evidence of species range constrain by climate.
- Play crucial roles in natural and farmland ecosystems.

Where?

Southern French Alps

Sierra Nevada

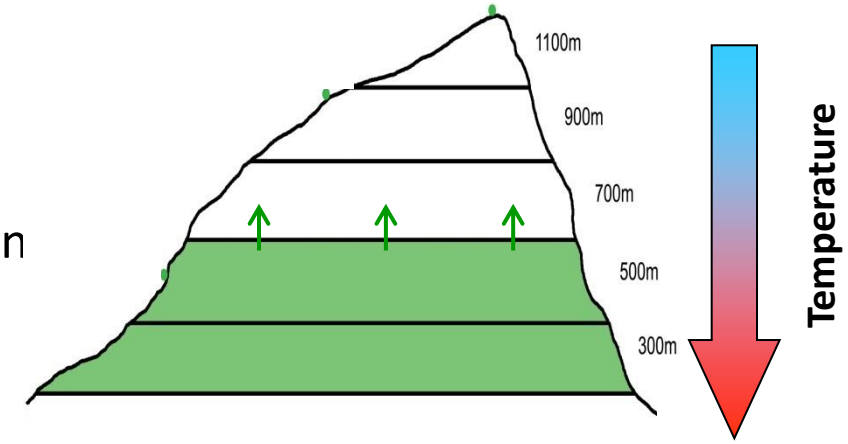
Altitudinal range:	600-2300m	800-2500 m
Previous survey:	14 years	25 years
Sampling sites:	36	36 (18)

Distributional changes: predictions

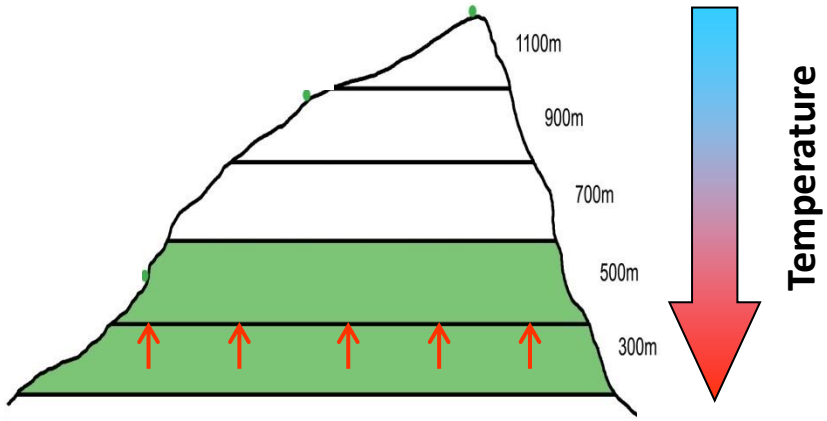
Both mountains: Uphill shifts in species elevation range due to a increase in Tª

Altitudinal range

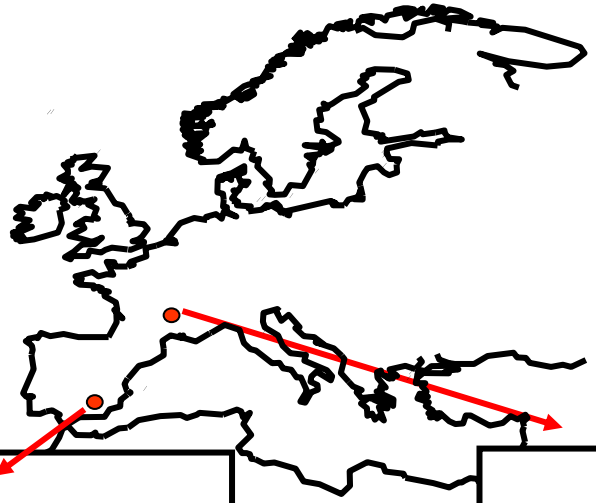
1) Expansions towards higher elevations: In south western Europe. Most species Mediterranean. No specialist.



2) Contractions at lower elevations: In north-western Europe. Dominated by central and north European species. Specialist.



Dung beetles as the model system



Sierra Nevada

Dung beetles richness: 65 sp.

Mainly Mediterranean sp. (44.5 %). No specialist.

1.2 – 1.3 ºC warming between periods at low and mid elevation.

S Alps

Dung beetles richness: 55 spp.

Only a few Mediterranean. With specialist.

