

How insects survive in mountains?

A behavioural and physiological perspective

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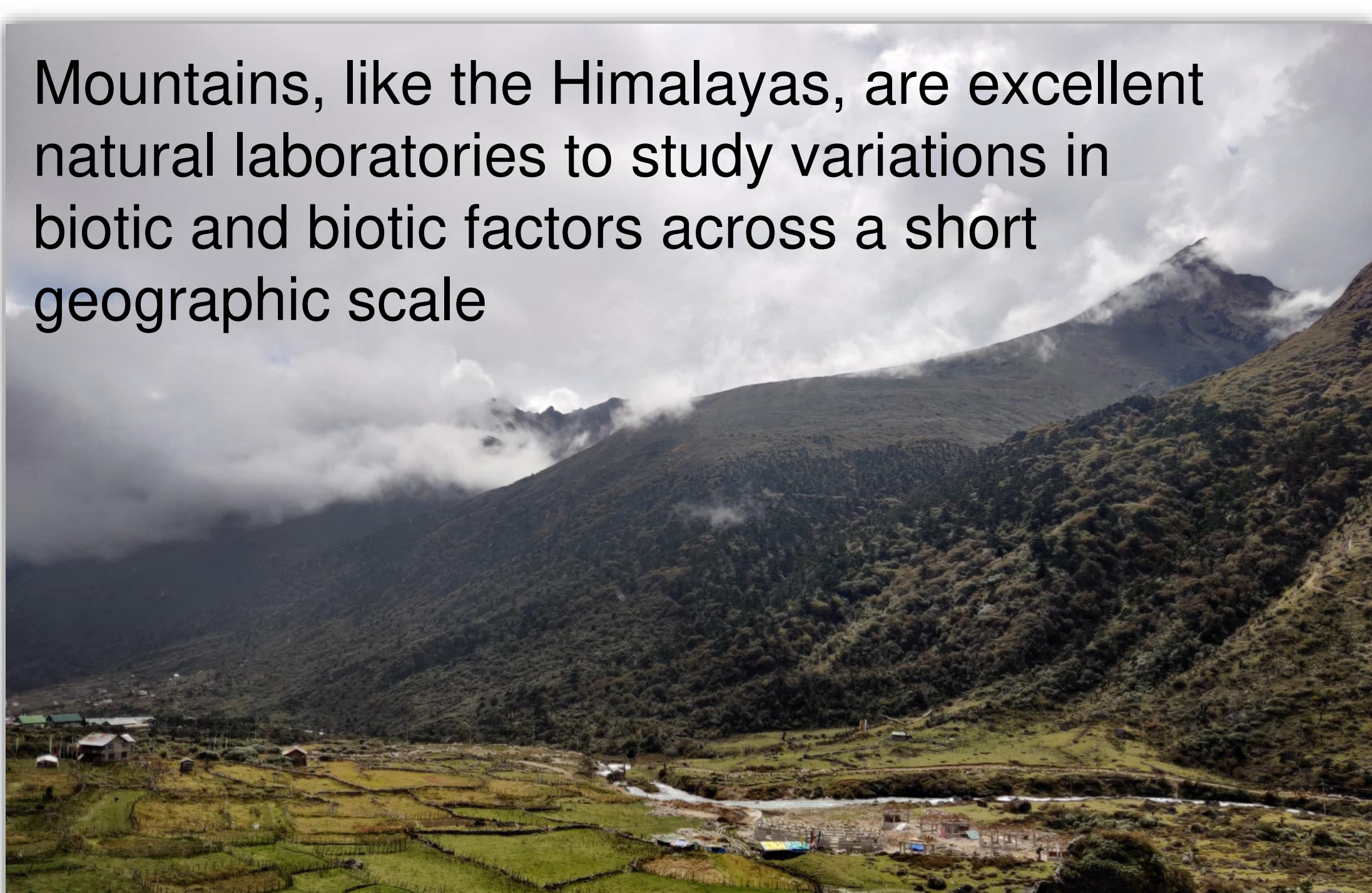
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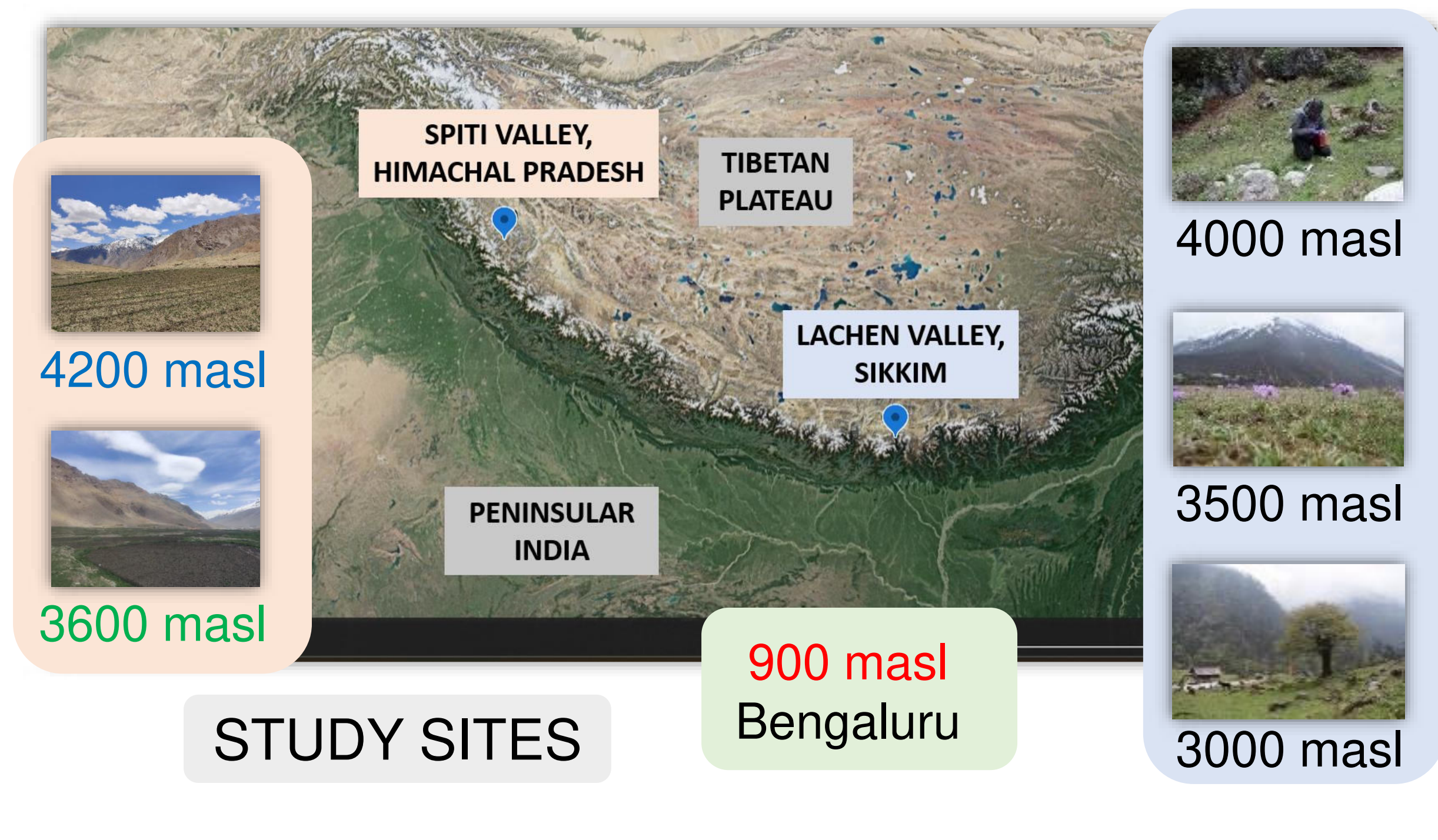


