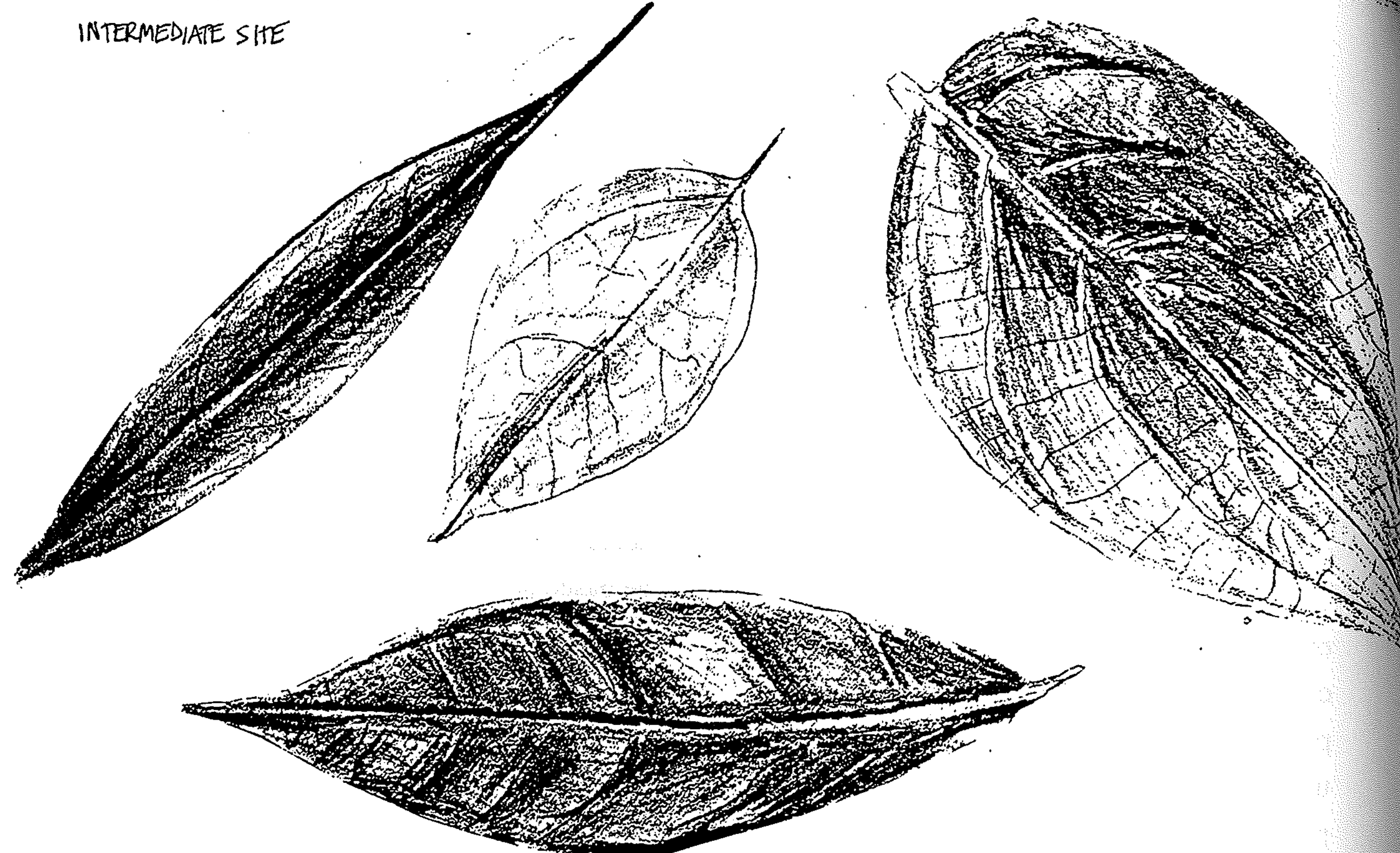

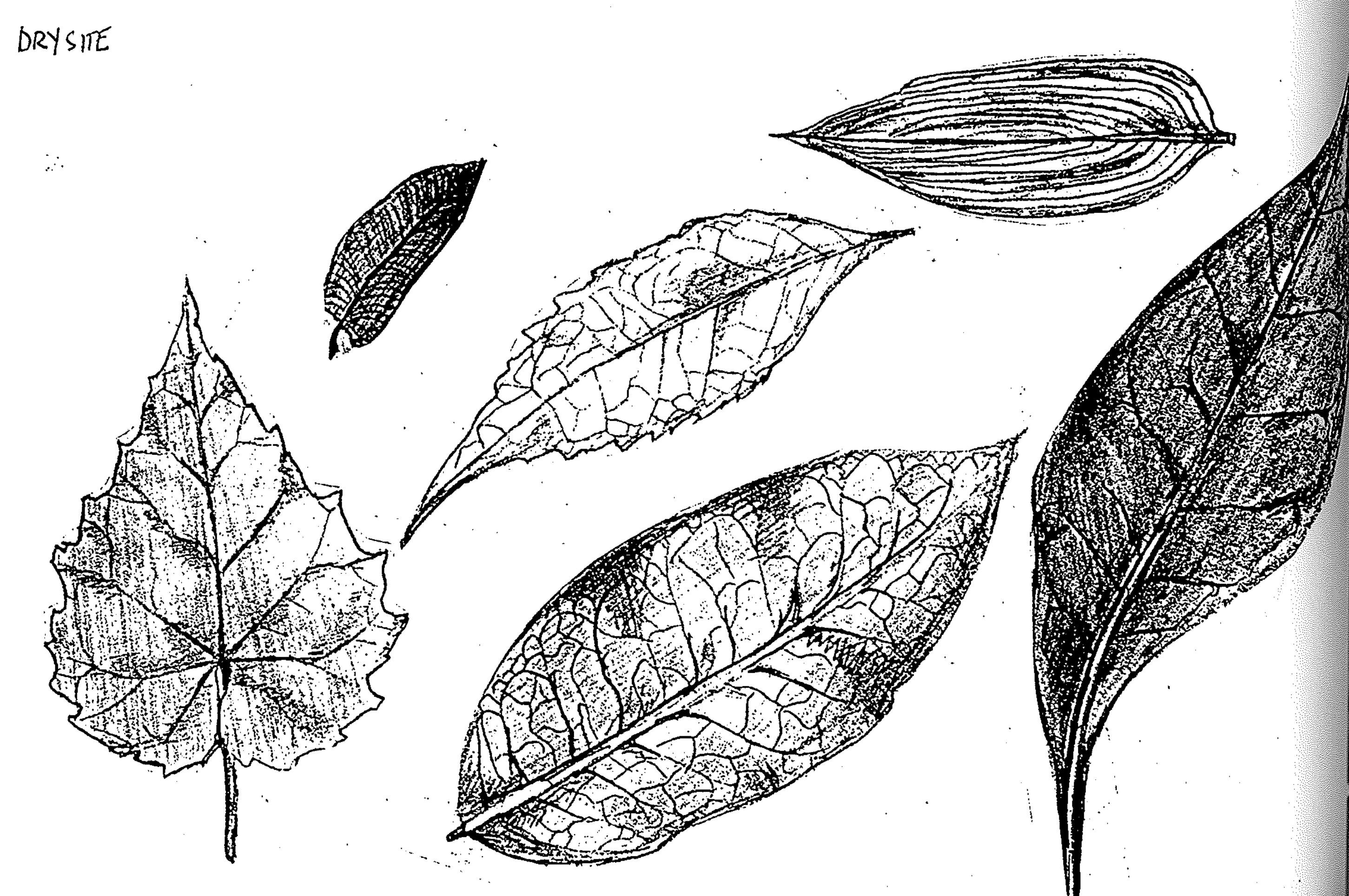

LEAF MORPHOLOGY AS A FUNCTION OF LIGHT INTENSITY, WIND SPEED AND MOISTURE: A STUDY OF MELASTOMATACEAE IN A MONTANE FOREST

Hannah M. Fouts and Pamela L. Kunz

ABSTRACT (PLK)

We examined leaf morphology of various species in the family Melastomataceae in Cerro Cacao, Guanacaste Province, Costa Rica. We hypothesized that light intensity, wind speed and soil moisture would affect the leaf morphology of Melastomataceae and the surrounding flora in similar ways. In sites with high wind speed, the mass, toughness, and surface area tended to be low, with intermediate levels of light intensity, mass toughness, area and specific mass were high; and with increasing moisture, mass toughness, area, and specific mass tended to increase. Pubescence was most common in areas of low moisture and high wind. Plasticity of leaf morphology within the Melastomataceae may contribute to their success in tropical systems.

