How does photorespiration beat the heat and maintain photosynthesis at elevated temperatures?

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Introduction and Experimental Aims

As the planet continues to warm, it is becoming increasingly important to understand how plants can adapt to elevated temperatures. C_3 species are particularly vulnerable to changes in temperature due to the impact of photorespiration and WUE. Therefore, understanding how C_3 plants can adapt to manage high photorespiratory fluxes and optimize water use efficiency at elevated temperatures is critical.

- We aim to determine how the C_3 desert extremophile, *Rhazya stricta*, facilitate high rates of photorespiration while maintaining photosynthesis and water-use efficiency at elevated temperatures.

Why Study *Rhazya stricta*?

Rhazya stricta is a good model species for studying heat adaptation as it native to hot-arid environments with low rainfall in the Middle East.

Temperature Response of Photorespiration and Photosynthesis

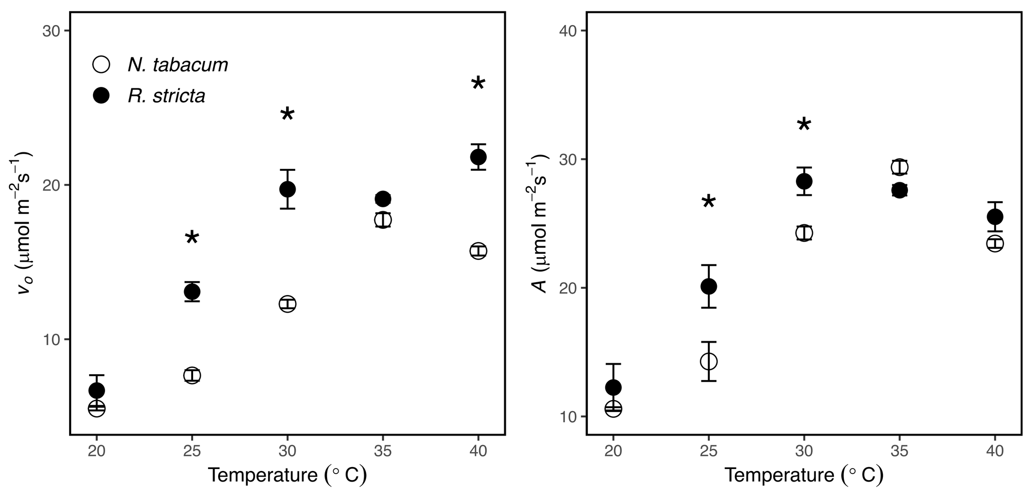
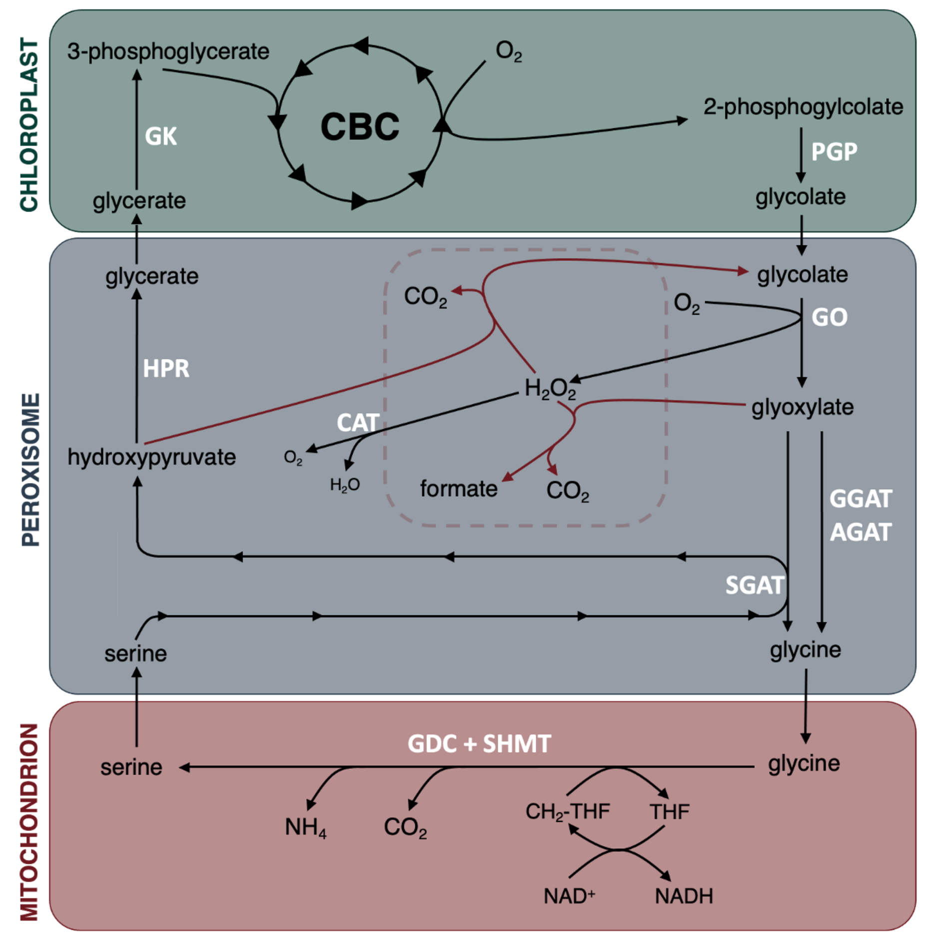