Insects, being ectotherms, are expected to be significantly impacted by changes in the biotic and abiotic factors in their environment.

Tropical mountains are vulnerable to effects of climate change, often leading to upslope migration of species, jeopardising crucial ecosystem services along the way.



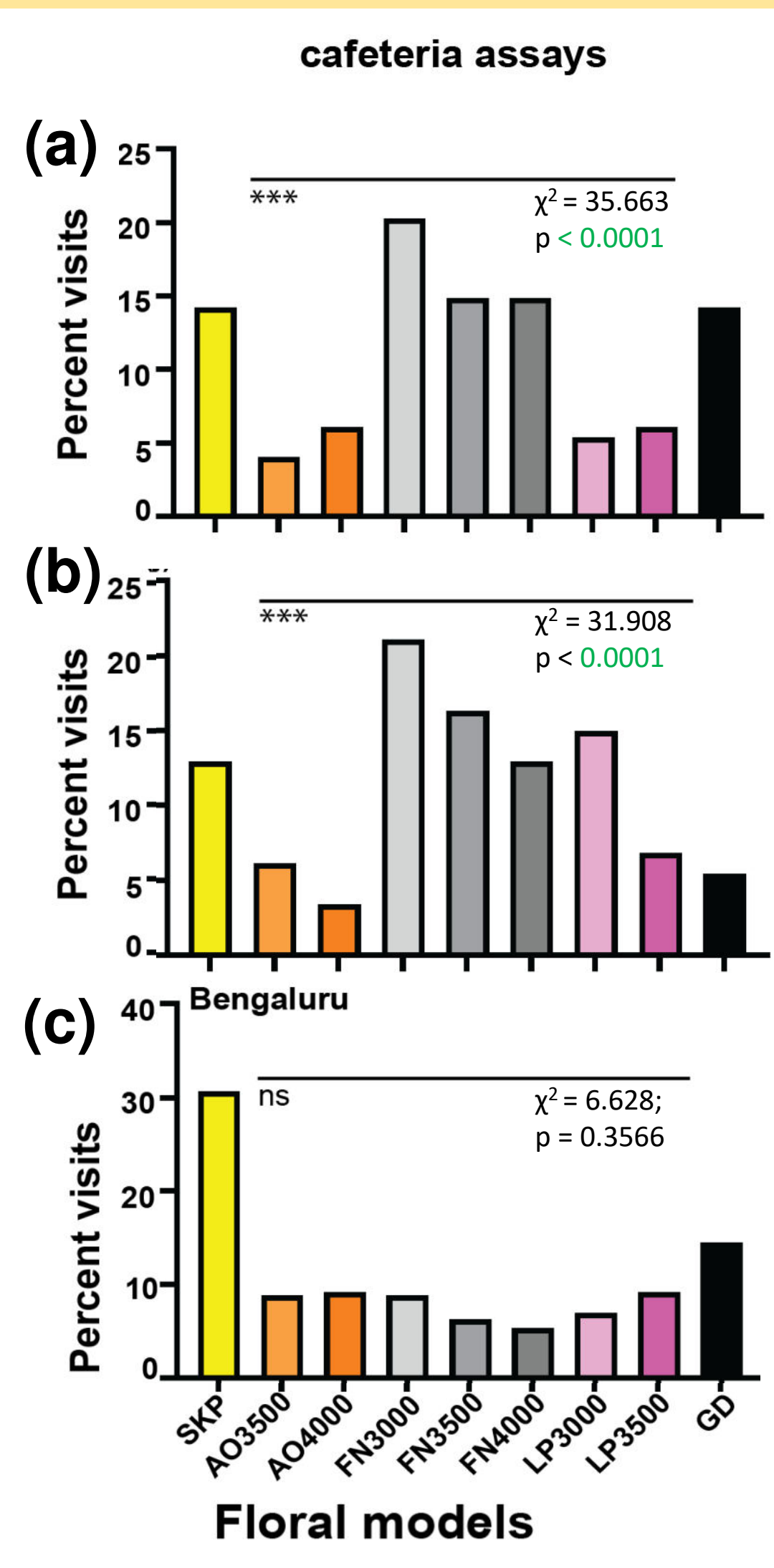
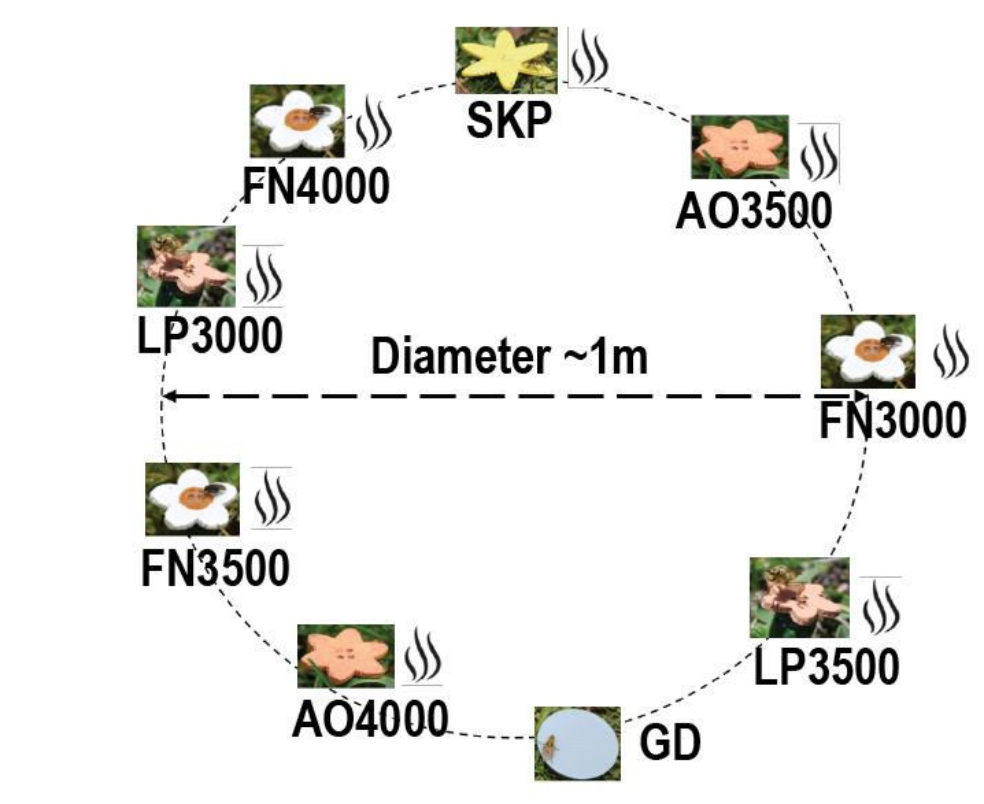
Mountains, like the Himalayas, are excellent natural laboratories to study variations in biotic and abiotic factors across a short geographic scale



