Figure 2 Comparison of estimated percent damage on older leaves to age class of the most recently flushed leaves on the same branch.

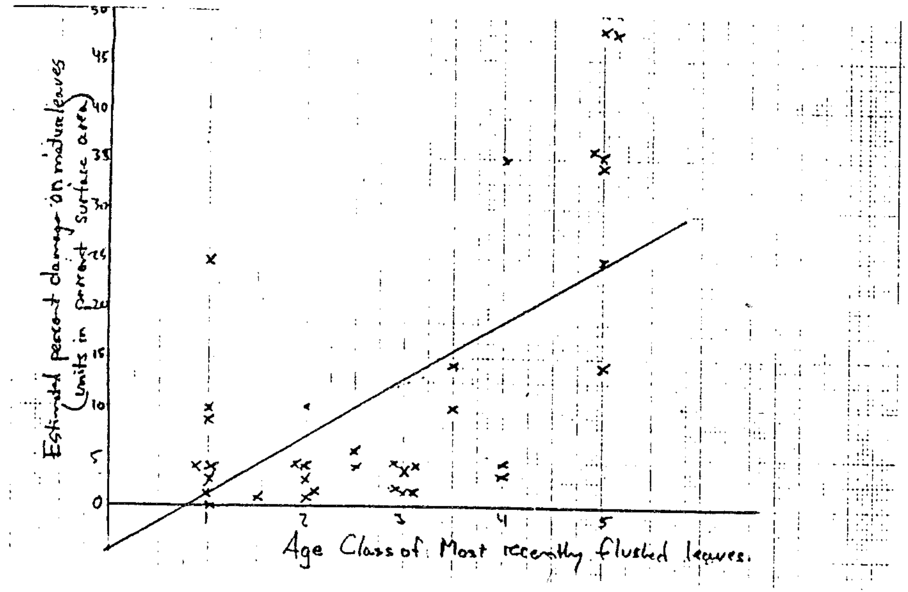
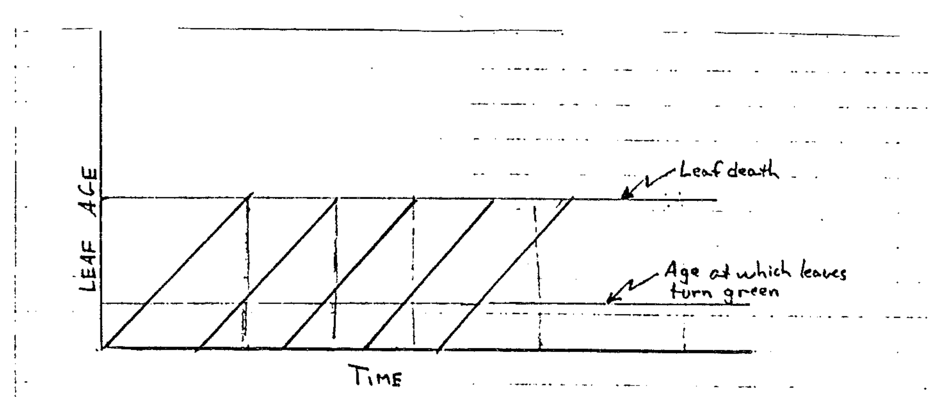



Figure 3 Model of leaf replacement in T. cacao. Each line represents a generation or flush of leaves. Any vertical line determines the age structure of the leaf population at a specific point in time.

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# TO DRIP OR NOT TO DRIP (DRIP TIP EFFICACY)

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## Abstract (A.S.)

We studied the effects of drip tip removal on water drainage from leaves. Drip tips are thought to expedite water drainage from the leaf surface, thus reducing epiphyllic growth. Epiphylls may compete with the leaves for light thus decreasing the fitness of the host individual.

We found that on three species of plants, removal of the drip tips significantly increased the amount of water retained on leaves. We suspect that the great number of tropical species with drip tips is due to the selective pressure to drain water from leaves, which may in turn reduce epiphyllic growth.


## Introduction (J.K.)

Most tropical plant leaves have drip tips on their leaves. It is generally though that drip tips have evolved to drain water off the leaf, hence, forestalling epiphyllic growth which may compete with the leaf for light. We examined a basic assumption of this theory by attempting to demonstrate that drip tip morphology drains water faster than the same leaves without drip tips. By examining the efficiency of this mechanism we hoped to gain insight into the strong selective pressure that has brought about the drip tip throughout so many tropical plant families.

