THE EFFECTS OF LEAF MORPHOLOGY ON WATER CONDUCTION IN A MONTANE CLOUD FOREST

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ABSTRACT (AEL)

We studied the efficiency of water conduction of the surfaces of various plant species in their different sample sites on Cerro Cacao, Costa Rica. Because it may be advantageous to remove surface water to maximize photosynthesis and reduce epiphyllic growth, we predicted that there would be more leaves that could efficiently conduct water off their surfaces in wetter than dryer areas. We characterized leaves based on a priori scale of water conduction efficiency and tested their ability to shed water. Our results showed that leaves in wetter areas were more efficient at conducting water; however, there was no significant relationship between epiphyllic growth and water retention.

Key Words: epiphylls, drip tip, leaf morphology, montane wet forest

INTRODUCTION (JLB)

In the cloud forest of Cerro Cacao, leaves vary considerably in shape and leaf-surface characteristics; glabrous and pubescent, elaborate venation patterns, heart shaped and sheath-like (Appendix I). All leaves, however, were similar in one aspect: their apex was tapered, forming a "drip tip".

Drip tips have been shown to be effective at conducting water off of the surface of the leaf, which is important in the high humidity and rainfall of the montane forest, presumably to minimize epiphyll growth. Epiphylls impair photosynthetic activity of leaves and often are parasitic upon their hosts (Richards, 1952).

The leaves of the introduced citrus trees at the station were covered with a white epiphyll, yet none of the nearby understory growth appeared to be hosts. Further exploration in wetter areas of Cerro Cacao revealed a greater abundance of epiphyllic growth on the ground over species.

Given these observations, we hypothesized that there are certain morphological characteristics which enhance water conduction off of leaf surfaces, and would serve to minimize epiphyll establishment.

METHODS (AEL)

We conducted our study in three areas with different understory microclimates west of Cerro Cacao, Guanacaste Province, Costa Rica. We randomly selected five 1 x 1m understory plots within each of the three sites. Site one was located in a wet montane forest near the top of Sendero Cacao, site two was an area of intermediate moisture of the foot of Sendero Cacao, and site three was a dry, more open site along the trail on the eastern face of Cerro Pedregal. We took soil samples at the middle plot in each site and weighed them before and after drying overnight in order to determine the soil moisture characteristic of each site. In each of five plots, we collected samples of every species of herbaceous ground cover present (1 stem with > 3 leaves). We found 30 species in the dry site, 16 species in the intermediate site, and 21 in the wet site. We categorized the leaves according to five morphological characteristics which we assumed to be indicators of efficient conduction of water from the leaf surface. These characteristcs were: 1) lowered midvein, 2) tapered leaf apex ("drip tip"), 3) prominent primary veins, 4) glabrous surface, and 5) minimal distance from midvein to leaf edge.

For the fifth category, the measurements of distance from midvein to leaf edge was evaluated as small or large based on whether the value was above or below the mean. We used the number of characteristics present as an index of water conduction efficiency. We also noted the presence or absence of epiphyllic growth on the leaves.

To measure efficiency of water conductance, we held each stem under the shower for 30 seconds, (Due to a water shortage near the end of the study, we were forced to improvise using a squirt bottle and plastic bag) and then weighed three wet leaves from each species. After the leaf surface dried, we weighed them again. The difference between wet and dry mass divided by total mass gave us a percentage of water retained by each leaf (not conducted off surface).

We did a regression of water conduction index versus percent water retained for all three sites. For each site, we also compared the means of water conduction indices and percent water retained. We calculated a G-statistic to test for independence between the presence of epiphylls and water retention.

RESULTS (JLB)

Soil moisture was lowest at the Sendero Pedregal site, and greatest at the higher elevation Sendero Cacao site (Figure 1). This supported our initial characterization of the sites as "dry", "intermediate", and "wet".

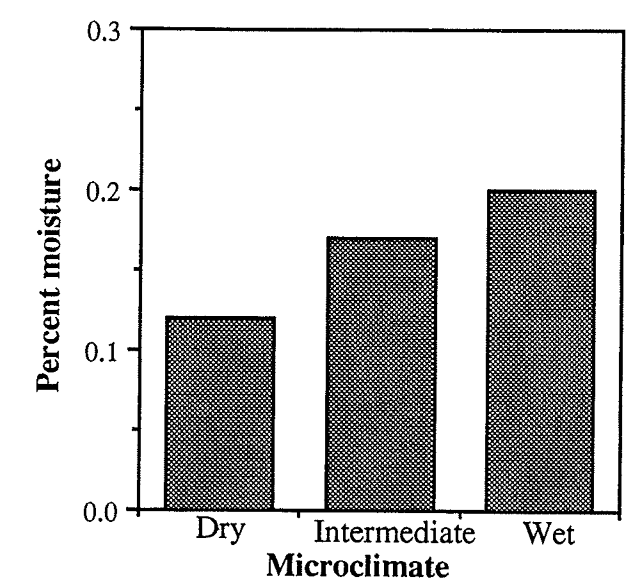


Figure 1. Soil moisture content of three sample sites

Table 1: Number of plant species with and without epiphylls at the wet site. Plant species were classified as having low or high water retention (based on rank order from Figure 3)

