Variation in drip tip length across cloud forest habitats

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Abstract: Drip tips are one morphological adaptation that allow plants to persist in the high moisture cloud forest in Monteverde, Costa Rica. Past research suggests that drip tips enable leaves to dry more quickly by facilitating water dispersal. We tested the hypothesis that leaves with drip tips will retain less water than leaves whose drip tips have been experimentally removed. In addition, we hypothesized that drip tip length would vary with moisture levels, predicting that drip tip length would increase with elevation and would be smaller in gaps than in closed canopy. Leaves with a drip tip intact retained less water than leaves that had their drip tip removed. Leaves in gaps had a significantly lower drip tip ratio than those in areas of closed canopy and drip tip ratio was greater at low elevation than at high elevation. Drip tips may be less necessary at higher elevations and in gaps due to higher evaporative losses associated with increased exposure to sun and wind.

Key Words: drip tip, elevational gradient, epiphyll, leaf morphology

Introduction

The cloud forest in Monteverde, Costa Rica, presents several challenges to plant growth, such as high moisture, shading, and variability in sun and wind exposure. Adaptations in leaf structure can help plants persist in these environmental conditions. One such adaptation is the presence of a drip tip– a tapered leaf tip. Over 80% of leaves have drip tips in tropical rainforests (Richards 1981).

Past research suggests that drip tips allow leaves to dry more quickly than leaves lacking drip tips (Richards 1981, Lightbody 1985). Excess water on the leaf surface can reduce transpiration (Richards 1981), photosynthesis ability (Lightbody 1985), and the rate of nutrient uptake (Leigh 1975). Furthermore, leaves with a drip tip are less likely to be overgrown with epiphyllae because drip tips keep the leaf surface cleansed from spores of epiphyllae, the eggs of insect larvae and other substances that favor epiphyllae growth (Richards 1981). Yet, an increased drip tip decreases the leaf surface area available for photosynthesis, suggesting that there is a tradeoff with drip tip size.

We tested the hypothesis that leaves with drip tips would retain less water than leaves whose drip tips have been experimentally removed. In addition, we hypothesized that drip tip length would vary with moisture levels, predicting that drip tip length would increase with elevation and would be smaller in gaps than in closed canopy. In Monteverde, cloud water and precipitation increase near the continental divide (Clark et al. 1998). Additionally, gaps have less accumulated moisture than closed canopies because gaps receive greater exposure to sun and wind.

Methods

To determine the relative water retention ability of leaves with and without a drip tip, we selected 30 leaves from the same plant (Melostomataceae). We removed the drip tip from 15 leaves. The remaining 15 leaves were not manipulated. We measured the dry weight (g) of each leaf. Each leaf was positioned point down on an inclined clipboard at an angle of 25 degrees and then sprayed with 5 comparable squirts of water. After 30 seconds, we reweighed the leaf. The difference between the wet weight and dry weight was recorded as relative water retention.

We conducted our field study at low elevation (less than 1550 m) and high elevation (greater than 1800 m). At each elevation, sites were chosen in canopy gaps and under closed canopy, using the light meter of a 35 mm manual camera to judge light intensity. Three 5 m transects in gap areas and three transects in closed canopy were selected. Within 0.5 m of the transect on either side, we sampled vegetation that was between 0.5 m and 2.0 m tall. Four leaves were taken from each plant. We chose every third leaf, beginning with the leaf closest to the base of the plant, taking only leaves without excessive herbivory damage. We used calipers to measure leaf length (from the tip of the leaf to the intersection of the petiole and the leaf) and leaf width at the widest point. We measured drip tip length from where the leaf was no greater than 10% of its maximum width to the tip. We established a drip tip ratio (drip tip/(leaf length•leaf width)) to account for the various leaf morphologies sampled.

Results

In the drip tip manipulation experiment, we found a significant effect of drip tip presence or absence on leaf surface water retention (Fig. 1). Leaves with a drip tip intact retained less water than those leaves which had drip tips removed (ANOVA, $F = 5.39$, $df = 28$, $P = 0.028$).

Habitat and elevation both significantly affected drip tip ratio (Fig. 2). Leaves in gaps had a significantly lower drip tip ratio than those in areas of closed canopy (2-way ANOVA, $F = 11.38$, $df = 1$, $P = 0.0008$). Drip tip ratio was greater at low elevation than at high elevation (2-way ANOVA, $F = 6.17$, $df = 1$, $P = 0.013$). There was no interaction between elevation and habitat on drip tip ratio (2-way ANOVA, $F = 1.70$, $df = 1$, $P = 0.19$).