Figure 1. *Rhazya stricta* exhibits higher rubisco oxygenation rates (v_o) and net assimilation rates (A) compared to *Nicotiana tabacum* under ambient oxygen concentrations (21%) at saturating light intensity (1750 µmol PAR m^{-2} s^{-1}).

Hallmarks of a Temperature-Tolerant Photorespiratory Pathway



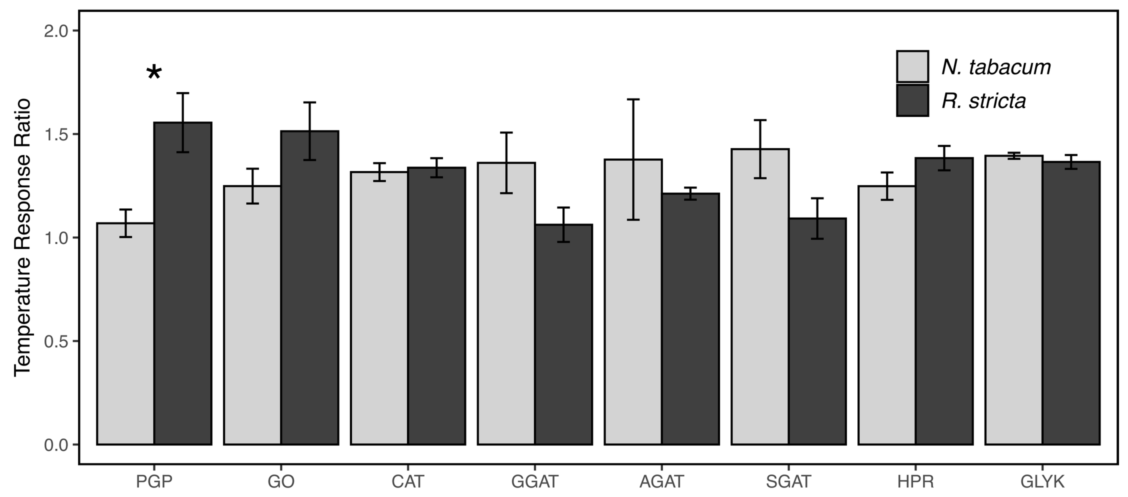


Figure 2. The temperature response ratio of the photorespiratory enzyme activities in *Rhazya stricta* and *Nicotiana tabacum*