	Number of plant species	
	low water retention	High water retention
Epiphylls	7	5
No Epiphylls	3	6

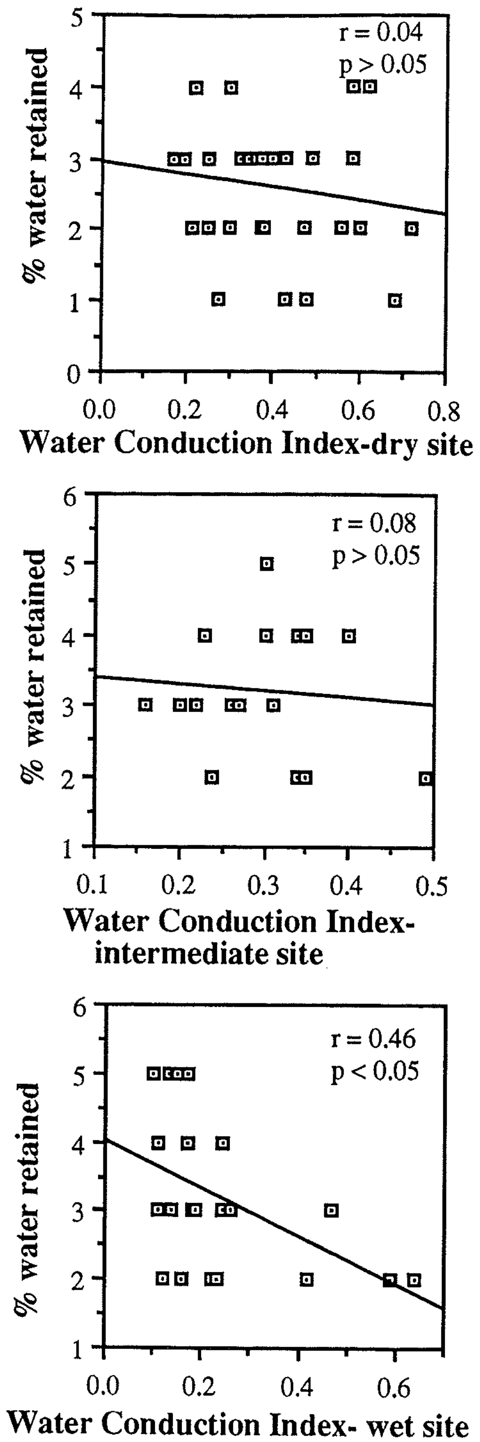


Figure 2. Observed leaf water retention compared to expected conduction efficiency at three different sites.

There was no significant relationship between percent of water retained per leaf and rank on the water conduction index for the dry or intermediate sites (Figure 2). However, there was a significant negative relationship for the wet site ($p < 0.05$; Figure 2).

Leaves at the wet site displayed none of our five water conduction characteristics than leaves in the dry site ($F_{63} = 3.33$, df = 2, p = 0.04) while the intermediate sites rank was equal to that of the wet site (Figure 3).

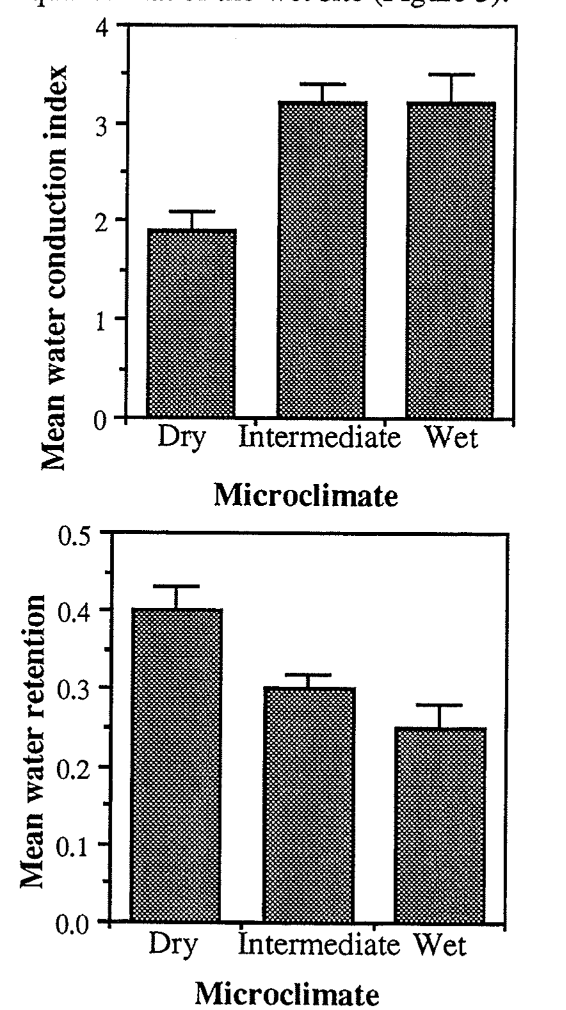


Figure 3: Mean index of water conduction and water retention for three sites.

