

Driptips, Drop Size and Leaf Drying

While most hypotheses purport that leaf driptips facilitate drying of the leaf surface through water removal after rainfall (Richards 1952), one other possible function of driptips is to reduce the drop size of leaf runoff and thereby abate soil erosion under a plant (Williamson 1981). And the ecological distribution of phenotypic traits often provides evidence to evaluate such alternate hypotheses.

Within wet tropical forests relative humidity decreases from ground level to the canopy, so evaporation potential is greatest in the canopy and lowest at the soil surface. Consequently, the rate of post rainfall leaf drying should be an increasing function of leaf height. If driptips function in water removal to facilitate leaf drying, then they should be well developed in the lower plant strata and poorly developed in the canopy.

However, if driptips function to reduce drop size, they should be poorly developed in ground stratum plants because drops from leaf runoff attain little velocity and cause little erosion when falling less than 0.5 m. Driptips should be evident from the shrub layer to intermediate heights where leaf runoff directly impacts the soil with sufficient velocity to cause splash erosion. Higher in the canopy, leaves should lack driptips because runoff is intercepted by lower foliage.

Both functions, leaf drying and drop size reduction, predict a decline in development of driptips from intermediate heights to the canopy, and this pattern has been widely observed (Richards 1952). However, scant data are available for the understory shrub and ground layers.

Understory and ground strata plants were sampled in lowland wet forest at the Organization for Tropical Studies' Finca La Selva. All plant species less than 2.0 m tall were sampled in two transects, 1 m by 15 m, one in primary forest and one in a cacao plantation abandoned for twenty years. The two sites were selected because they contained somewhat distinct sets of understory species. Plants in the cacao transect were usually less than 1 m tall, so the transect was extended an extra 10 m to record more species in the height range 1.0–2.0 m. Driptip width, measured at 3.0 mm from the leaf tip, and leaf height at the tip were recorded for the highest and lowest intact leaves on each

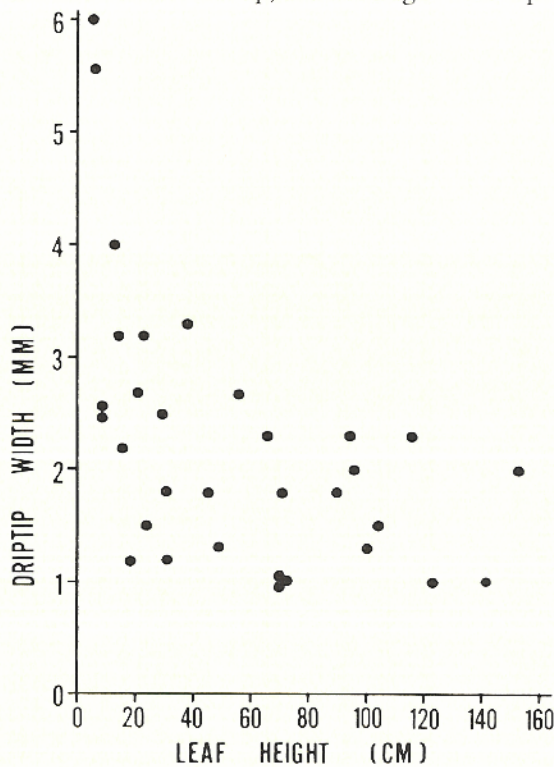


FIGURE 1. Mean driptip width, measured 3 mm from the tip, and mean leaf height of La Selva understory plants.

