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# Functional Ecology

## Body size determines the thermal coupling between insects and plant surfaces

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### Author Contributions statement

SP, MED and HAW conceived the ideas and designed methodology; SP, MED and HAW collected the data; SP, MED and HAW analysed collectively the data; SP, MED and HAW wrote the manuscript. All authors contributed critically to the drafts and gave final approval for publication.

### Data availability statement

Data available from the Dryad Digital Repository: <https://doi.org/10.5061/dryad.4qrfj6q9c> (Pincebourde, Dillon & Woods, 2021)

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## **Body size determines the thermal coupling between insects and plant surfaces**

### **Abstract**

1. Most studies in global change biology predict biological impacts of warming from information on macroclimates. Most organisms, however, live in microhabitats with physical conditions which are decoupled to varying degrees from those in macroclimates depending partly on organism body size.
2. Small ectotherms of a few millimetres in length live deep in surface boundary layers such that their heat budgets are dominated by different processes compared to larger ectotherms, whose bodies emerge from surface boundary layers. We therefore hypothesized that the body size relative to surface boundary layer thickness generates different patterns of body temperature variation for organisms in the same nominal habitats.
3. We tested this hypothesis in a community of arthropods living on a subalpine plant by combining physical models to acquire high-resolution time series of operative temperatures, thermal imaging to assess the strength of coupling between physical models or arthropod bodies and surrounding leaf temperatures, and a cross-scale approach to infer the temperature distributions available to small ectotherms.

- Accepted Article
4. The size of the physical model strongly influenced operative temperature dynamics: the bigger, the warmer. Small models were just a few degrees warmer than leaf surfaces whereas large models deviated from leaf temperature by  $>10^{\circ}\text{C}$ .
  5. We found similar patterns of body temperature of naturally occurring arthropods. Temperatures of small insects closely tracked leaf surface temperatures even in full sun, whereas larger insects were warmer than leaf surfaces.
  6. At the whole plant scale, the thermal diversity of leaf surfaces was high, especially in the sun, typically generating a range of microclimatic temperatures (for small insects) of  $>10^{\circ}\text{C}$ . Larger insects instead could move between shaded and sunny portions of the whole plant to vary body temperatures by a larger extent.
  7. The bulk of animal biodiversity consists of small terrestrial arthropods, the majority of which are associated with plant surfaces at some point in their life cycles. The distribution of body sizes determines how much thermal diversity is available for behavioural thermoregulation, thereby contributing to their potential response to climate change.

**Keywords:** Biophysical ecology; Body size; Body temperature; Boundary layer; Heat budget; Infrared imaging; Leaf surface; Microclimate.