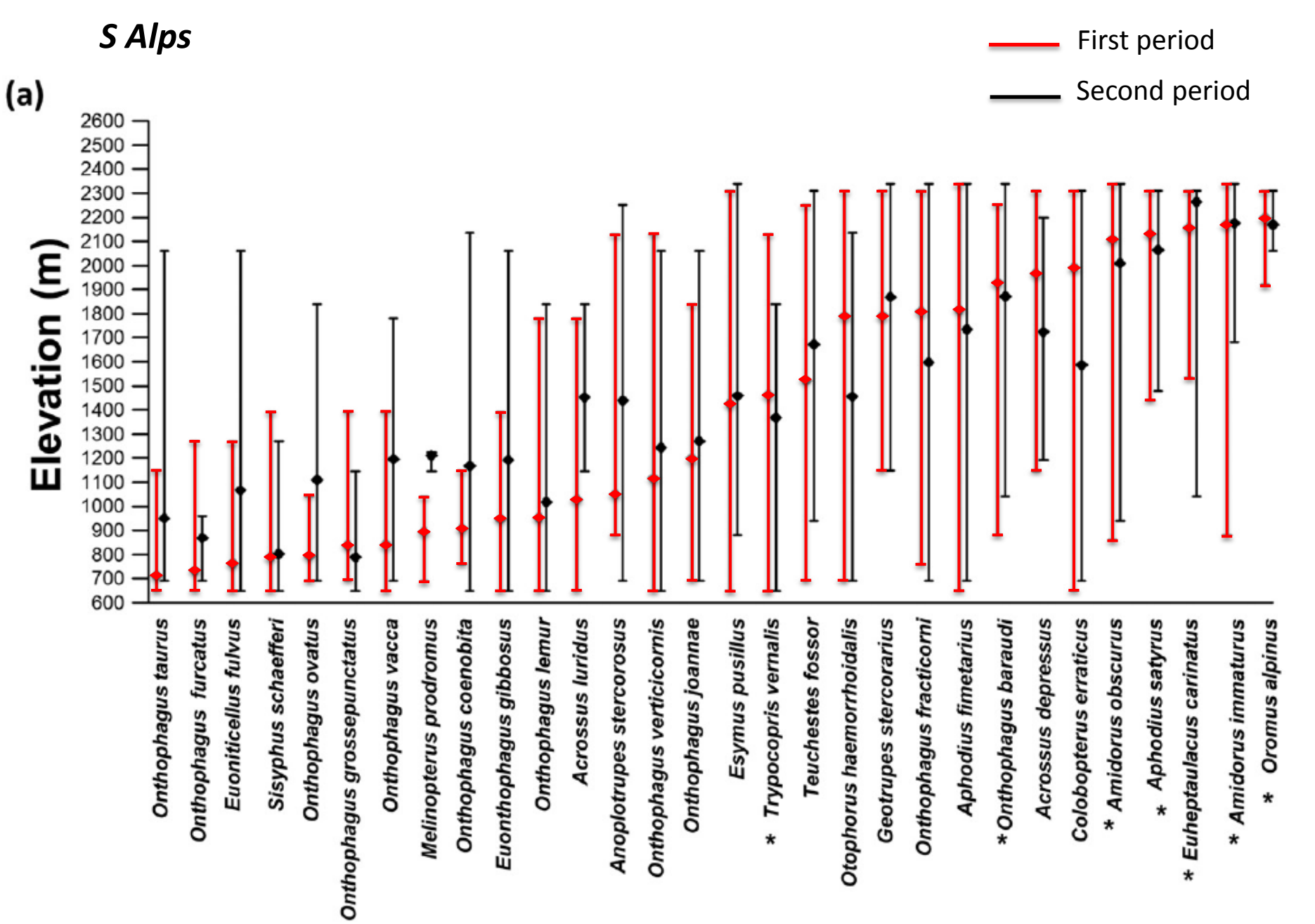
0.8 – 0.9 ºC warming between periods at low and mid elevation.

