Monstera, the early years

Maureen L. Coleman, Kristin S. Nowak and Robert F. Rogers

Abstract: Some plants have evolved the ability to switch leaf morphology during development, and this plasticity may enable them to survive in a broader range of conditions than would otherwise be possible. *Monstera tenuis*, a tropical climbing vine, undergoes a heteroblastic series of leaf morphology changes during its life. Although the developmental point at which *M. tenuis* shifts to its second leaf morphology is genetically predetermined, the timing of this change may be affected by environmental conditions. We hypothesized that light regime affects the height of leaf morphology change. We also explored the hypotheses that herbivory or epiphytic load may affect the growth rate of the first morphology leaves. We found that neither PAR nor canopy cover affected height of leaf morphology change. Herbivory appeared to have no effect either, but epiphyte load on the host tree was positively correlated with internode length and negatively correlated with height of leaf change. Epiphytes could change microclimate conditions and thereby affect *M. tenuis* growth. The environmental factors influencing timing of morphology change warrant further study, as do the costs and benefits of this developmental plasticity.

Key Words: Araceae, epiphyte, heteroblasty, Janzen's credibility, leaf morphology, Monstera tenuis, *PAR*

Introduction

Plants have evolved a wide variety of morphologies that may be adaptive for a wide variety of habitats. Some species have the ability to change morphology during development, which may maximize their fitness in different environments. Morphological changes can result from environmental cues (heterophyllic) or be genetically predetermined and occur regardless of external factors (heteroblastic). *Monstera tenuis* (Araceae) is a neotropical climbing herbaceous vine that changes its leaf morphology when its leaves reach a certain size. Although it has been established that *M. tenuis* leaf transitions exist in a heteroblastic series, environmental factors may affect the rate at which leaf morphology changes occur (Janzen 1983).

M. tenuis seedlings must germinate within 1 – 2 m of a tree if they are to survive through the leafless skototropic phase on resources in the seed endosperm reserves. Upon reaching a host tree, seedlings produce small round leaves that are pressed against the trunk and increase in size as the vine ascends. When the appressed leaves reach approximately 25 – 30 cm in size, leaf morphology changes to a larger pinnatified form, developing deep clefts and resembling fern fronds that are held well away from the trunk on their petioles (Janzen 1983).

Janzen (1983) stated that environmental factors are not responsible for the change from appressed to pinnatified leaf morphologies, but hypothesized that increased light availability can cause appressed leaf size to increase more rapidly to the 25 – 30 cm height threshold. Thus, the morphological change could occur sooner in time (i.e., lower on the host tree) in high light areas. Alternatively, it is possible that in shady areas, *M. tenuis* would undergo the change sooner to increase light capture. We hypothesized that light availability does affect the timing of the morphological change in *M. tenuis*. Contrary to Janzen, we predicted that in areas of low light availability, *M. tenuis* would switch morphology lower on the host tree to increase light gathering potential. We also explored the hypotheses that herbivory or epiphyte loads on the host tree could influence the height of the morphological change.

Methods

On the afternoon of 15 February 2002, we sampled 30 individuals of *M. tenuis* exhibiting both appressed and pinnatified leaf morphologies in secondary forest along the first 1300 m of the Sendero Tres Rios at La Selva Biological Station, Costa Rica. For each individual, we measured the height on the host tree at which the first pinnatified leaf occurred. We used a quantum light sensor to measure photosynthetically active radiation (PAR) at the height of the morphological change and at three or four 60 cm increments downward along the trunk of the tree to quantify light extinction. We also measured canopy cover with a spherical densiometer at waist height near the vine and diameter at breast height (DBH) of the host tree.

On the afternoon of 16 February, we explored the hypotheses that herbivory or epiphytic load may affect the growth rate of the appressed leaves. We sampled 16 individuals of *M. tenuis* along the Sendero Tres Rios, eight plants showing the two leaf morphologies and eight plants that had not yet changed from appressed leaves. For each individual, we measured canopy cover at waist height and PAR at the first pinnatified leaf or at the highest point of the vine for the individuals that had not yet undergone the morphology change. We measured leaf size and distance between nodes for five consecutive leaves, starting at a constant height for each individual. Leaf size was measured from the leaf base to the widest point on the opposite edge of the leaf. We scored herbivory on a scale of 0 to 4 (0 = unaffected, 1 = < 25% damage, 2 = < 50% damage, 3 = < 75% damage, 4 = > 75% damage) for three leaves on each vine, starting at a constant height and surveying every third leaf. We categorized epiphyte load on each host tree as either low, medium or high within 3 m of where PAR was measured. We tested for correlations among all the tree properties, vine characteristics, and environmental factors within each data set or within the second day's sampling (n = 16).