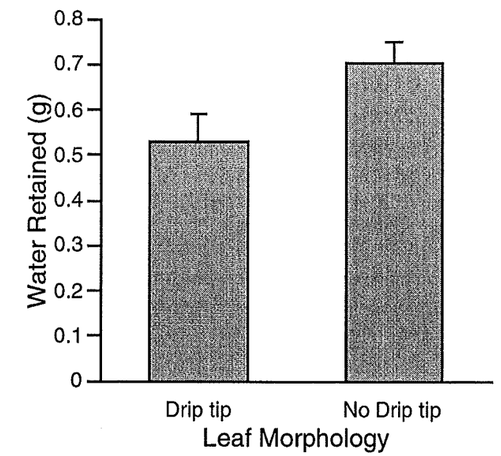

Fig. 1. Mean water retention (± 1 SE) on surfaces of leaves with and without a drip tip. Water retention = wet weight of leaf - dry weight of leaf.

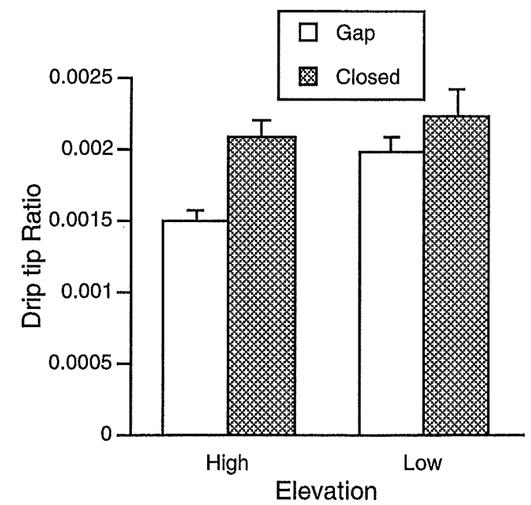

Fig. 2. Effects of elevation and habitat on mean drip tip ratio (± 1SE). Drip tip ratio = drip tip length / (leaf length * leaf width).

Discussion

Results from the experimental manipulation of leaf drip tips support the hypothesis that drip tips help rid leaves of surface water (Fig. 1). In an environment where accumulated leaf moisture can have negative effects, such as epiphyll growth, a drip tip would be advantageous to shed water. In areas of high exposure to sunlight and wind, such as in gaps or in the high elevation forests on a ridge, this increased water shedding is probably not as necessary as in the closed canopy environment of the lower elevation understory.

As predicted, drip tip ratio — drip tip length relative to leaf area — was greater in the moist, shaded areas of closed canopy than in gaps (Fig. 2). Since exposure to sun and

wind is greater in gaps, relatively high evaporative losses in gap areas are likely to reduce the need for drip tips. Under closed canopy, vegetation is buffered from the wind and receives very little sunlight, such that a drip tip may be necessary to prevent the buildup of excess water.

In predicting that drip tip ratio would be greater at higher elevations than at lower elevations, we focused on the role of moisture in determining the necessity of a drip tip. While it is true that moisture increases with elevation at Monteverde, another factor to consider is the difference in exposure to wind and sunlight between low and high elevation sites. The high elevation transects we sampled were all at or above 1800 meters, where we observed that the forest canopy is much lower and less dense than at lower elevations. At this ridge-top location, the light intensity and wind exposure are much greater than at lower elevations. Despite higher moisture levels at higher elevations, drip tips may be less necessary at higher elevations due to higher evaporative losses associated with increased exposure to sun and wind on the ridge.

Alternatively, pressure to reduce epiphyll growth may be less on the ridge. According to Richards (1981), drip tips help to keep a leaf surface free from spores of epiphylls and other substances that favor the growth of epiphylls. While the growth of epiphylls can have negative effects on plants, certain epiphylls have the ability to benefit the host plant by fixing nitrogen or producing substances that deter herbivores (Kursar and Coley 1992). Vegetation growing on the ridge is probably exposed to high levels of disturbance from weather, which suggests high levels of competition to grow quickly in the wake of a disturbance. Since nitrogen is a key nutrient for explosive growth, leaves with N-fixing epiphylls, such as cyanobacteria, may have a growth advantage after a disturbance from this extra boost of nitrogen (Kursar and Coley 1992).

Future study of the positive roles of epiphylls as nitrogen-fixers and deterrents of herbivory could provide a better understanding of the variation in leaf morphology, including relative drip tip size, between habitats with differing environmental demands.

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