Behaviour: How do insect pollinators respond to different floral VOCs?

Conspecific flowers of *Anemone obtusiloba*, *Fragaria nubicola* and *Lysimachia proliifera* were found to have different floral VOCs across elevations.

We presented 3-D printed floral models to pollinators in a cafeteria assay to assess preferences of insect pollinators to different odour profiles. We did this in two different flowering seasons at 3500masl, and also in Bengaluru.



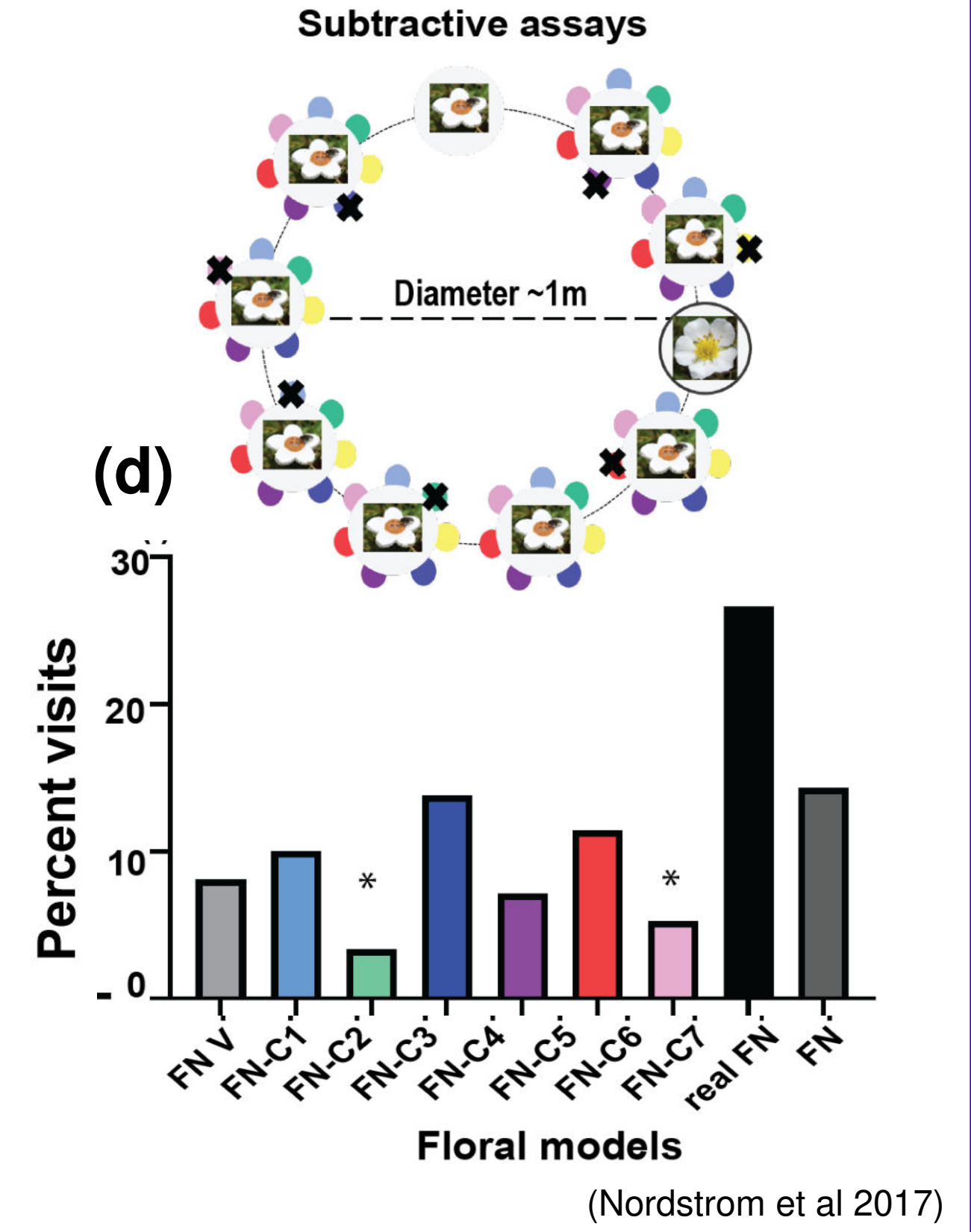
| Flower species | Elevation of VOC sampling | Model name |
|------------------------------|---------------------------|------------|
| <i>Anemone obtusiloba</i> | 3500masl | AO3500 |
| <i>Anemone obtusiloba</i> | 4000masl | AO4000 |
| <i>Fragaria nubicola</i> | 3000masl | FN3000 |
| <i>Fragaria nubicola</i> | 3500masl | FN3500 |
| <i>Fragaria nubicola</i> | 4000masl | FN4000 |
| <i>Lysimachia proliifera</i> | 3000masl | LP3000 |
| <i>Lysimachia proliifera</i> | 3500masl | LP3500 |

(a) Insect pollinators visit all floral models, but not equally. Pollinators show preference to certain models, notably FN.

(b) In different flowering season, when real flowers of AO, FN and LP are not around, we see a significantly different preference ($\chi^2=21.193$, $p=0.0067$).

(c) However, preferences are completely lost in a novel environment (Bengaluru).

(d) Chemicals (C2: 2-pentylfuran and C7: α -cedrene) are critical for pollinator visitations in FN models (Fischer's exact test, $p=0.0068$ and $p=0.0408$ respectively).