INTRODUCTION (HMF)

Melastomataceae is a diverse family of tropical dicots containing 240 genera and 3000 species, including treelet, understory, subcanopy and epiphytic growth forms. Habitats encompass wet slopes, windy ridges, dry plateaus, and sunny pastures (Janzen, 1983). We hypothesized that environmental characteristics such as light intensity, wind speed, and moisture availability would contribute to differences in leaf characteristics. For example, we predicted that as wind increased, toughness would increase and leaf area decrease to reduce physical damage. We also hypothesized that the vegetation surrounding Melastomataceae should follow similar trends in leaf morphology. This allowed us to test whether melastomates are phylogenetically constrained in their leaf morphology relative to the plant community as a whole.

METHODS (HMF)

We conducted our study in the premontane cloud forest of Cerro Cacao, Guanacaste Province, Costa Rica. We chose eleven sites with 11 different Melastomataceae species and varying environmental conditions. Seven sites along the main trail of Cerro Cacao (west, southwest exposure) typified moist, low light, low wind conditions. For contrast, we also chose four sites along the trail leading to the summit of Cerro Pedregal (eastern exposure) where the environment was much drier and windier. Each site contained a different focal species of Melastomataceae, from which we collected two leaves. We established a 10m transect parallel to the trail, 5m on each side of the focal plant. At 1m intervals along the transect, we removed 2 leaves from the nearest plant of any taxa. At the focal melastomate we measured light intensity (light meter, Extech Instruments), wind speed (anemeter, Dwyer Instruments Inc., Michigan City) and soil moisture. We estimated relative soil moisture as percent of initial mass lost to evaporation during 18 hours of drying at room temperature. For each leaf (n = 22 per site), we measured mass (Pesola ®, Switzerland), toughness (penetrometer, Chatillon Instruments, N.Y.), surface area, and specific mass (mass/area). The data were analyzed with linear and stepwise regressions.

RESULTS (PLK)

At sites with wind speeds > 10mph, the leaves from Melastomataceae and the associated floral community tended to have lower masses, lower toughness and smaller areas, although the specific mass of the leaves was more variable (Table 1, Figure 1). There tended to be an intermediate light intensity at which mass, toughness, area and specific mass were highest (Figure 2). As soil moisture content increased, the mass, toughness, area, and specific mass tended to increase (Table 1, Figure 3). We also performed a stepwise regression to test whether leaf morphology could be better explained by two or more independent variables. In no case was a regression model significantly improved by the addition of a second independent variable. Three out of four plant species with conspicuous pubescence were found in areas with windspeeds > 30mph and very low soil moisture.

A comparison of Melastomataceae with the associated floral community for each of the four leaf characteristics indicated that melastomates exhibit as much or more variation in leaf morphology as the full plant community (Figure 4). Variation in leaf mass and toughness was similar among melastomates and the

