ALLELOPATHY IN TREE FERNS (CYATHEACEAE)

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Abstract (C.G.)

Allelopathy has been described for tree ferns colonizing fresh landslides, but it is largely uninvestigated for other conditions. We mapped the distribution of three genera of tree ferns - Trichipteris sp., Nephelea sp., and Cnemidaria sp. - on - five 254m^2 plots adjacent to the S. Brilliante ridge of Monteverde, Costa Rica. We predicted that allelopatric chemicals from an established tree fern would leach through the soil, allowing only conspecific spores to germinate. Neither Trichiptenis Sp. nor Cnemidaria Sp. within the drainage area of an established conspecific than above it. This distribution fits our predicted pattern of allelopathy, but could be attributed to other factors as well.

Introduction (D.G.)

Evidence exists for the chemical control of plant distributions by the leaching of root exudates (Barbour et al 1987). Goméz (1983) proposes that tree ferns use an allelopathic mechanism that facilitates establishment of conspecifics in gap situations. Although there is no account on record on the ecology of tree ferns, they may leach phytotoxins that are selectively toxic to other genera of the tree fern family, cyatheaceae (Goméz 1983). Such a mechanism would create a microenvironment that is favorable only to conspecifics and plantlets of the first established species. Thus, this mechanism creates a competitive advantage for the individual and its progeny. However, no evidence exists that indicates allelopathy is a driving force of succession in light gaps (Barbour et al. 1987).

To test the existence of this mechanism, we examined the distributions of three genera identified as Trichipteris, Nephelea, and Cnemidaria. These identifications may be incorrect. We reason that older individuals have influenced the success of propagules dispersed within the leaching "shadow" of the established tree. Our hypothesis states that the species composition downslope of the oldest tree fern in a study site should have more conspecifics than up slope of the oldest tree.

Methods (V.V.)

Our study was conducted on 31 January 1991, in Monteverde, Costa Rica, in a primary cloud forest area along Sendero Brilliante. We chose our study site on sloping

terrain that contained more than 15 tree ferns in a circular area of 9.0m radius. For the study site we chose a focal tree that was usually the largest and most centrally located tree fern in the survey site. The focal tree was used as the axis of measurement for the site. For each tree fern within a 9m radius of the focal tree we measured the following:

1) distance from focal tree;
2) direction from focal tree;
3) relative slope from focal tree;
4) DBH;
5) height.

We also classified each tree as belonging to Trichipteris, Nephelia or Cnemidaria. We conducted a map of the tree ferns in each of the 5 sites (Fig. 1 A-E). We analyzed the data, looking for patterns of clumping of conspecifics. We also looked for abundance of conspecifics in zones above and below a focal tree for each of the genera.

Results (C.G.)

We measured the distance from each individual to its nearest conspecific, and pooled the data for all five plots. Overall, Nephelia sp. occurred more closely clumped than either Trichipteris sp. ($n_1 = t = 4.218$, $p < 0.01$) or Cnemidaria sp. ($T = 4.373$, $p < 0.01$). There was no significant difference between Trichipteris's and Cnemidaria's proximity to their nearest conspecific ($t = 0.59$, $p > 0.5$).

For each map, we designated the largest individual of each of the three species as the forest tree for that species. For a drainage area 90° wide, downhill from each focal tree, and the opposite region uphill from the tree, we calculated the proportion of each species of all tree ferns. Neither Trichipteris sp. or Cnemidaria sp. showed any difference in their relative abundance above and below their focal trees ($n = 5$, $t = 1.95$, $p > 0.05$; $n = 5$, $t = 1.36$, $p > 0.20$). However, Nephelia sp. occurred significantly more frequently below its focal trees than above ($n = 4$, $t = 3.73$, $p < 0.01$).

Discussion (G.K.)

Trichipteris Sp. and Cnemidaria Sp. failed to show an increased relative abundance in the drainage shadow of a large, established conspecific, indicating that this older tree has no apparent allelopathic effect on the establishment of other nearby tree ferns. The distribution of Nephelia sp., however, indicates that allelopathy may be present. The greater proportion of young Nephelia sp. below an old individual than above it may be caused by the release of allelopathic chemicals by the old tree, inhibiting the establishment of other fern genera while allowing the establishment of its own.