## Methods (A.S.)

We studied drip tips of La Selva Biological Reserve, Sarapique District, Costa Rica. We chose complete leaves without epiphylls from three unidentified plant species in the open area around the station. Our fourth species was a palm found 10 meters down the South Research Trail. One of the species from the open area had rounded leaves. The others had drip tips.

We tested all leaves in the lab. We supported the leaves at a 30° angle with two strings. The leaf was attached to the top string by the petiole and rested on the bottom string with the drip tip pointing down into a catch basin.

We marked the leaves with an ink marker at a point 6-8cm above the drip tip. We then sprayed each leaf with 10 squirts from a spray bottle at a rate of two squirts per second, and allowed the leaf to drain for 30 seconds. Using a microbalance accurate to

0.01g, we weighed one square of toilet paper, wiped the remaining water off the leaf up to the mark, and reweighed the paper. The difference between these two weights was the weight of the water left on the leaf. We did this twice to control for the possibility of wiping some cuticular substance off the leaf while collecting the water. In our analysis of the data, we used the one that held the most water. We then cut the drip tip off to form a rounded end to the leaf and repeated the water measuring procedure once. These three measurements were performed on 10 leaves from each drip tip species we used leaflets of the compound leaf when conducting the experiment on the palm.

To control for the effect of cutting the distal edge of leaves, we performed the same series of procedures on a species with leaves that lacked drip tips. In lieu of cutting off the drip tips, we cut a fraction of the leaf tip off following the same contours of the original tip.

## Results (J.K.)

We conducted two trials for each of the three species with intact drip tips. We attribute the significance of a species to an increase of water left on the second intact drip tip trial. This is most likely due to sore cuticles from wiping at the first participation.
Species 1: There was a significant difference between the amounts of water left on the leaf with the drip tip ($T_S = 7$, $n = 11$, $p < 0.01$).
Species 2: There was an significant difference between the amounts of water left on the leaf with the drip tips ($T_S = 15.5$, $n = 10$, $p < 0.01$).
Species 3: There was no significant difference between the amounts of water left on the leaf with the drip tip ($T_S = 14$, $n = 10$, $p > 0.05$).

For each of the three species, we conducted one trial with the drip tip cut off and compared it with the average of the two uncut tip trials above. There was a significantly more water remaining without the drip tip for all three uncut drip tip species (same for all three: $T_S = 0$, $n = 10$, $p < 0.005$). As a control we tested one species that naturally had no drip tip for a difference between uncut and cut edges. There was no significant difference ($T_S = 7$, $n = 5$, $p > 0.05$).

## Discussion (E.G.)

There appears to have been strong evolutionary pressure for plants with drip tip leaves in the tropics. Evidence for this is that our careful observations of the La Selva flora reveals that nearly all local plants have drip tips. Another common occurrence in the tropics, that we also observed, is that epiphylls such as lichens, masses, and algae often cover substantial amounts of tropical leaf surfaces and thus compete with their host for



light. Many of these epiphylls grow better in moist environments, so leaves should lose less light to epiphylls if they reduced moisture on their surface. Our test of the hypothesis that drip tips reduce leaf moisture levels has revealed that drip tips indeed do reduce residual water on leaves. This result provides evidence that drip tips are selected for because they limit residual surface water on leaves, which may enhance leaf productivity by limiting epiphyll cover.

We recognize that drip tips are not the only adaptation for surface moisture reduction, and they are not the only element of epiphyllic growth inhibition. Also, it has been proposed that epiphylls might enhance leaf productivity through fixing atmospheric nitrogen and increasing leaf longevity by deterring herbivory. If these are true, leaves would not necessarily benefit from more efficient drainage. Reducing residual moisture is not necessarily the only adaptive significance of drip tips either. For example, we read in old OTS course books that others have hypothesized that smaller droplets from leaves reduces splash and soil displacement below the plant. This could decrease the amount of soil and moisture splashing back onto the lower leaves, which can reduce harmful fungal growth. Smaller droplets might also cause less local erosion of the limited tropical topsoil.

We have demonstrated that drip tips do enhance drainage of water from leaf surfaces. Follow-up studies could investigate if this trend holds for more than the three particular leaf types we studied, and assess the effects of leaf surface moisture on epiphyll growth, and the costs and benefit associated with epiphylls on leaves.