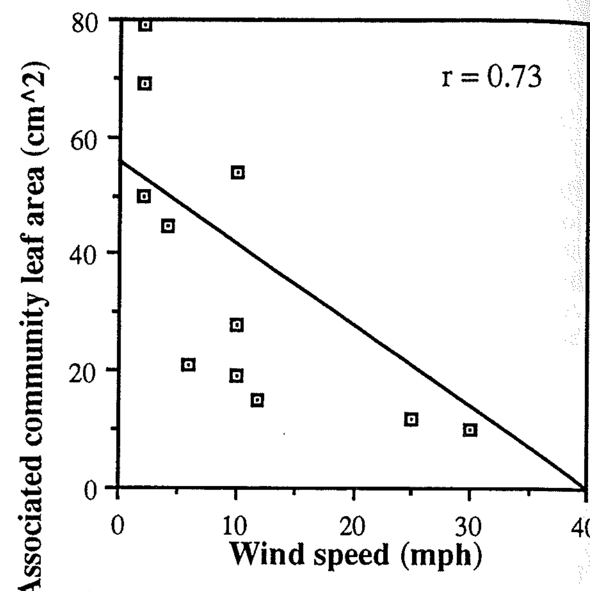

Figure 1. Associated community leaf area as a function of wind speed

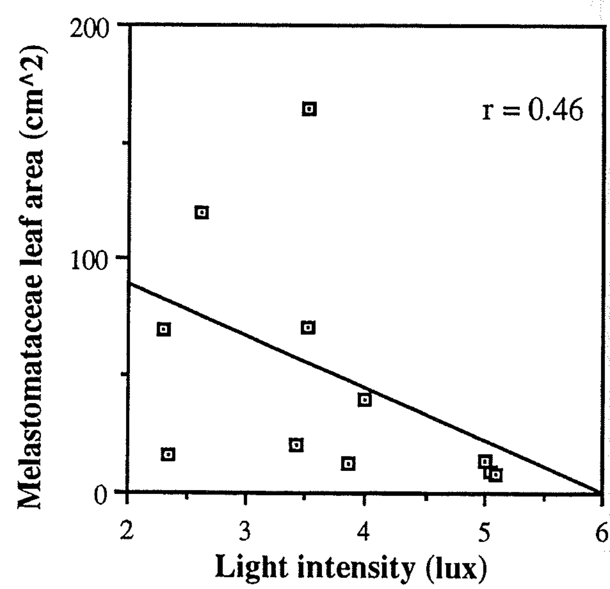

Figure 2. Melastomataceae leaf area as a function of light intensity

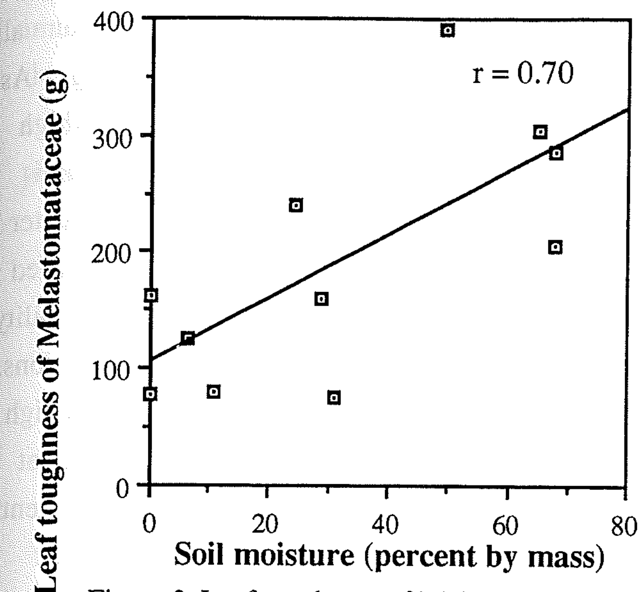

Figure 3. Leaf toughness of Melastomataceae as a function of soil moisture

surrounding plant community. At 8 of 11 sites, leaf mass and leaf toughness were less in the melastomates than in the surrounding vegetation, but variation within the melastomates was as large as variation in the surrounding vegetation (Figure 4). Leaf area and specific mass had similar means for the melastomates versus the surrounding vegetation (49.6 vs 36.5cm^2 and 0.27 vs .033 g/cm^2), but the variation among melastomates was actually greater than variation in the surrounding vegetation (standard deviations = 51.9 vs 24.0 cm^2 and 0.19 vs .0097 g/cm^2; Figure 4).

Table 1: A correlation matrix of light intensity, wind speed moisture, leaf mass, leaf toughness, leaf area, and leaf specific mass.