Our study was limited in that we were unable to conduct soil analyses to test directly for the presence of allelopathic chemicals. Instead, we looked at population distribution as an indicator for these chemicals. It may be that all three genera of tree ferns were producing allelopathic chemicals, but that their effective leaching range was too small to influence overall population distribution. We found that Nephelia sp. tends to occur in clumps while Trichipteris sp. and Cnemidaria sp. do not; Nephelia sp.'s allelopathy may simply be more visible due to the additive effect of several nearby trees leaching chemicals into the same drainage area.

Allelopathy in tree ferns has been described (in the conditions produced by a recent landslide) (Gomez, 1983). Tree ferns are light gap colonizers, able to grow in great abundance in a large light gap produced by landslides. In this situation, with light, the tree fern's main limiting resource, readily available, the allelopathic chemicals may register a significant effect on the emerging downslope population. It is possible that these effects are diminished in a forest environment where light gaps are relatively rare. While a tree may have created a chemical zone below it (agreeable) only to tree ferns of its own species, this advantage may go unexploited if an absence of light gaps precludes the establishment of any tree fern.

The effectiveness of allelopathy in the forest may also be significantly reduced by the presence of a litter layer. On a landslide, chemicals may leach unobstructed through the soil, resulting in a large effective range. Forest litter, however, slows water flow and may absorb some of the secreted allelopathic chemicals, resulting in a greatly reduced effective leaching range.

This chemical effect could clearly place allelopathic species such as Nephelia sp. in a competitive advantage. Not only do these chemicals protect an individual from direct competition by suppressing the growth of other ferns around it, but they also increase the likelihood that its progeny will survive if its spores land within its leaching zone. Although allelopathy if present at all, does not appear to be as effective on forested slopes than on bare soil, this trait would provide a competitive advantage should a light gap appear.

Literature Cited

Barbour, Burk and Pitts. Terrestrial Plant Ecology. The Benjamin/Cummings Publishing Company, Inc. (c)1987. p. 120, 261.

Gomez, L.D. "Cyatheaceae and Dicksoniaceae" in Costa Rican Natural History. Ed. Daniel H. Janzen. University of Chicago Press. 1983. p. 225-8.

Figure 1A Distribution of three species of tree ferns at Site 1, a 25 m^2 plot along the ridge trail S. Brilliante, Monteverde, Costa Rica.

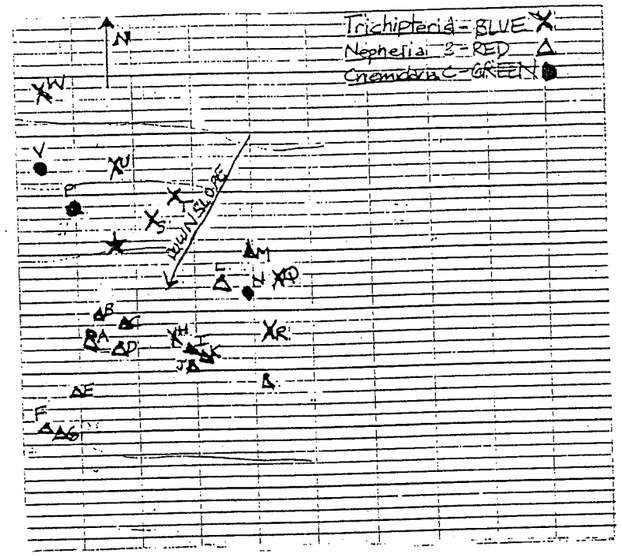

Figure 1B Distribution of three species of tree ferns at Site 2, a 25 m^2 plot along the ridge trail S. Brilliante, Monteverde, Costa Rica.