If species are tracking temperature increases……

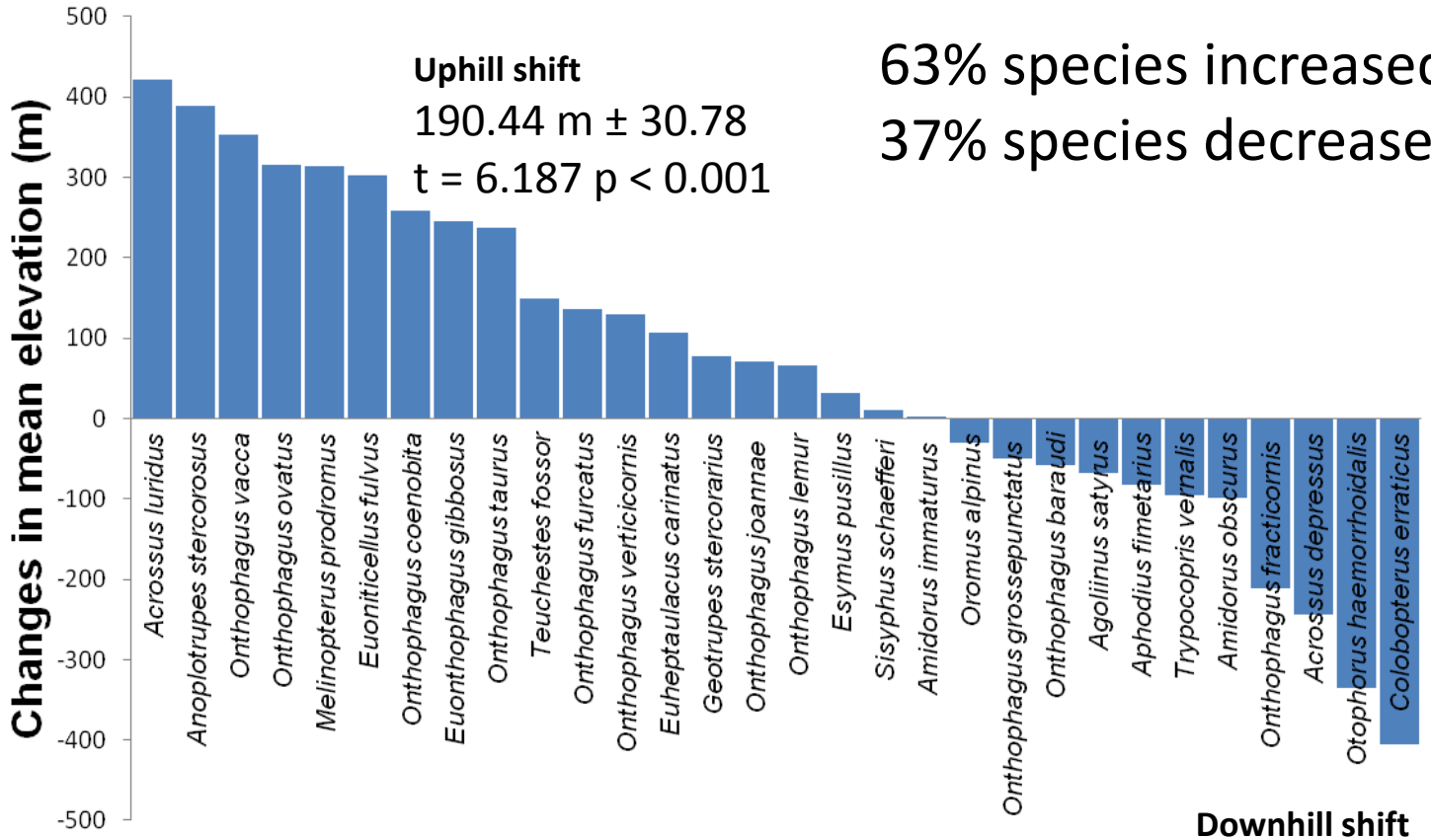
197-213 m up-slope

154-173m up-slope


Southern Alps, France


S Alps
(a)
First period
Second period
Elevation (m)
2600
2500
2400
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
Onthophagus taurus
Onthophagus furcatus
Euoniticellus fulvus
Sisyphus schaefferi
Onthophagus ovatus
Onthophagus grossepunctatus
Onthophagus vacca
Melinopterus prodromus
Onthophagus coenobita
Euonthophagus gibbosus
Onthophagus lemur
Acrossus luridus
Anoplotrupes stercorosus
Onthophagus verticicornis
Onthophagus joannae
Esymus pusillus
* Trypocopris vernalis
Teuchestes fossor
Otophorus haemorrhoidalis
Geotrupes stercorarius
Onthophagus fracticorni
Aphodius fimetarius
*Onthophagus baraudi
Acrossus depressus
Colobopterus erraticus
* Amidorus obscurus
* Aphodius satyrus
* Euheptaulacus carinatus
* Amidorus immaturus
* Oromus alpinus

