The effectiveness of the cuticular transpiration barrier of a desert plant

The efficient control of water loss from plant organs to the atmosphere is essential to enable plant survival. The water loss regulation mainly occurs via the stomata, small adjustable apertures controlling the gas exchange. Drought induces stomatal closure, the water loss is minimized and then controlled by the plant “skin”, the so-called cuticle. The matrix of the plant cuticle is the cutin polymer. Embedded within this polymer are the cuticular waxes, which are responsible for regulating the water loss rate. It is often claimed that desert plants should have a transpiration barrier with extra-low permeabilities. In warm deserts, plants are exposed to high temperatures. Non-desert plants show a pronounced decrease of the transpiration barrier properties at elevated temperatures (> 35°C). The impact of temperature on the cuticular water permeability of desert plants has not been investigated so far.

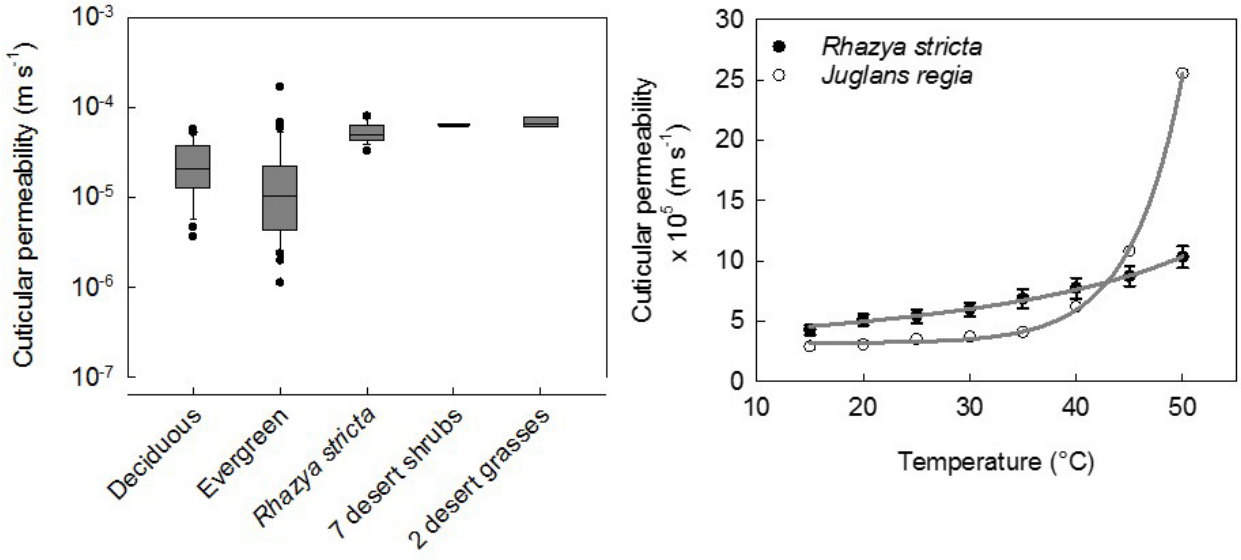

Fig. 1. Comparison of the cuticular permeability of the desert plant Rhazya stricta at 25°C with 12 deciduous and 13 evergreen plant species and with desert shrubs and grasses and over the whole measured temperature range compared with Juglans regia.

We studied the effect of temperature on the leaf cuticular permeability of *Rhazya stricta*, an evergreen shrub from the Arabian Desert. We tested whether this desert plant indeed has very low cuticular water permeabilities and whether there is a steep decrease of the barrier properties at elevated temperatures. In addition, the chemical composition of the plant cuticle was analyzed to relate the cuticular function to the chemistry.

Fig. 2. The temperature-dependent increase of the leaf cuticular water permeability of the desert shrub Rhazya stricta is much smaller than in all other species studied so far. It is proposed that large amounts of triterpenoids mechanically stabilize the cuticle and, thus, prevent the thermal disruption of the cuticular transpiration barrier.

The water loss through the leaf cuticle under conditions that induce maximum stomatal closure was determined and cuticular permeabilities calculated. In comparison to all available literature data, *Rhazya stricta* leaves showed a high cuticular permeability. This contradicts the assumption that desert plants have an extraordinary effective transpiration barrier when stomata are closed to survive in arid climates. The decrease of the barrier properties at elevated temperatures for leaves of the deciduous tree *Juglans regia* from temperate climates is caused by the steep increase in the cuticular permeability (factor 8.8 from 15°C to 50°C, Fig. 1). In comparison, the cuticular permeability of *Rhazya stricta* leaves increases continuously over the same temperature range (factor 2.4). What makes *Rhazya stricta* cuticles different from others (at elevated temperatures) and can this difference be related to the chemistry of the cuticle? We propose that high amounts of pentacyclic triterpenoids may act as fillers mechanically stabilizing the cutin polymer matrix and, thus, restrict the thermal expansion of the polymer preventing thermal disruption of the cuticular transpiration barrier (Fig. 2).

This study provides new insights into how the composition and structure of the cuticles from xerophytic plants affect their association with the temperature-dependent water permeability. For desert plants exposed to elevated temperatures, the thermal stability of the cuticle is decisive, maybe even to a higher degree than the baseline cuticular permeability.

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