DIFFERENCE IN SPECIES RICHNESS IN THE UNDERSTORY FLORA OF RIDGE AND COVE FORESTS

CHRIS I. DUMS, PHUONG T.X. HANG, TINA RUTAR, AND EMILY B. SOHN

Abstract. Species richness has been shown to decrease with increasing elevation in terrestrial environments. We tested this pattern in understory plants in the Monteverde Cloud Forest between two habitats at different elevations. We counted the number of plants, the number of plant morphotypes, and percent understory cover in order to evaluate differences in species richness and density between the two sites. We found that plant density was 60% higher in the ridge forest, but that morphotype density did not differ between the two habitats. Species richness in terms of both individual plants sampled and area sampled, appeared to be higher in the cove forest, although the extent of this difference could not be determined by our study.

Key Words: elevational gradient, diversity, morphotypes, understory cover, density

INTRODUCTION

Species richness in plant communities often decreases with increasing altitude (Kikkawa and Williams 1971). In Costa Rica, Estación Biológica Monteverde consists of several different habitat types along an elevation gradient, including a high elevation exposed ridge forest and a lower elevation cove forest. The ridge forest, elevation 1780 m, is characterized by a short canopy and high wind and cloud inputs. The sheltered cove forest, elevation 1560 m, has a more developed, taller canopy. Our objective in this study was to examine whether species richness decreases for these two neotropical habitats with only a 220 m elevational difference.

We quantified the difference in species richness between the ridge and cove forest understory flora at Estación Biológica Monteverde. Estimates of species richness, the total number of species in a habitat, and species evenness, the distribution of individuals among the different species, are necessary to compare differences in species diversity between habitats. We hypothesized that there would be greater species richness of understory plants in the cove forest than in the ridge forest. Mechanisms for this difference could include higher disturbance rates, lower seed pool diversity, and lower heterogeneity of micro-habitats in the ridge forest as compared to the cove forest. We also examined for differences in plant density between the forest types, which might explain differences in species richness curves generated by sampling individual plants or area.

METHODS

We collected data for our study on 21-22 January 1997 from two elevations (1780 m and 1560 m) at the Estación Biológica Monteverde, Costa Rica. We chose areas within those sites that were representative of the typical forest structure at each altitude. We sampled the ridge forest site along a trail moving southwest from the Vista Arenal, and the cove forest on a trail near the Estación Biológica Monteverde.

At each site, we randomly selected ten 1 m2 quadrats. Starting at an arbitrary point on the trail, we chose two quadrats between 5 and 15 m off both sides of the trail. We chose our next two quadrats off the trail in the same way after walking between 0 and 100 paces down the trail. We repeated this process five times.

In each quadrat, we estimated percent cover as the forest floor covered by understory vegetation when viewed from a height of 2 m. We classified percent cover into four categories: 0-25%, 26-50%, 51-75%, and 76-100%. We then collected one leaf from every plant between 10 cm and 2 m tall in the quadrat.

We counted the number of individuals of each morphotype from each quadrat and the number of leaf morphotypes across all 10 quadrats in a site. We classified morphotypes based upon leaf characteristics such as shape, size, toughness, venation, and margin. We then counted the number of morphotypes shared by the two habitats.

To analyze species richness as correlated with individuals sampled and area sampled, we generated species richness curves by randomizing the quadrat sampling order and using this order to cumulatively count morphology numbers.

RESULTS

We sampled 275 plants in the cove forest and 450 in the ridge forest, but found slightly more morphotypes in the cove forest quadrats (53) than in the ridge forest quadrats (50). Fifteen morphotypes were common to both forest types.

On average we found a new morphotype for every four plants sampled in both the ridge and cove forests until 160 plants had been sampled. Beyond 160 plants, the number of new morphotypes per plant sampled continued to increase at the same rate in the cove forest, but began to slow in the ridge forest (Fig. 1a).

We found a higher initial rate of increase in the total morphotypes per quadrat with successive quadrats in the ridge forest than in the cove forest. Beyond four quadrats, however, the number of new morphotypes per quadrat began to asymptote in the ridge forest while remaining relatively constant in the cove forest. By the ninth quadrat there were more new morphotypes per quadrat in the cove forest than in the ridge forest (Fig. 1b).

Plant density was approximately 60% higher in the ridge than in the cove forest (t-test, t=2.415, df=18, P=0.02; Table 1). We found no significant differences in the number of morphotypes per quadrat in the ridge forests and cove forests (t-test, t=0.633, df=18, P=0.535; Table 1), or in the percent understory cover between the ridge and cove forests (t-test, t= 0.861, df=18, P=0.401; Table 1).

DISCUSSION

Several mechanisms could explain the higher species richness, as well as probable species diversity, in cove forests. The ridge forest canopy suffers heavy disturbance due to wind. Few tree species are adapted to establishing in the extreme wind conditions of the canopy, possibly limiting the diversity of seeds available to colonize the understory. Seed diversity should not be a limiting factor in the sheltered cove forest, as it contains a high diversity of canopy trees. Furthermore, the cove forest has the potential for acquiring seeds from the ridge forest through downhill and down-wind dispersal.