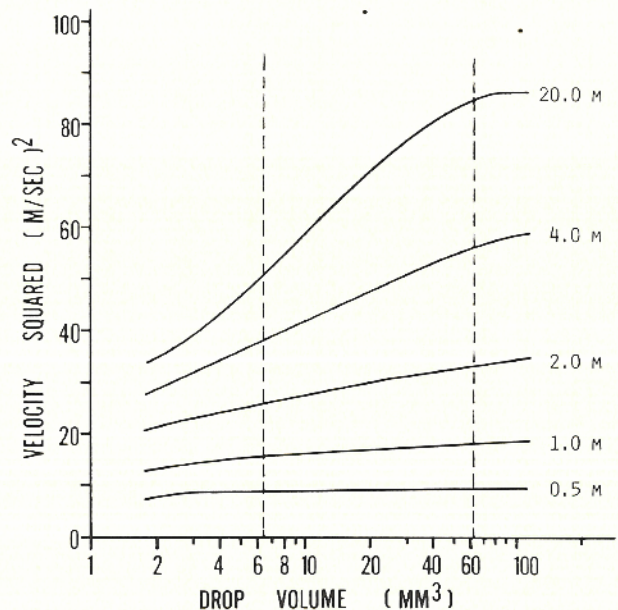


FIGURE 2. Square of the velocities of water drops of different volumes after falling different distances (modified from Laws (1941)). Broken lines indicate the maximum and minimum drop volumes measured from tips of leaves (Williamson 1981).

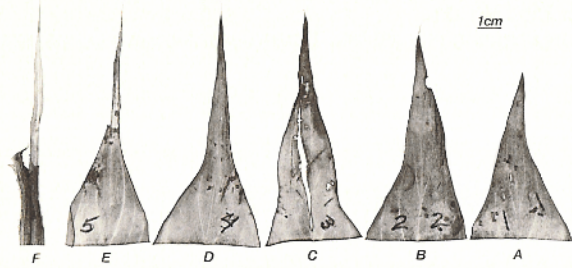


FIGURE 3. Excised tips of leaves of a 3 m stem of *Heliconia mathiasii*. Leaves were removed from stem bottom to top (A to F). All leaves were fully expanded except F.

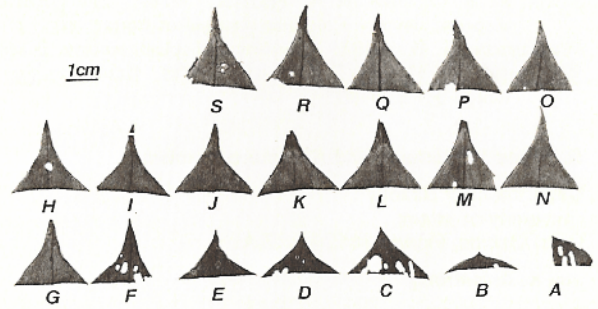


FIGURE 4. Excised tips of leaves of a 2 m stem of *Costus malortianus*. Leaves were removed from stem bottom to top (A to S). All leaves were fully expanded, but herbivore damage is apparent.

plant. When available, three plants of each species were measured within each transect. If fewer than three plants occurred in the transect, plants from the adjacent area were sampled to satisfy the deficiency. Seedlings of canopy trees were not included in the study because canopy species often lack driptips.

Driptip widths and leaf heights from both transects are plotted in Figure 1. (Species' data appear in the Appendix.) A Spearman rank correlation of mean driptip width and mean leaf height reveals a highly significant inverse relationship ($r_s = -0.60$, $P < 0.01$, $N = 32$), indicating that driptips are more acuminate in taller plants over the range of heights sampled.

The observed relationship is predicted from the kinetic energy of falling water drops. The kinetic energy of a falling water drop, which will translate into work done in displacement of soil and water upon impact, is given by the product of one-half the mass of the drop and the square of its velocity (v^2) at impact. For a given volume of water running off a leaf, mass is constant, but velocity is not; smaller drops, produced by more acuminate leaf tips, attain lower velocities than do larger drops. The maximal difference in velocity between large and small drops is reached at their terminal velocities, which are approached asymptotically with increasing height of fall (Laws 1941). The resultant differences in kinetic energy ($0.5 \text{ mass} \times v^2$) can be compared directly as the differences in v^2 of different drop sizes falling from different heights because the mass of a given volume of water is constant whether the water falls as a few large drops or many small drops. Figure 2 shows that the reduction in drop size lowers the v^2 and that the effective reduction increases with height of fall up to 20 m, a distance sufficient to allow development of terminal velocities by the falling drops (Laws 1941). Kinetic energy differences below 0.5 m are negligible within the known range of drop volumes of leaf runoff, 6.5–62.5 mm³ (Williamson 1981) as shown by the broken lines in Figure 2.