Physiology

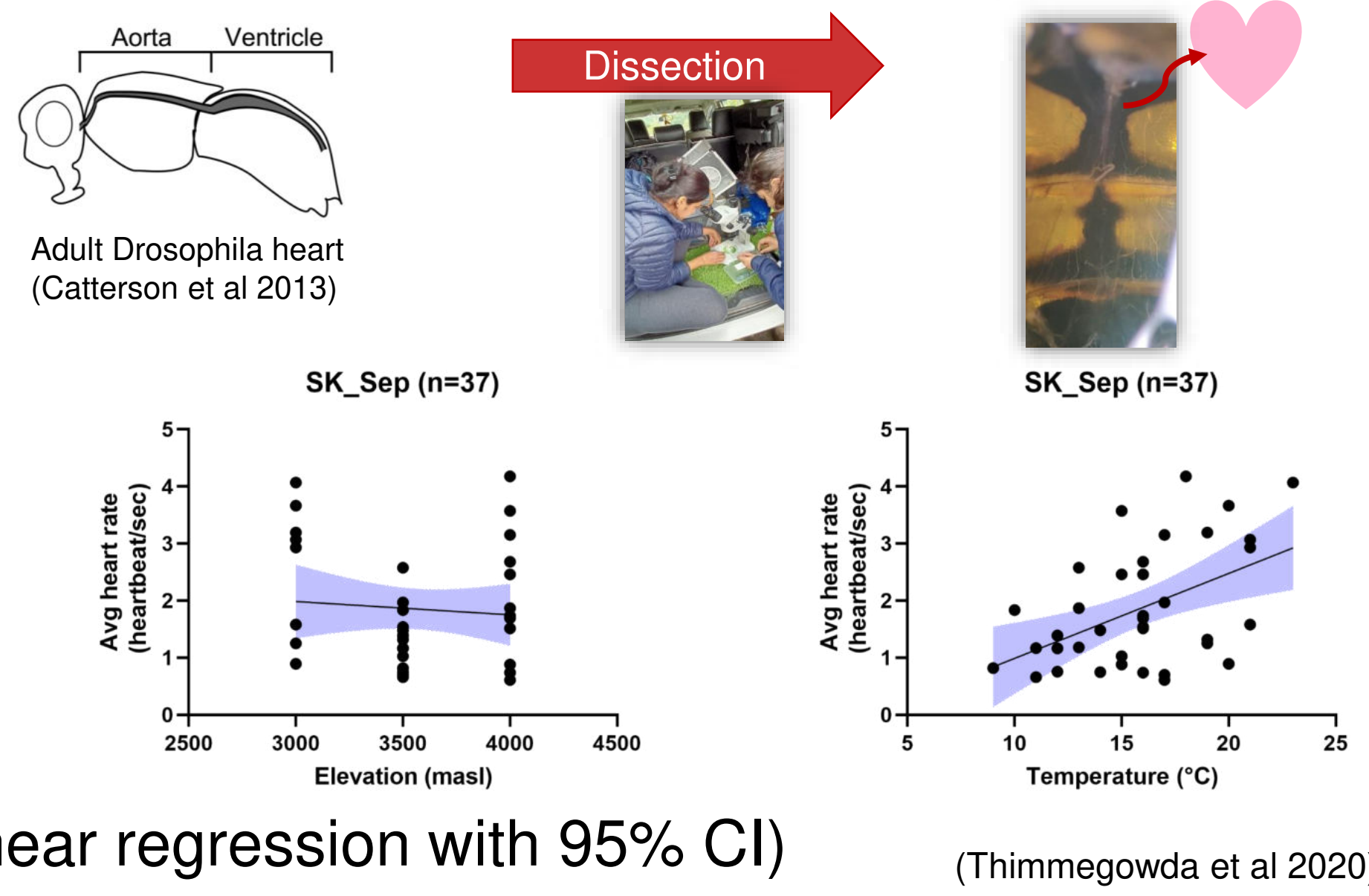
Eristalis tenax
(Diptera: Syrphidae)