Results

The height at which leaf morphology changed varied from 247 to 555 cm (Table 1). From our first day's sampling (n = 30), we found no relationship between height of morphology change and PAR at the change or canopy cover (Table 2). The PAR 120 cm below the morphology change was also not related to height of change ($r = 0.07$, $df = 29$, $P = 0.70$).

In the vines that had not changed morphology (n = 8), we found a correlation between internode distance and leaf size (Table 2). Vine height was correlated to amount of herbivory damage ($r = 0.75$, $df = 7$, $P = 0.03$). In our sample of vines with both morphologies (n = 8), we found a significant correlation between epiphyte load and internode distance and epiphyte load and height of change (Table 2). Node length tended to be negatively correlated with height of change, while herbivory and height of change were not correlated (Table 2).

TABLE 1. Summary of morphological and environmental measurements of *Monstera tenuis* (n = 30) at La Selva, Costa Rica.

	Mean	SD	Minimum	Maximum
Height at morphology change (cm)	376.1	81.1	247	555
PAR at morphology change ($\mu mol*m^{-2}*s^{-1}$)	55.3	51.2	7.5	259.0
Canopy cover (% closure)	93.5	6.6	63.6	100
Diameter of tree at breast height (cm)	37.9	28.2	4.8	132.7

TABLE 2. Correlation matrix of factors hypothesized to affect leaf morphology change in *M. tenuis*.

	Height at morphology change	PAR at morphology change	Canopy cover	Inter-node length	Leaf size	Herb-ivory score	Epiphyte score	DBH
Height at morphology change	1	0.04[a]	0.11[a]	-0.59[b]	ND	0.26[b]	-0.79[b]*	-0.22[a]
PAR at morphology change	-	1	-0.38[a]	-0.03[b]	ND	<.01[b]	-0.32[b]	-0.15[a]
Canopy cover	-	-	1	0.03[c]	-0.10[b]	-0.36[c]	-0.42[c]	-0.22[a]
Internode length	-	-		1	0.96[b]***	0.25[c]	0.53[c]*	ND
Leaf size	-	-		-	1	-0.01[b]	0.58[b]	ND
Herbivory score	-	-		-	-	1	-0.29[c]	ND
Epiphyte score	-	-		-	-	-	1	ND
DBH	-	-		-	-	-	-	1

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$
[a]n = 30, [b]n = 8, [c]n = 16
ND = no data

Discussion

Our hypothesis was rejected; light availability did not affect height at which *M. tenuis* leaf morphology changed. We found no evidence for the prediction that in high light, increased leaf growth rate will cause the morphology change lower on the tree. We also found no evidence for the competing prediction that in shady environments, the change will occur sooner to increase light gathering potential. We therefore looked to other hypotheses to explain the variation in growth rate and height of change that we observed.

Herbivory could conceivably affect growth rate and height of morphology change in *M. tenuis*. Due to diminished photosynthetic area, individuals sustaining high herbivory damage may have lower growth rates with smaller internode distances and leaf sizes, and thus change morphology higher up the tree. However, we saw no correlation between herbivory damage and internode length or leaf size. Apparent growth rate (based on internode distances and leaf sizes) and height of morphological change, were not affected by herbivory.

Another plausible factor affecting height of change is epiphyte load on the host tree. Besides blocking light, epiphytes could be competing for space on the trunk and/or changing the microclimate on the host tree. We found that as epiphyte load increased, internode distance increased, and the morphology change occurred lower on the tree. It is possible that some other factor is creating suitable epiphyte habitat on the tree, and that this factor is also responsible for *M. tenuis* changing morphology low on the tree.

Other factors such as soil microhabitat could be affecting the height of change. Nutrient-rich microsites may enable faster growth and a lower height of change. Future studies could also investigate the runner stage, from when the seed germinates until it reaches the host tree. If this distance is long and seed reserves are quickly diminished, the individual may grow slowly at first, potentially affecting the height of change.

It is difficult to assess the environmental factors that influence the timing of the heteroblastic change in *M. tenuis* because a snapshot of present conditions does not necessarily reflect historical conditions. Therefore the most valuable future studies will track individuals through time, monitoring environmental conditions and growth rates. The ability of *M. tenuis* to undergo this morphological change may increase niche breadth, enabling the plant to grow in a variety of light regimes and on a variety of tree species (Owens 2001). It also appears to offer protection from herbivory during the appressed leaf stage (Strauss 2000). An analysis of the costs and benefits of this developmental switch may provide insight into its adaptive value.

Literature Cited

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