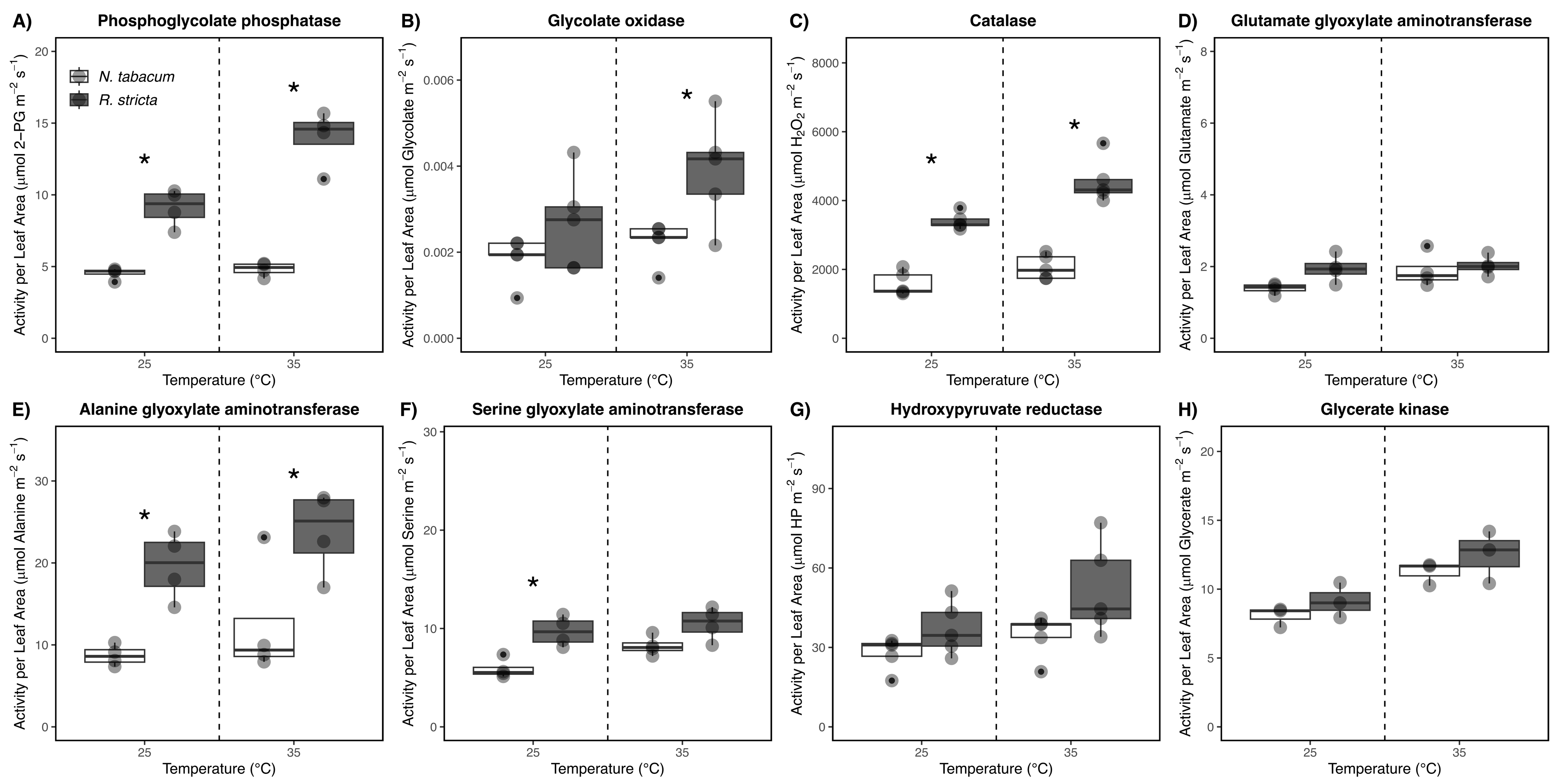


Figure 3. Photorespiratory enzymatic activity of crude protein extract at 25°C and 35°C in *Rhazya stricta* and *Nicotiana tabacum*.

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Managing CO_2 Transfer Conductance to Optimize WUE

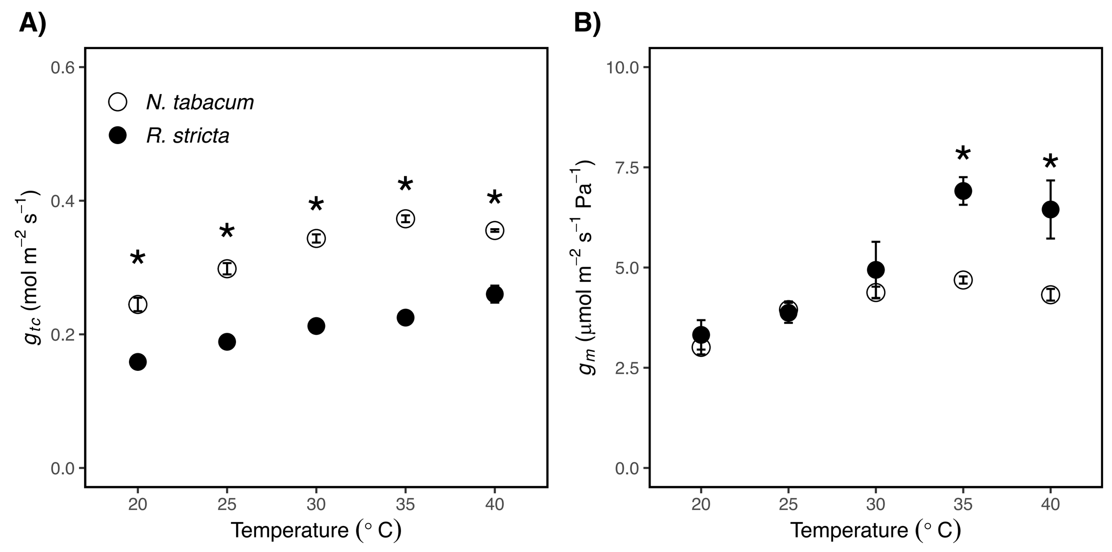
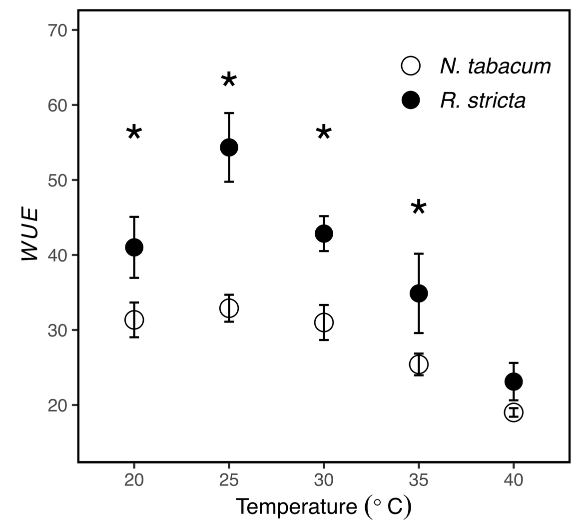