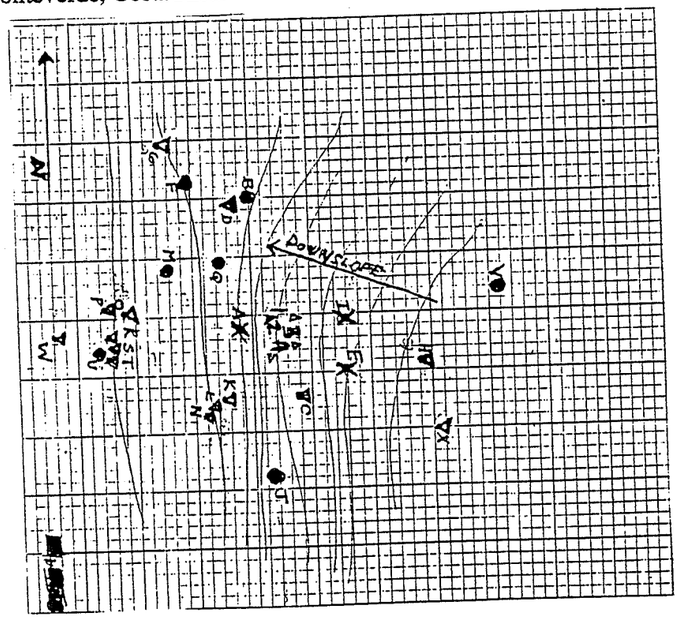

Figure 1C Distribution of three species of tree ferns at Site 3, a 25 m^2 plot along the ridge trail S. Brilliante, Monteverde, Costa Rica.

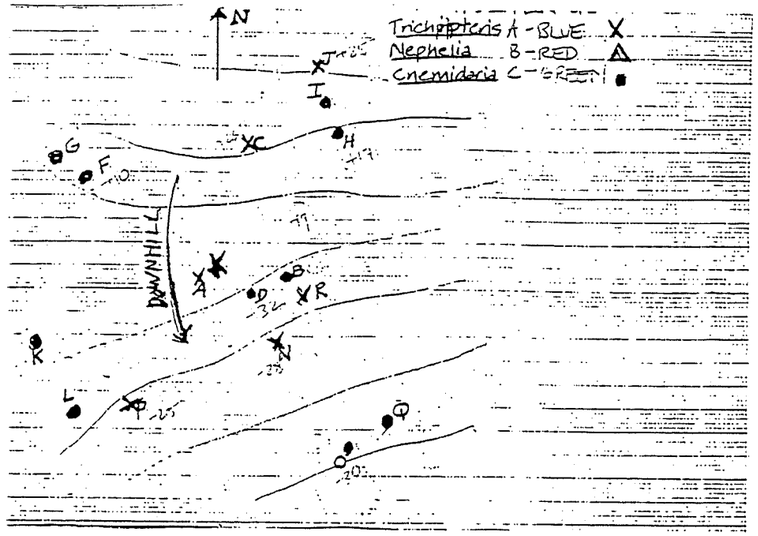

Figure 1D Distribution of three species of tree ferns at Site 4, a 25 m^2 plot along the ridge trail S. Brilliante, Monteverde, Costa Rica.

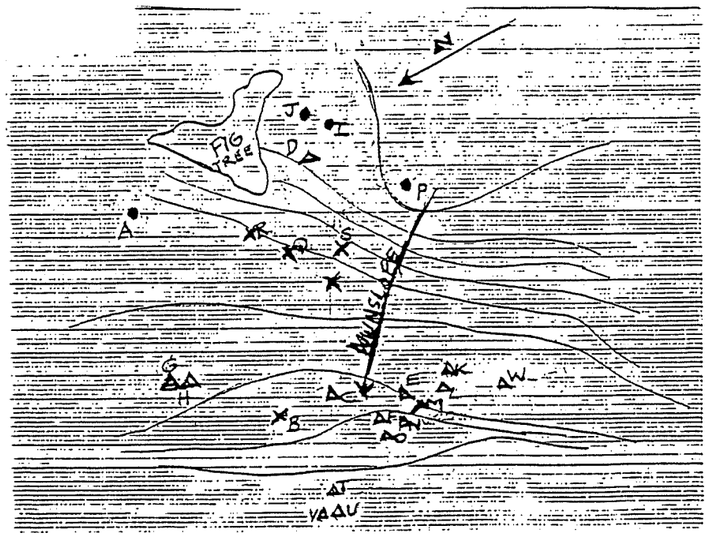

Figure 1E Distribution of three species of tree ferns at Site 5, a 25 m^2 plot along the ridge trail S. Brilliante, Monteverde, Costa Rica.