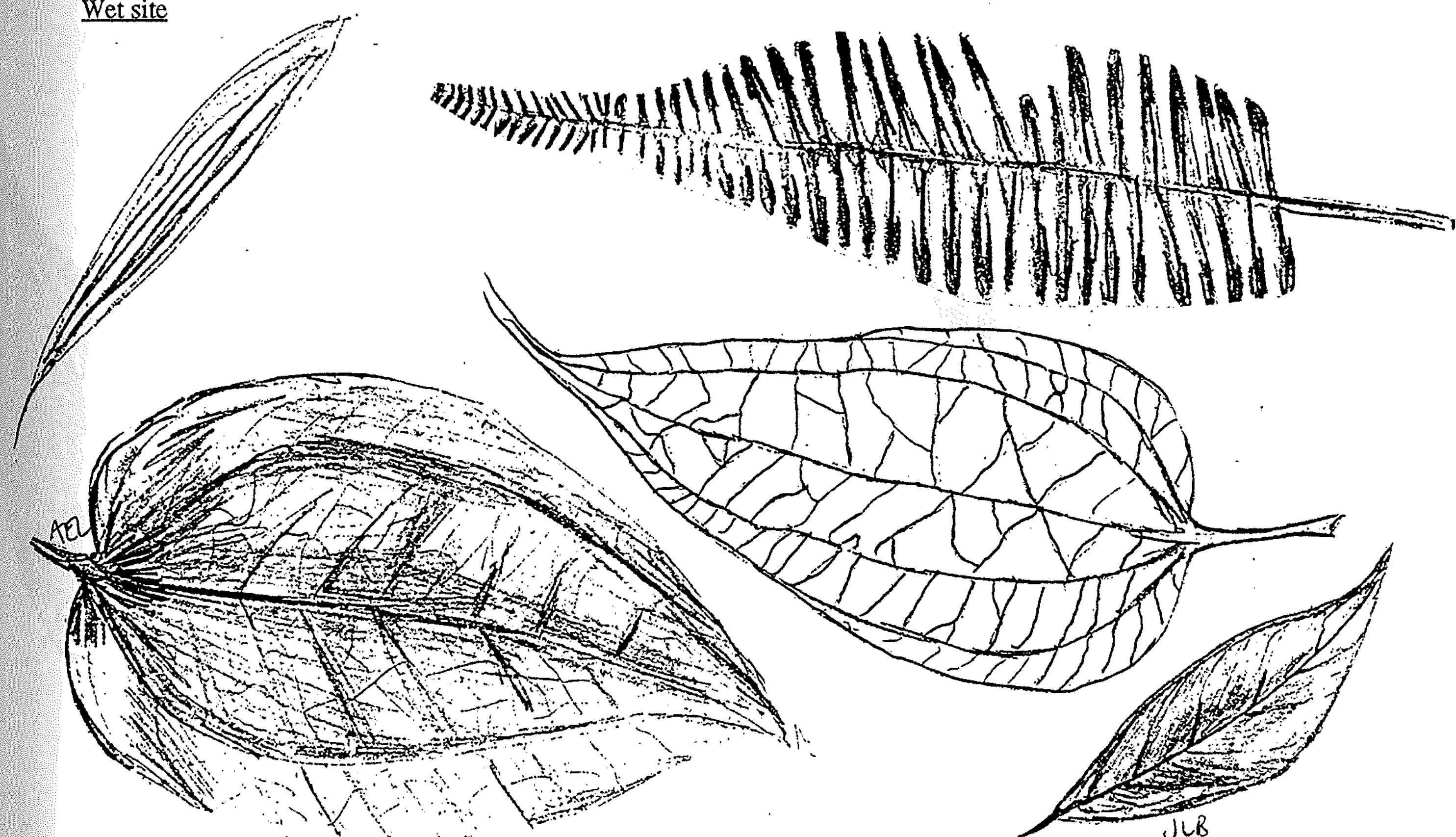
Water retention of leaves from the dry site was significantly greater than that of leaves from the wet site ($F_{63} = 8.3$, df = 2, p = 0.0006, Figure 3). Within the wet site, epiphyllic growth was not clearly related to water retention (G = 0.64, $p > 0.05$; Table 1)