Richards (1952) emphasized driptip presence in the lower tree story and absence in the canopy by citing some canopy species that produce leaves with driptips as saplings but not as adults. A previously undescribed and equally notable fact is that some understory plants show increased driptip development on their higher leaves. Figure 3 shows the pattern for leaf tips removed from *Heliconia mathiasii*; leaves were from a single 3 m vertical stem from bottom to top (A to F). Figure 4 shows tips of leaves removed from a 2 m vertical stem of *Costus malortianus* from bottom to top (A to S). Clearly, driptip development is enhanced on the upper leaves in these two species.

Related studies of falling water have shown that increasing drop size of direct rainfall increases soil displacement (Wischmeier and Smith 1958) and that drop size of leaf runoff affects the efficiency of splash-cup and springboard dispersal mechanisms (Savile and Hayhoe 1978). Driptips may provide a natural mechanism to minimize soil erosion through drop size reduction of leaf runoff.

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APPENDIX

Species (family), mean driptip width in mm, and mean leaf height in cm for plants in the primary forest and in abandoned cacao transects are given below.

PRIMARY FOREST TRANSECT: *Danaea wendlandia* (Danaeaceae) 5.7, 7; *Socratea durissima* (Arecaceae) 1.0, 70; *Thelypteris lingulata* (Thelypteridaceae) 2.3, 66; *Saccoloma* sp. (Dennstaedtiaceae) 1.8, 31; *Henrietella tuberculata* (Melastomataceae) 1.8, 72; *Clidemia densiflora* (Melastomataceae) 2.3, 116; *Cyclanthus bipartitus* (Cyclanthaceae) 1.0, 123; *Psychotria suerrensis* (Rubiaceae) 2.2, 16; *Spathophyllum weddiana* (Araceae) 2.7, 22; *Cyathea multiflora* (Cyatheaceae) 2.0, 153; *Zebrina huebuetecana* (Commelinaceae) 2.5, 8; *Piper* sp. #1 (Piperaceae) 6.0, 6; *Conostegia* sp. #1 (Melastomataceae) 2.0, 96; Unknown sp. 3.2, 14; *Geonoma congesta* (Arecaceae) 1.0, 142; and *Spathophyllum fulvovirens* (Araceae) 1.3, 48.

CACAO FOREST TRANSECT: *Panicum lacsum* (Poaceae) 1.2, 32; *Standleyacanthus* sp. (Acanthaceae) 3.2, 23; *Calathea microcephala* (Marantaceae) 2.5, 8; *Piper* sp. #2 (Piperaceae) 2.7, 56; *Conostegia* sp. #2 (Melastomataceae) 4.0, 13; *Palmorchis* sp. (Orchidaceae) 1.5, 24; *Dieffenbachia* sp. (Araceae) 1.2, 28; *Renanthera cernua* (Zingiberaceae) 1.3, 101; *Campelia zanonii* (Poaceae) 1.0, 70; *Carludovica palmata* (Cyclanthaceae) 1.5, 104; *Miconia barbanervis* (Melastomataceae) 1.8, 90; *Piper* sp. #3 (Piperaceae) 2.3, 94; *Welfia georgii* (Arecaceae) 1.0, 71; *Psychotria marginata* (Rubiaceae) 2.5, 28; and *Psychotria brachiata* (Rubiaceae) 1.8, 46.

Species common to both transects: *Costus malortianus* (Costaceae) 3.3, 38.