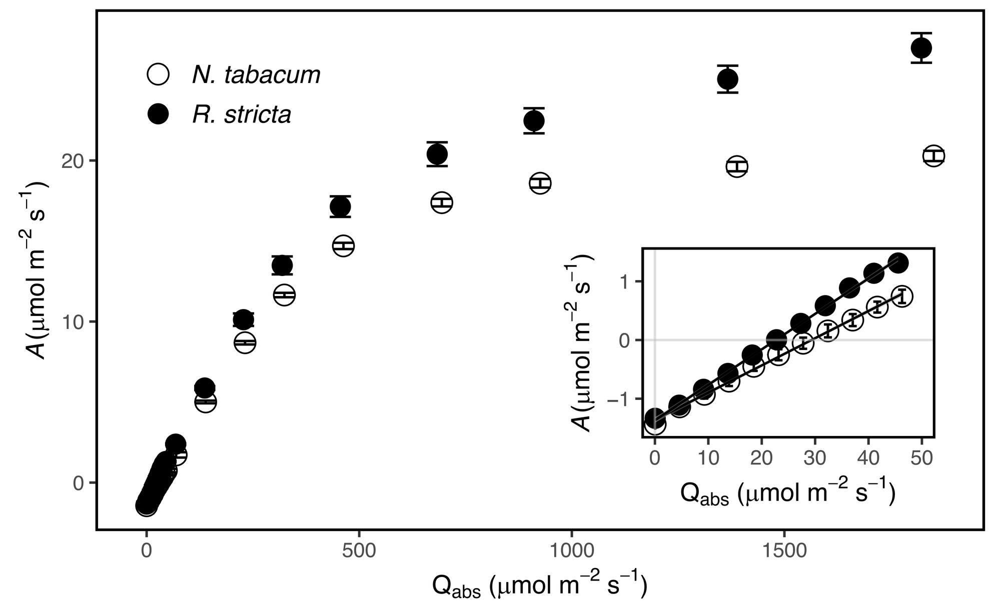
Figure 4. Temperature response of stomatal conductance (g_{tc}) to CO_2 (A) and mesophyll conductance (g_m) to CO_2 (B).

Figure 5. *Rhazya stricta* exhibits greater water use efficiency (WUE) than *Nicotiana tabacum.*



Other Adaptive Strategies of Photosynthesis

Figure 6. Light Response Curve of *Rhazya stricta* and *Nicotiana tabacum* under ambient CO_2 (40 Pa) at 25°C. The maximum quantum yield of CO_2 (Φ_{CO2}) was greater in *Rhazya stricta* (0.060 ± 0.0047) compared to *Nicotiana tabacum* (0.046 ± 0.0017).