DISCUSSION (AEL)

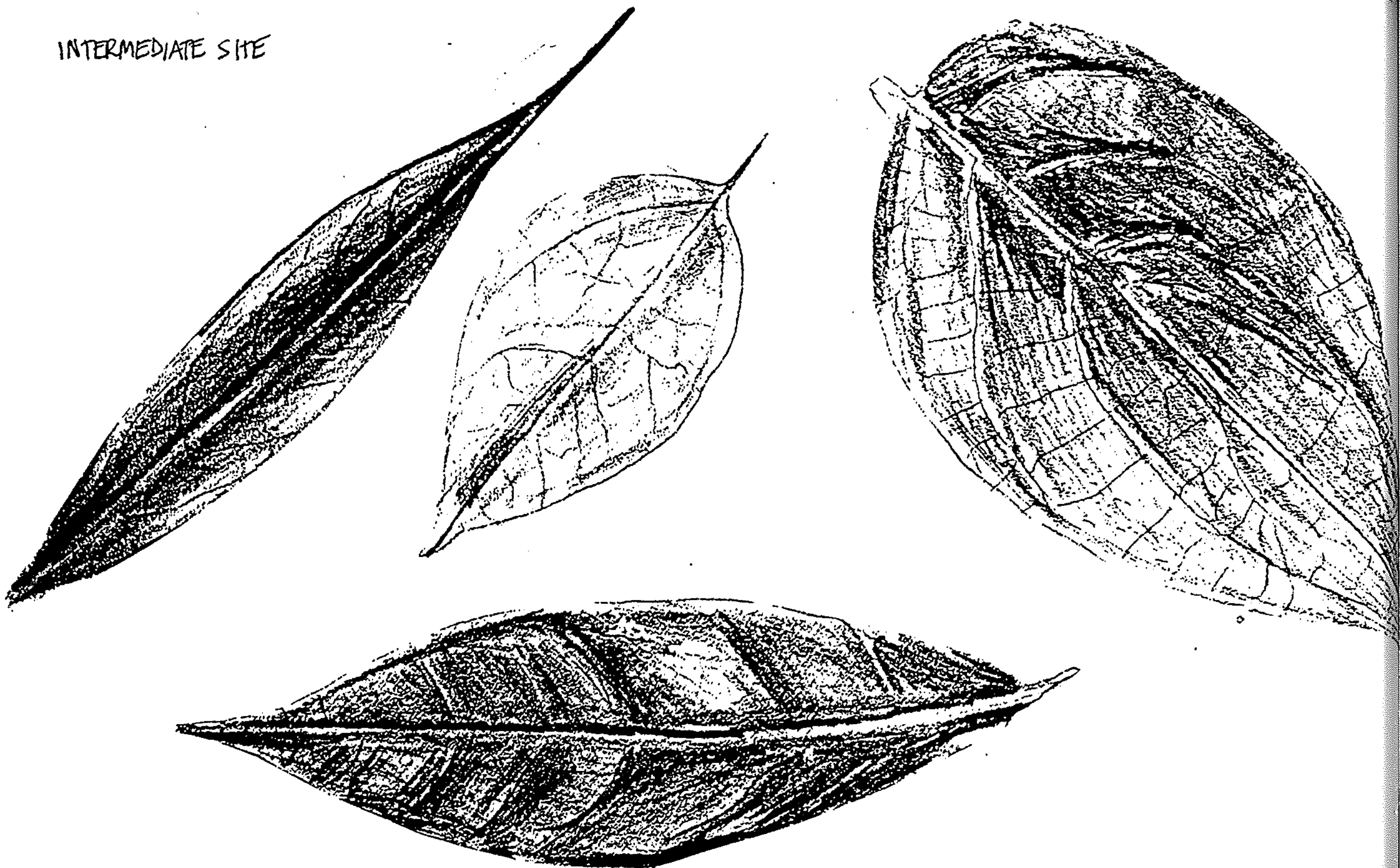
These findings suggest that leaves in areas of greater moisture are more efficient at water conduction. Our water conduction index appeared to be a good general prediction of actually conduction efficiency. Howver, epiphyll presence was not statistically linked to water conduction. Thus, the relationship between epiphyllic growth and water on leaf surfaces, which is the basis for these hypotheses, remains unclear. Further study with larger numbers of plant species and more rigorous characterization of epiphyll coverage would be beneficial. It is also likely that our five characteristics of water conduction efficiency were not comprehensive. Water conduction efficiency may not be based solely on leaf morphology. For instance, we did not account for the potential impact of sunlight or prevailing winds on evaporation from leaf surfaces. Further studies should investigate these other factors.

Appendix. Illustrations of leaf morphologies present in dry, intermediate, and wet sites, Cerro Cacao.

Wet site



INTERMEDIATE SITE



DRY SITE