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First experimental evidence for carbon starvation at warm temperatures in epiphytic orchids of tropical cloud forests

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Tropical cloud forests are among the most climate sensitive ecosystems world-wide. The lack of a strong seasonality and the additional dampening of temperature fluctuations by the omnipresence of clouds and fog produce year-round constant climatic conditions. With climate change the presence of clouds and fog is, however, predicted to be reduced. The disappearance of the cooling fog cover will have dramatic consequences for air temperatures, that are predicted to increase locally well over 5 °C by the end of the 21st century. Especially the large number of endemic epiphytic orchids in tropical cloud forests that contribute substantially to the biological diversity of these ecosystems, but are typically adapted to a very narrow climate envelope, are speculated to be very sensitive to the anticipated rise in temperature.

In a phytotron experiment we investigated the effect of increasing temperatures on the carbon balance (gas-exchange and the carbon reserve household) of 10 epiphytic orchid species from the genera Dracula, native to tropical, South-American cloud forests. The orchids were exposed to three temperature treatments: i) a constant temperature treatment (23°C/13°C, day/night) simulating natural conditions, ii) a slow temperature ramp of +0.75 K every 10 days, and iii) a fast temperature ramp of +1.5 K every 10 days. CO_2 leaf gas-exchanges was determined every 10 days, and concentrations of low molecular weight sugars and starch were analyses from leaf samples throughout the experiment.

We found that increasing temperatures had only minor effects on day-time leaf respiration, but led to a moderate increase of respiration during night-time. In contrast to the rather minor effects of higher temperatures on respiration, there was a dramatic decline of net-photosynthesis above day-time temperatures of 29°C, and a complete stop of net-carbon uptake at 33°C in all investigated species. This high sensitivity of photosynthesis to warming was independent of the speed of the temperature increase. Most importantly, the decline of photosynthesis was accompanied by a rapid and complete depletion of leaf starch reserves followed by the prompt death of the plants. We therefore conclude, that temperature increases to 29 - 33°C lead to carbon starvation in epiphytic orchids of tropical cloud forests that is driven by the break-down of photosynthesis. The physiological reason for the observed dysfunction of photosynthesis at only moderately warm temperatures are currently not well understood. Within an ongoing phytotron study, we thus are aiming to confirm and deepen the findings in the genus Dracula in Masdevallia, another orchid genera native and endemic to tropical cloud forests.