	Light Intensity (lux)	Wind Speed (mph)	Soil Moisture (% by mass)
Light Intensity (lux)	1.00	---	---
Wind Speed (mph)	0.79*	1.00	---
Soil Moisture (% by mass)	-0.42	-0.50	1.00
Melastomate leaf mass (g)	-0.22	-0.44	0.47
Melastomate leaf toughness (g)	-0.19	-0.48	0.70*
Melastomate leaf area (cm^2)	-0.46	-0.58	0.38
Melastomate leaf specific mass (g/cm^2)	0.14	0.00	0.50
Other leaf mass (g)	-0.21	-0.29	0.63*
Other leaf toughness (g)	0.48	0.39	0.37
Other leaf area (cm^2)	-0.82*	-0.73*	0.36
Other leaf specific mass (g/cm^2)	0.65*	0.59	-0.04

*$P < 0.05$ (critical value of r = 0.60)

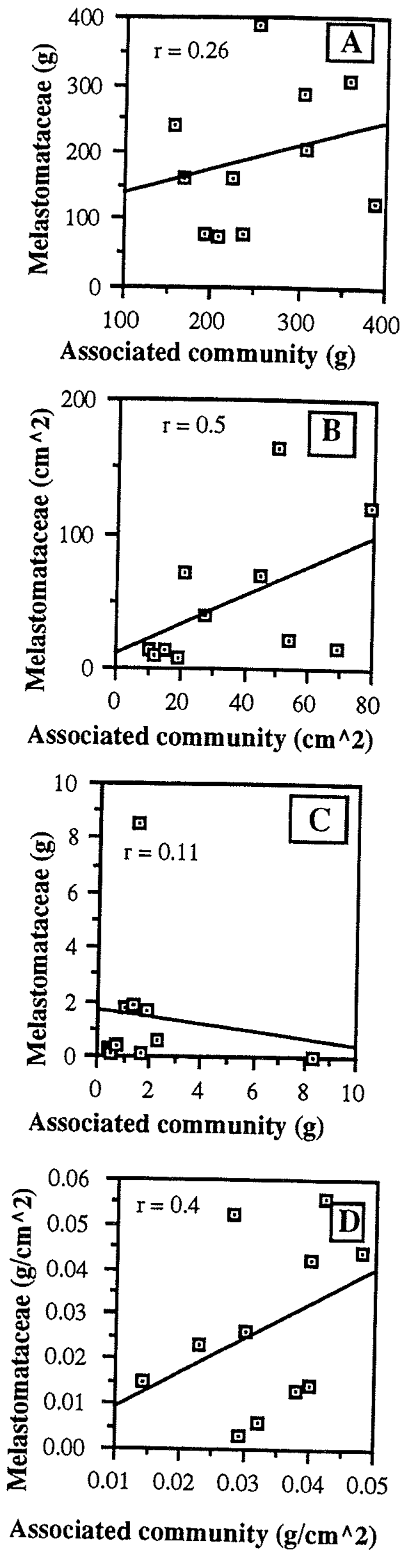

Figure 4. Foliage attributes of 11 spp. of Melastomataceae from a range of physical environments compared to the foliage of the neighboring plant communities.

DISCUSSION (HMF)

Wind, light intensity and soil moisture all appeared to contribute to leaf morphology. As predicted, leaves tended to be smaller in high wind environments, perhaps because it minimizes mechanical damage. However, counter to our prediction, overall toughness decreased in high wind sites possibly providing flexibility and buffering the impact of windier conditions. Smaller leaves dominate in both low and high levels of light intensity. Thus, large leaves at intermediate light levels may be more efficient at harvesting the intermediate levels of solar radiation. Multiple light readings at each site would strengthen the results as single readings cannot encompass diurnal variation. Pubescence was most common in drier habitats, suggesting that these hairs trap water and reduce transpiration by increasing the leaf boundary layer.

Presumably, both genotypic and phenotypic variation contribute to observed patterns in leaf morphology although our results do not allow us to assess their relative contributions. Investigations using clones and genetically identical individuals in various habitats may help to separate these contributions. In addition, further studies should include a larger number of Melastomataceae leaves (e.g. five leaves per site) in order to balance the large sample size surrounding vegetation types. Sampling additional sites with additional combinations of environmental variables (i.e. low moisture with low wind or high sun and low wind) may reveal further adaptations in leaf

morphology and allow us to separate the contributions of wind, sun, and moisture.

Our results indicate extensive variation in leaf morphology within the Melastomataceae; there was no suggestion of phylogenetic constraint. Evolutionary plasticity in leaf morphology may contribute to the success of melastomates in tropical systems

LITERATURE CITED

Hartshorn, G.S. 1983. "Plant Introduction" page 171 in D.H. Janzen, editor, Costa Rican Natural History. 1983. The University of Chicago Press: Chicago and London.