In addition, Clark and Clark (1989) have found that tree and branch fall from the canopy are the primary cause of seedling and sapling mortality in tropical forests. Extreme levels of tree and branch fall disturbances would limit understory species diversity. Due to high winds in the ridge forest, tree and branch fall occurs more frequently there than in the cove forest, but we do not know whether the level of disturbance in the ridge forest is actually high enough to limit species diversity (intermediate disturbance hypothesis of Connell 1979).

Another mechanism commonly used to explain limitations to species diversity is competitive exclusion (Begon et al. 1990). One would expect that in areas of high percent understory cover, a few plant species could out-compete their neighbors to dominate the community structure, whereas in areas of low percent understory cover, plants are more widely spaced and are less likely to compete for light. Since there was no difference in the mean percent understory cover between the ridge and cove forests, competitive exclusion is not likely to be the mechanism explaining the different species richness between the two habitats.

A surprising finding of our study was that even after sampling more than 275 plants in the cove forest, we found no indication of a limit to its species richness. Clearly, a habitat cannot support an infinite number of species. With our sampling area of 10 m2, however, we probably encountered enough microhabitats in the cove forest to maintain the rate of new

Table 1: Comparison of morphotype richness, percent cover, and plant densities of the understory plant community in ridge and cove forests.

Forest type	Total # of morphotypes	Plants per quadrat (mean ± S.E.)	Morphotypes per quadrat (mean ± S.E.)	% Understory cover (mean ± S.E.)
ridge	50	44.1 + 5.6 *	12.1 ± 0.9	43.0 ± 8.2
cove	53	27.5 + 4.0 *	10.9 ± 1.7	53.0 ± 10.0

*=significant (P < 0.05)

morphotype discovery. Our randomly selected quadrats in the cove forest fell into several microhabitats, including level forest, steep slopes, the edges of gaps and stream riparian zones, while our ridge quadrats were located in a more homogeneous appearing environment.

Increasing the area sampled in the cove forest would give us a better indication of its species richness. Although we have shown that species richness is higher for the cove forest than the ridge forest, we do not know the extent of this difference. We hope that further studies will also investigate the mechanisms responsible for creating differences in species richness curves and community composition in habitats separated by just a 220 m elevation gradient.

LITERATURE CITED

Begon, M., J.L. Harper and C.R. Townsend, editors. 1990. Ecology: Individuals, Populations, and Communities. Blackwell Scientific Publications, Cambridge, Massachusetts, USA.

Clark, D. B., and D. A. Clark. 1989. The role of physical damage in the seedling mortality regime of a neotropical rainforest. Oikos 55: 225-230.

Connell, J. H. 1978. Diversity in tropical rain forests and coral reefs: high diversity of trees and corals is maintained only in a nonequilibrium state. Science 199: 1302-1310.

Kikkawa, J. and W.T. Williams. 1971. Altitudinal distribution of land birds in New Guinea. Search 2: 64-69. [cited *in* Begon, M., J et al. - see above]

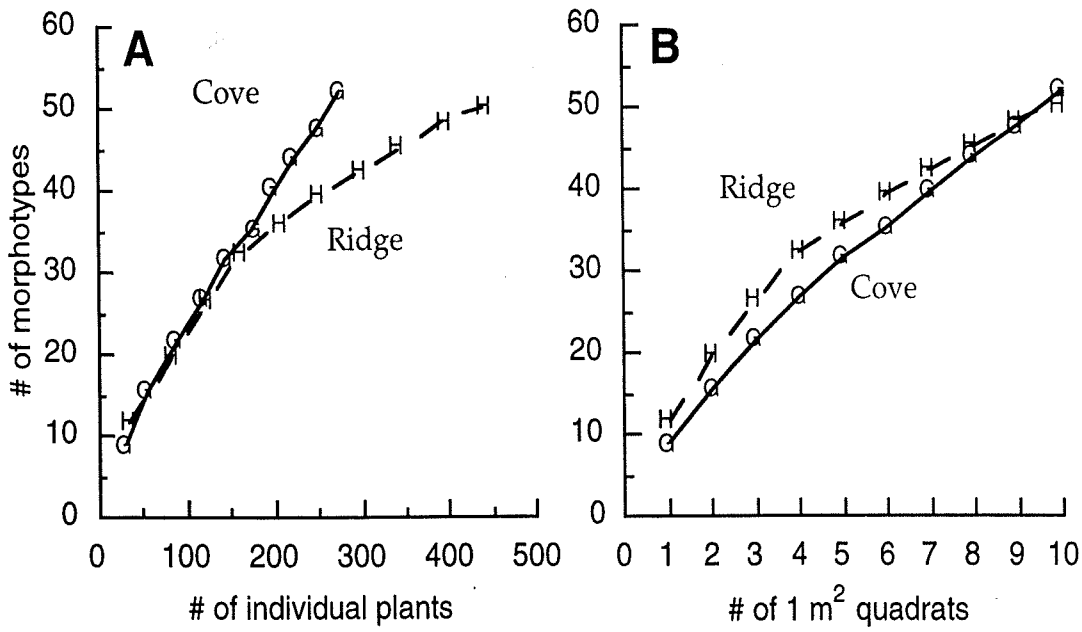

FIG. 1. Cumulative number of morphotypes as a function of A) number of plants sampled and B) number of quadrats sampled in both the ridge and cove forests.