Changes in Mean elevation



Uphill shift

190.44 m ± 30.78

t = 6.187 p < 0.001

63% species increased

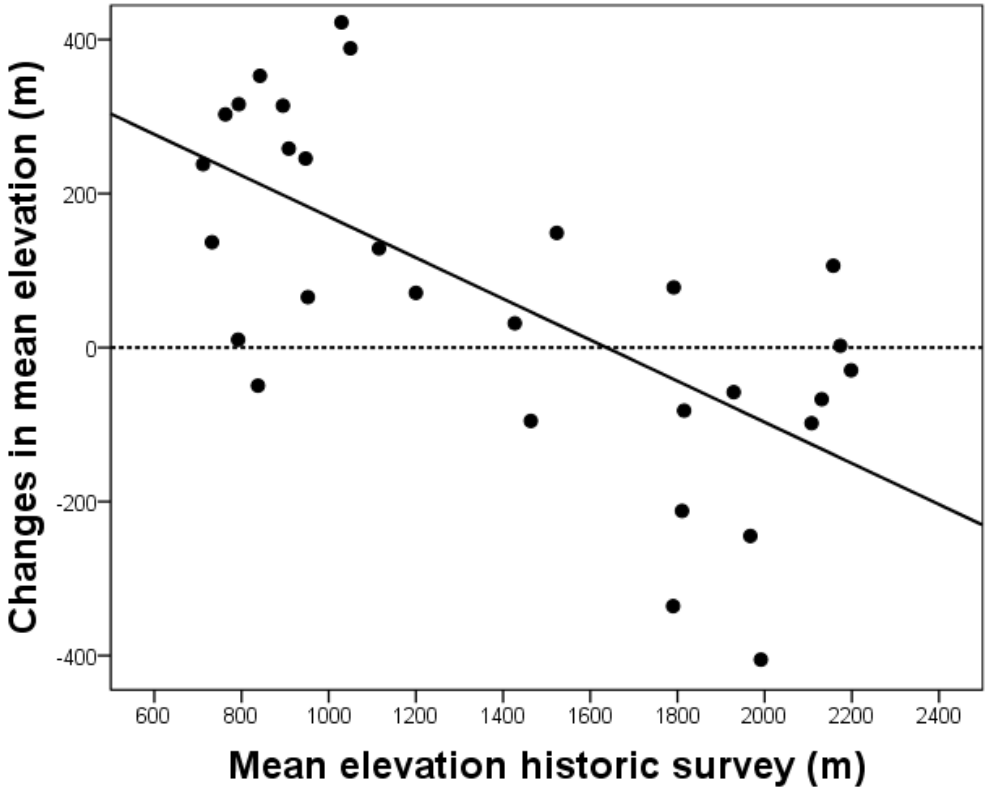
37% species decreased

Downhill shift

152.44 m ± 38.45

t = -3.965 p = 0.003

Changes in Mean elevation



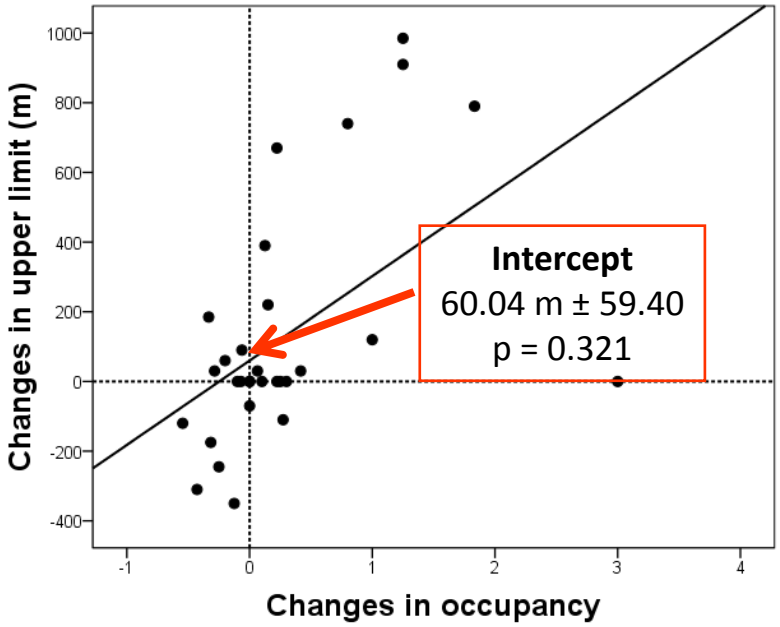
Lowland species showed uphill shift.