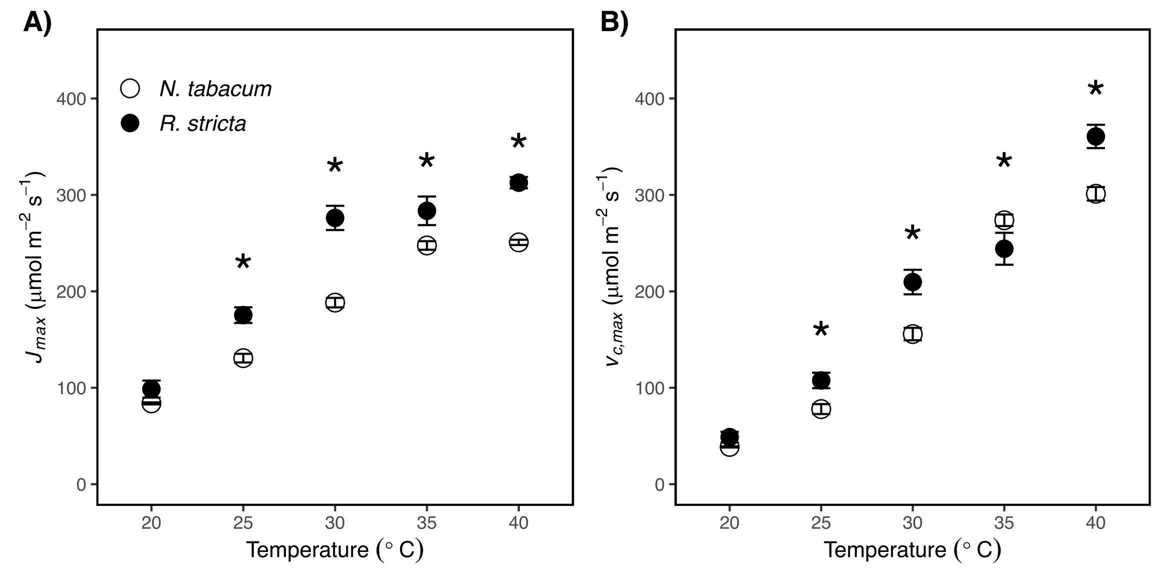
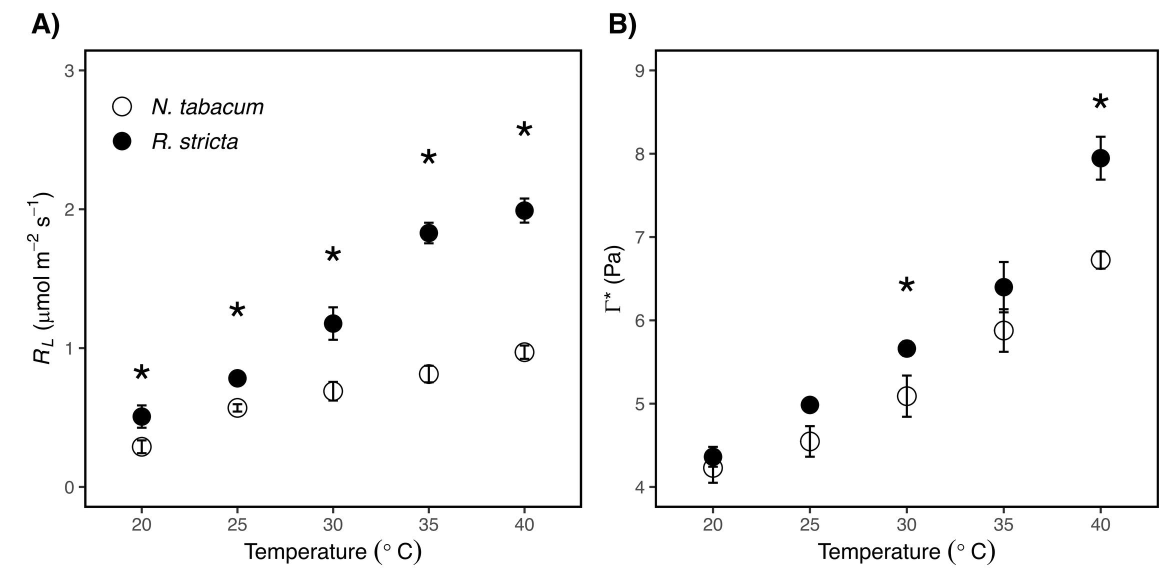


Figure 7. Temperature response of maximum rate of electron transport (J_{max}; A) and maximum rubisco carboxylation rate ($v_{c,max}$; B) were estimated under ambient CO_2 (40-42 Pa) and at saturating light (1750 µmol PAR m^{-2} s^{-1}).

Figure 8. Temperature response of respiration in the light (R_L; A) and photorespiratory CO_2 compensation point (Γ^*; B).



Conclusion and Future Directions

These results suggest important adaptive strategies:

- To maintain high rates of photorespiration at elevated temperatures, *Rhazya stricta* increases photorespiratory capacity by reducing enzymatic bottlenecks associated with PGP and CAT.
- To maintain water-use efficiency, *Rhazya stricta* appears to shift the partitioning of CO_2 conductance from the stomata, which loses water, to the mesophyll, which does not, at elevated temperature.

These strategies found in *Rhazya stricta* may inform breeding and engineering efforts in other C_3 species to improve photosynthetic efficiency at elevated temperature.

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