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Climate uncertainty on leaf surfaces

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An enormous diversity of organisms lives on plant leaves (insects, spiders, mites, fungi, bacteria etc.), and the microhabitats that leaves provide are correspondingly important. The leaf surface is heated by sunlight and cooled by wind and transpiration, such that the leaf temperature can differ from ambient air temperature by several degrees or more. A key, unresolved question is how strongly climate change at larger spatial and temporal scales will propagate into the microclimatic spaces where leaf-associated organisms actually live. Our current knowledge on the leaf microclimate makes such predictions very uncertain. First, we need to know more about how plant stomata, which play the role of leaf thermostat, respond to environmental fluctuations and to local damage from leaf-associated organisms (e.g., herbivorous insects). Second, recent research has revealed strong patterns of leaf temperature at geographic scales: although air temperature increases from boreal to sub-tropical latitudes, the average temperature of tree leaves varies surprisingly little. Thus, at high latitudes, leaves are warmer than ambient air temperature but at low latitudes similar to ambient.

We develop two conceptual hypotheses to anticipate the outcome of global warming on such latitudinal gradients. The first focuses on the relative abilities of subtropical versus boreal leaves to buffer high temperatures. In particular, leaves in subtropical areas will continue to buffer temperature increases; subtropical animals, therefore, will not feel any difference despite global warming, whereas high-latitude animals will experience microhabitat warming because their leaves are not adapted to buffer elevated air temperatures. The second hypothesis focuses on the relative adaptation of leaves, across latitudes, to fluctuating conditions. In particular, high-latitude leaves, with a stronger evolutionary history of living with large daily and seasonal fluctuations in macro conditions, will be pre-adapted to cope with even warmer future temperatures. This hypothesis predicts that it is the microclimates on subtropical leaves that will change disproportionately. Such an outcome could have major effects on leaf-dwelling organisms, especially if subtropical organisms already are living closer to their temperature limits. Although recent advances in plant ecophysiology reduce the level of uncertainty, significantly more research is needed to anticipate these patterns.

A tropical caterpillar living at the leaf surface.

Image courtesy of Sylvain Pincebourde.