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Patterns of leaf surface wetness for montane and subalpine plants

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ABSTRACT

The frequency and duration of water on leaf surfaces have important consequences for plant growth and photosynthetic gas exchange. The objective of the present study was to compare the frequency and duration of leaf wetness under natural field conditions among species and to identify variation in structural features of leaves that may reduce surface wetness. During June–September 1992 in the central Rocky Mountains (USA), natural leaf wetting due to rain and dewfall was observed on 79 of 89 nights in open meadow habitats compared to only 29 of 89 nights in the understorey. Dew formation occurred at relative humidities that were often well below 100% because of radiational heat exchange with cold night skies and low wind speeds (< 0·5 m s^{-1}). A survey of 50 subalpine/montane species showed that structural characteristics associated with the occurrence and duration of leaf surface wetness differed among species and habitats. Both adaxial and abaxial surfaces accumulated moisture during rain and dewfall events. Leaf surfaces of open-meadow species were less wettable (P = 0·008), and had lower droplet retention (P = 0·015) and more stomata (P = 0·017) than adjacent understorey species. Also, leaf trichomes reduced the area of leaf surface covered by moisture. Ecophysiological importance is suggested by the high frequency of leaf wetting events in open microsites, influences on growth and gas exchange, and correspondence between leaf surface wettability and habitat.

Key-words: dew; leaf wetness; micrometeorology; montane; morphology; stomata; subalpine; trichome; water droplet.

INTRODUCTION

Most terrestrial plants frequently experience excess liquid water on photosynthetic surfaces (Barr & Gillespie 1987; Harrington & Clark 1989) which has potential to reduce photosynthetic gas exchange and growth (Brewer & Smith 1994, 1995; Ishibashi & Terashima 1995). The fact that CO_2 diffuses about 10 000 times more slowly through water than air (Weast 1979) suggests that CO_2 uptake should be seriously impeded when a significant portion of the leaf surface is covered by a film of water (Fogg 1947; Crisp 1963). Although there are scattered accounts of the effects of leaf surface moisture on transpiration (Stahl, 1898; Stone 1957, 1963; Schmitt, Martin, & Lüttge 1989), only a few studies have considered the importance of leaf surface wetness to CO_2 exchange and growth in terrestrial plants (Benzing & Renfrow 1971; Benzing, Seeman, & Renfrow 1978; Smith & McClean 1989; Terashima, Masuzawa, & Ohba 1993; Brewer & Smith 1994, 1995). Evidence from these studies suggests that photosynthetic CO_2 exchange in certain species is much reduced because of wet leaf surfaces.

In the past, leaf surface moisture was suggested as an important factor for plant growth due to the possibility of absorption of water (Stone 1957, 1963; Wallen 1967; Benzing *et al.* 1978; Schmitt *et al.* 1989). Interception of fog in eastern spruce-fir forests (Vogelmann *et al.* 1968) and dew collection by ragweed through stem flow (Shure & Lewis 1973) are other examples of moisture deposition that may influence plant ecology. Excess leaf wetness also may promote pathogen infection of native and agricultural species (Tubaki, Tokumasu, & Ando 1985; Reynolds *et al.* 1989; Evans, Nyquist, & Latin 1992). Pollutant deposition and foliar nutrient leaching from wetted leaves also are affected by leaf surface wetness (Adams & Hutchinson 1987; Pearcy & Baker 1991; Massman *et al.* 1994). Consequently, considerable effort has been made to predict daily and seasonal patterns of leaf surface wetness duration (Pedro & Gillespie 1982; Barr & Gillespie 1987; Bass, Savdie, & Gillespie 1991; Müller 1992). The extent to which surface moisture adheres to leaves has been shown to be related to the surface chemistry of the cuticle (Holloway 1970) and to surface roughness (Fogg 1947; Challen 1960, 1962).

Few studies have addressed the functional significance of leaf wetness for native plants. Brewer, Smith & Vogelmann (1991) hypothesized that a strong selective pressure exists for the repulsion of water films on leaf surfaces, especially in habitats with frequent leaf wetting events. Plant species show a broad range of leaf wettability, from being covered by a film of water to being completely water repellent (Smith & McClean 1989; Brewer *et al.* 1991). The purpose of this study was to examine natural leaf wetting by evaluating leaf wettability among species in different habitats that vary in their susceptibility to leaf

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