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Overlapping Leaves Prevent Reproductive Organ from Overheating in an Alpine Plant

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Short Communication

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The alpine subnival belt (4300-5000 m a.s.l.) of Himalaya-Hengduan Mountains (HHM) experiences a summer monsoonal climate, with heavy rain fall interrupted by short periods of intense solar radiance in the growing period [1]. Low temperature caused by rain (or cloud) slows the development of flowers and seeds; there has been an extensive interest in study how low temperature drives the evolution of highly-specialized morphological features in alpine plants [1-5]. For example, the densely pubescent inflorescences of *Saussurea medusa* (known as 'Himalayan woolly plant') have a key role in temperature control and water repellence in cool and humid summer [1,3]. On the other hand, the overlapping large semi-translucent bracts covering racemes of *Rheum nobile* (known as 'Himalayan glasshouse plant') function to warm floral tissues and have protective effects against UV-B radiation and rain [4]. However, none of the research has ever focused on the selective pressure of high temperature caused by transient strong solar radiation (particularly in the midday) in alpine plant. High temperature reduces pollen viability and some species have evolved cooling mechanisms (evaporation and self-shading) in tropical environments [6]. In a recent study, we used *Eriophyton wallichii* Bentham (Lamiaceae), an alpine perennial herb with woolly structures (particularly in leaves, corolla and calyxes) and overlapping leaves covering reproductive organs **(Figure 1),** to explore the specialized morphology of an alpine plant adapted to growth and reproduce in sites characterized by transient heavy rainfall and strong solar radiation [7].

Through field observations and laboratory experiments, our results showed that *E. wallichii* can use dense trichomes to accumulate heat, corroborating the pivotal role of the spectacular trichomes in keeping warm the interior tissues in cold habitats [1-3,7,8]. The majority of the growing season in the subnival belt of HHM is characterized by frequent rain, and we also found that trichomes could protect plant tissue from wetting in this region as previously reported for *Saussurea medusa* and E. *wallichii*; however, some species also have high density of trichomes on bracts and inflorescence (e.g. *Pedicularis kanei*) in Arctic region (e.g. Alaska) where precipitation is very limited [1,7,8]. It has been suggested that dense trichomes represent a convergent adaptation to cope with [8]. Thus, we were not sure if the negative effects of rainfall coupled with low temperatures have driven the evolution of trichomes with low temperature together in E. *wallichii*.

Although rain (cloud) predominately occurs during the growing season in the subnival belt of the HHM, solar radiance can also be very intense for short periods [1]. When the flowers and fruits of E. *wallichii* were directly exposed to peaks of solar radiation (after midday, 1300 h to 1500 h), the pubescent floral structures **(Figure 2b and 2c)** absorbed intense solar radiation and inhibited convective heat loss, resulting in temperature increasing and even overheating (35°C or even higher) inside the flowers and fruits [7]. Drastic temperature fluctuations and overheating reduces pollen viability and the production and viability of seeds [7]. Our results showed that overlapping leaves (extrafloral structures) prevented flowers and fruits from overheating caused by transient intense solar radiation, and kept optimal temperatures of flowers and fruits to an optimal level on sunny hours, thus promoting the development of pollen and seed in alpine environment [7].

The overlapping leaves cover flowers, which looks have protective effects for interior flowers and fruits to avoid damages induced by rainwsh and UV-B radiation **(Figures 1 and 2).** Nevertheless, the overlapping leaves have also been considered for

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protecting interior flowers and fruits from temperature fluctuations and overheating [7]. Previous studies have also suggested that traits such as overlapping bracts of *Rheum nobile* are multifunctional; the bracts simultaneously protect pollen from rain, UV-B and low temperature [4]. However, among these abiotic environmental factors, which factor has played the main role in the evolution of the specialized morphology, or both of them, is unclear. In a next work, we are trying to explore various abiotic environmental factors which may have contributed to the evolution of overlapping leaves covering reproductive organs in E. *wallichii*.

Figure 1. Native habit and gross morphology of *Eriophyton wallichii*.

Figure 2. (a) One gross plants of *Eriophyton wallichii* after rain. (b-c) the highly pubescent calyxes and corolla, respectively.

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