Common drone fly

Solitary, generalist pollinator of wildflowers and crops alike
Widely distributed, abundant, easy to handle

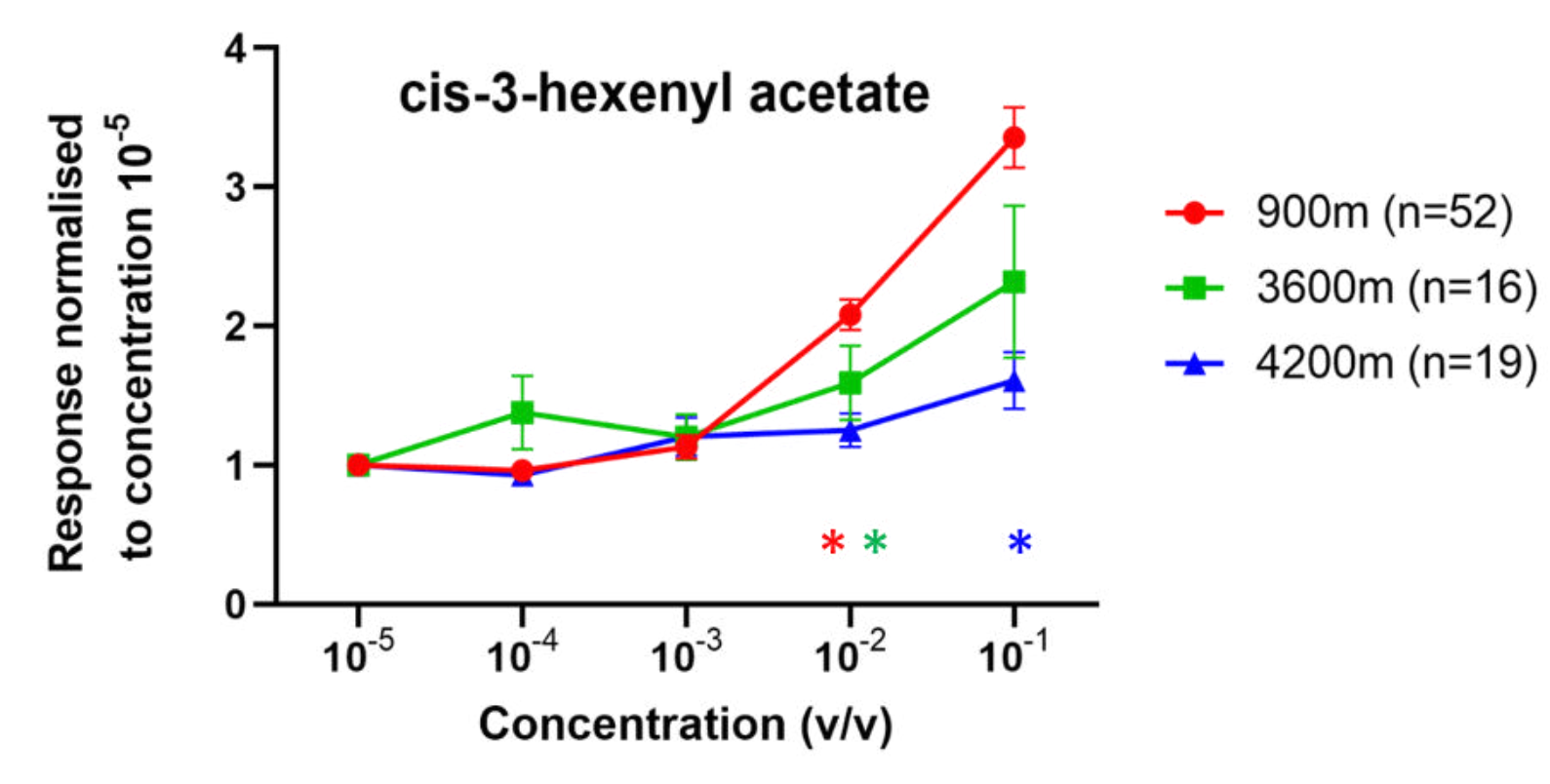
How does heart rate differ across elevations?