Upland species showed downhill shift .

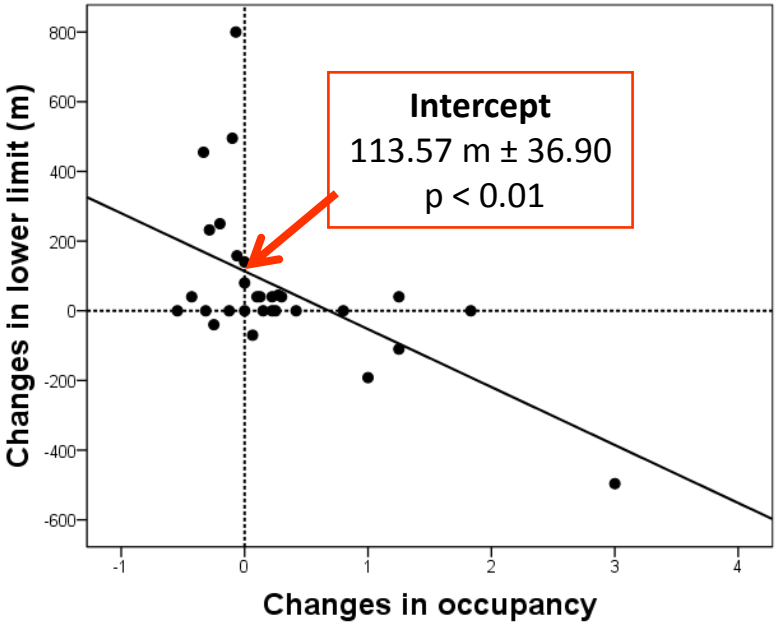
$R^2 = 0.46$, $F_{1,28} = 23.895$, $p < 0.001$

Are changes consistent with Climate Change?

Upper limit



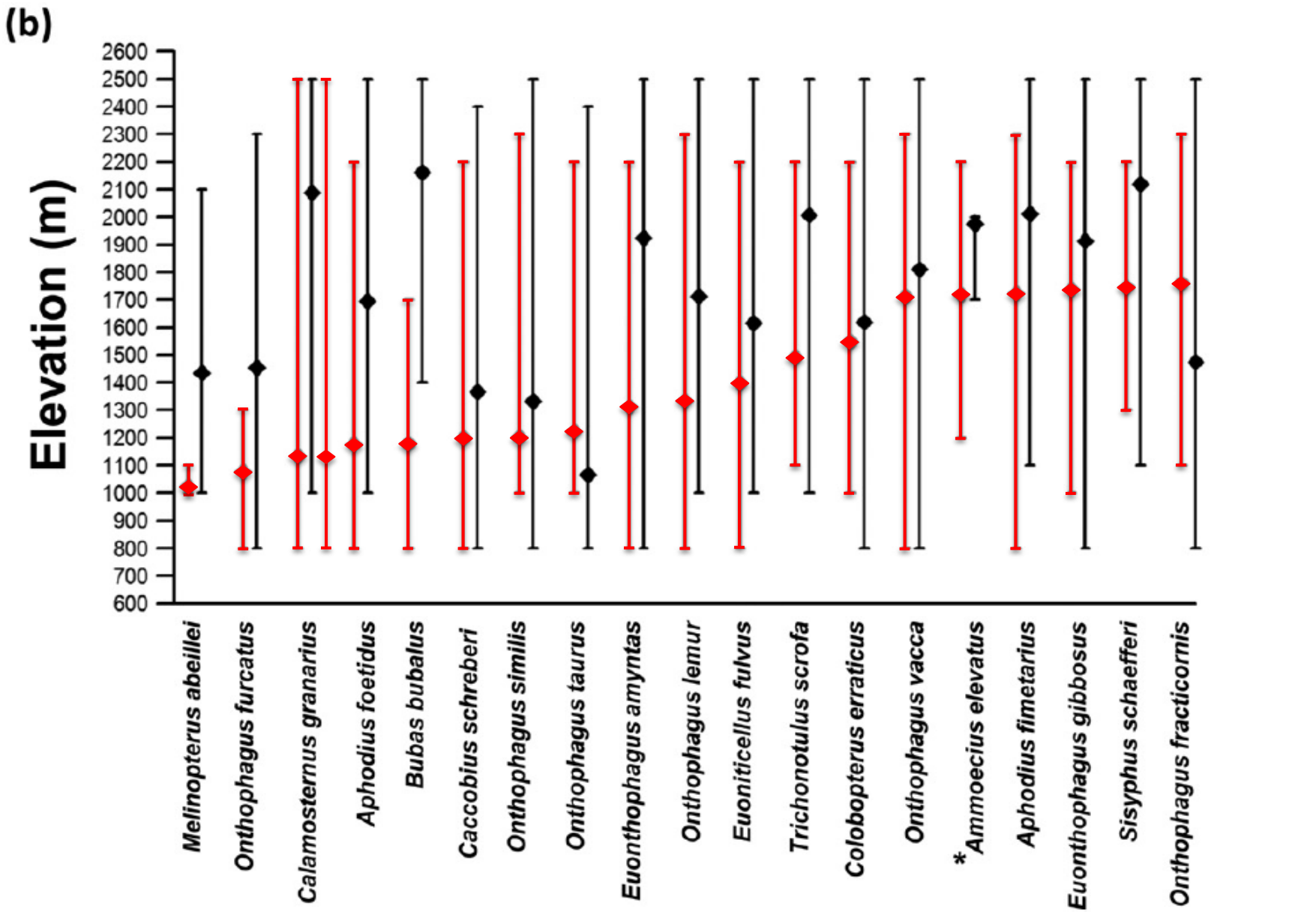
Lower limit



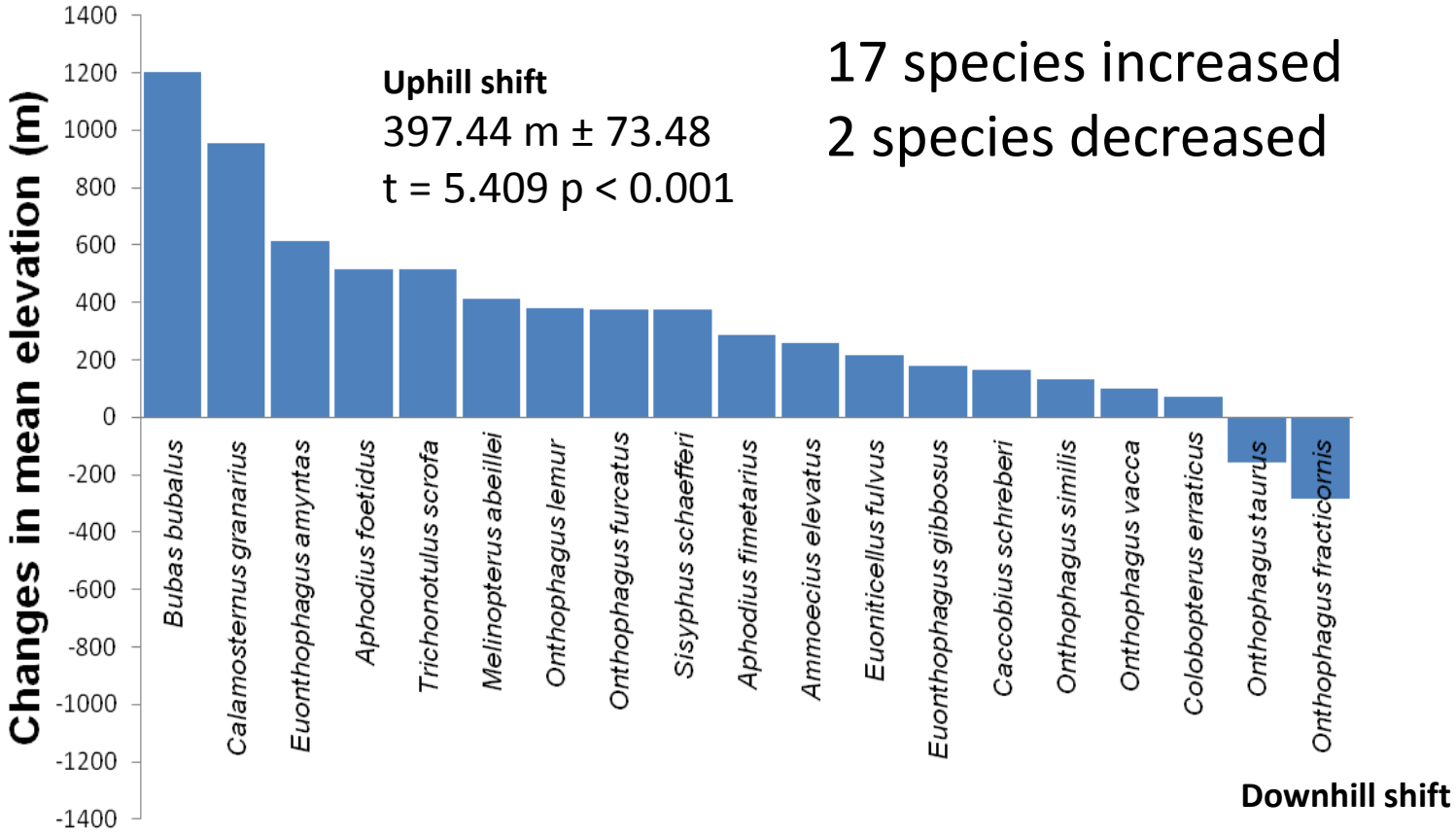
0.9 °C increase in temperature ~= 173 m


Sierra Nevada, Spain

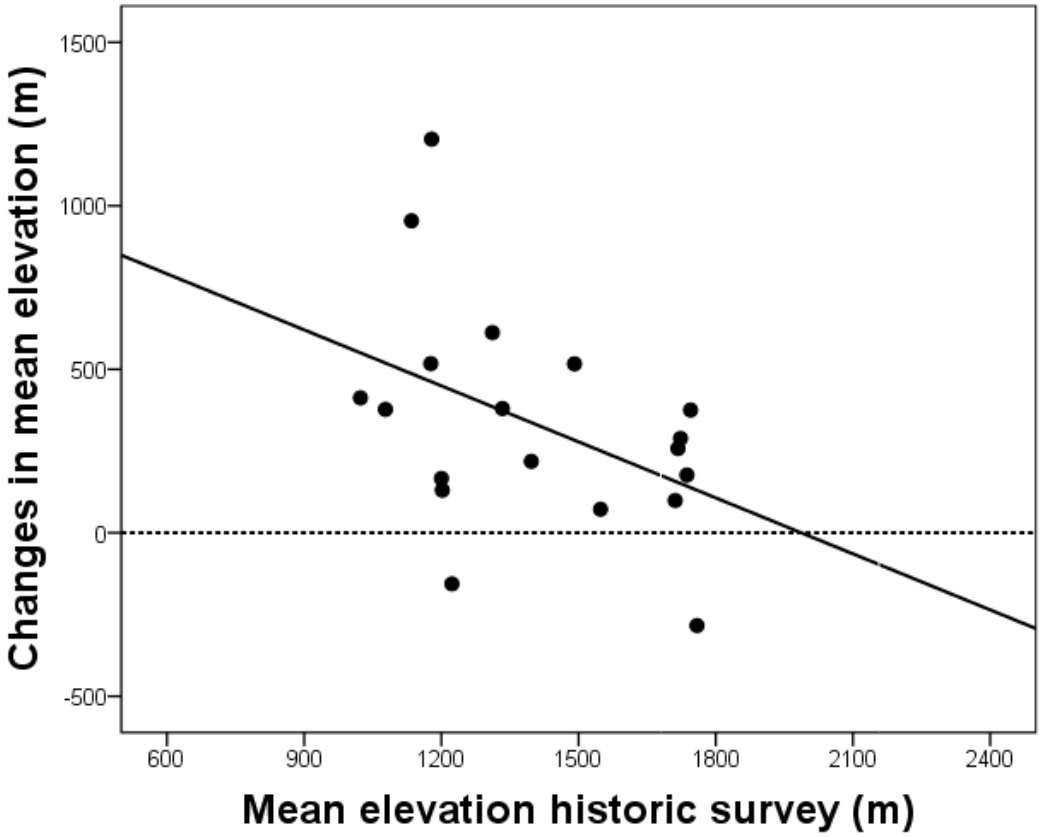
Sierra Nevada



Changes in Mean elevation



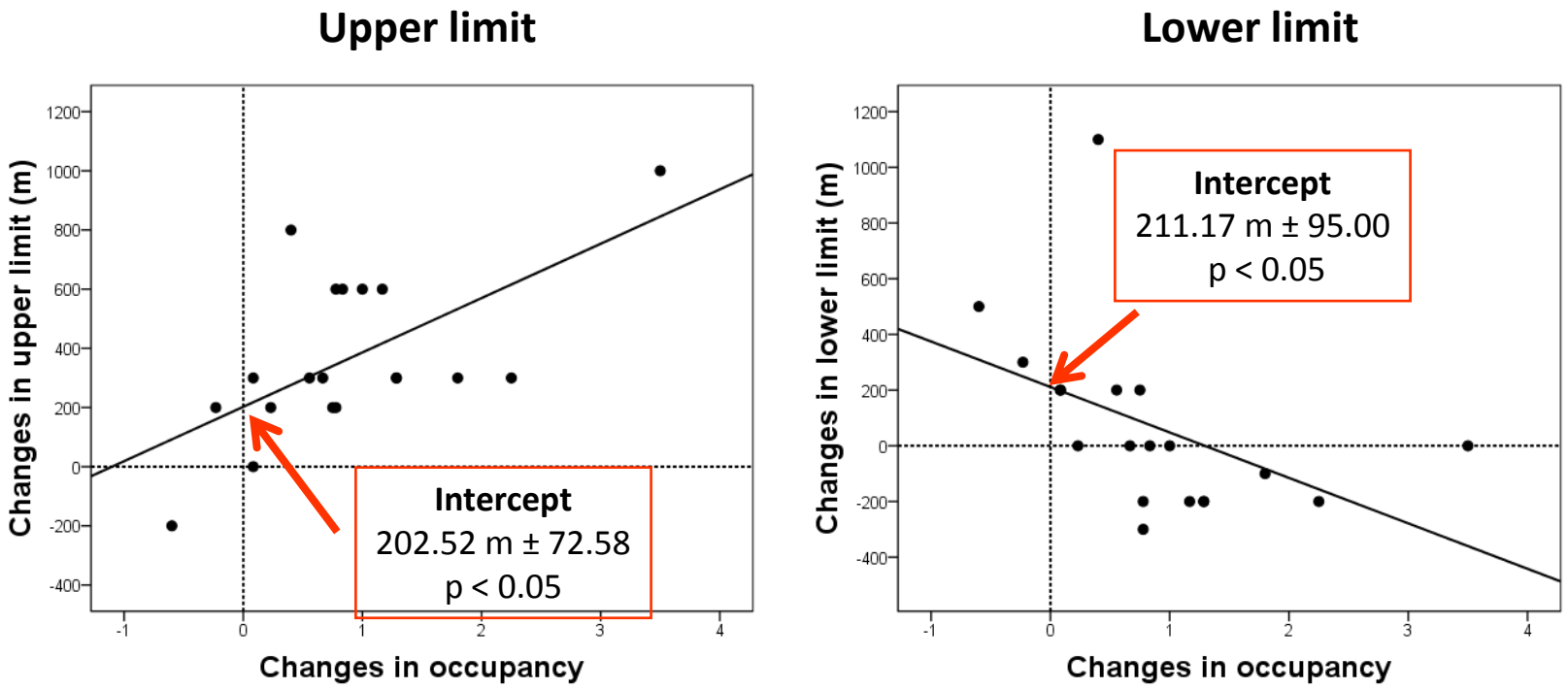
Changes in Mean elevation



Both lowland and upland species showed uphill shift.

$R^2 = 0.14$, $F_{1,17} = 3.879$, $p = 0.065$

Are changes consistent with Climate Change?



1.3 °C increase in temperature ~= 213 m

Conclusions

✓ Species have moved towards higher elevations in the two mountain areas, consistent with the increase in temperature.

✓ Species shifted their altitudinal ranges by range expansions at the upper limits in Alps and Sierra Nevada but also by range contractions at the lower lower limit in Sierra Nevada.

✓ Some species showed downhill expansion indicating that other factors as well as climate constrain species altitudinal ranges.

✓It is importance of considering both the biogeography of the mountain and the species pool when assessing the sensitivity of species to future climate change in mountain regions.

This work is a collaboration :

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Pierre Jay-Robert
Jean-Pierre Lumaret — Université Montpellier 3, France.

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