Average heart rate was found to be correlated with ambient temperature ($R^2=0.2341$, $p=0.0024$)

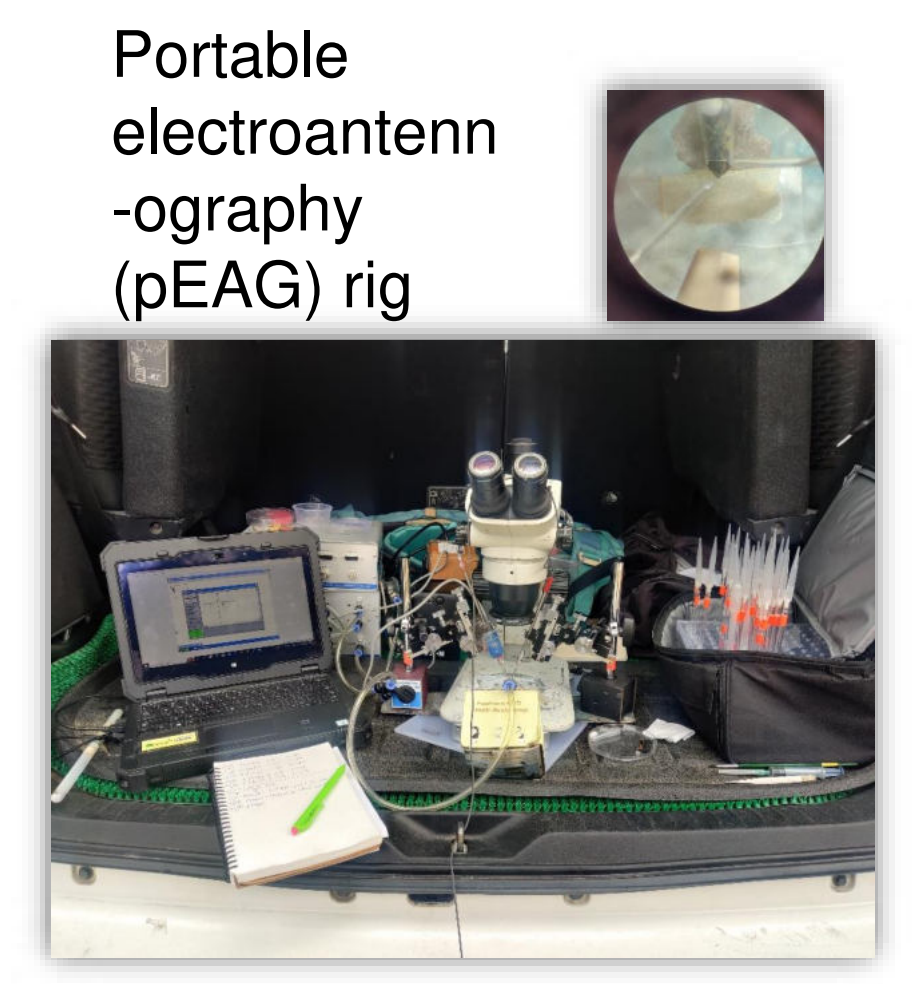


How does antennal sensitivity change across elevations?

The lower elevations consistently showed higher log-fold change in response



significant threshold of odour detection (t-test)
900masl: 10^{-5} vs 10^{-2} and 10^{-5} vs 10^{-1} ; $p<0.001$; 3600masl: 10^{-5} vs 10^{-2} ; $p=0.0432$, 10^{-5} vs 10^{-1} ; $p=0.0295$; 4200masl: 10^{-5} vs 10^{-1} ; $p=0.0079$



Key take aways

- Environment is the most important factor in determining insect pollinator preference to different floral VOC profiles.
- Physiological parameters of insects are affected differently by different abiotic factors.
- Insect pollinators are resilient to certain perturbations in their environment.

Other work

Micro-CT analysis of *E. tenax* anatomy to explore muscles, cuticle and other structures



Micro-CT scans of dorso-longitudinal muscles

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