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ANALYSIS OF THE VASCULAR EPIPHYTES OF TREE FERNS IN A MONTANE RAIN FOREST IN COSTA RICA

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Abstract

The relationships between epiphytes and host specifity are known. We investigated the relation between specific epiphytes and tree fern trunks. Only some epiphytes are frequent or very frequent on tree ferns. Most of the epiphyte species are unspecific on these trunks. *Blechnum fragile* are the only found exclusively on tree ferns. We also observed different epiphyte communities dependent on the tree fern species and the morphology of the tree fern trunk.

Resumen

La relacin entre plantas epfitac y las plantas que las alojan es conocoda. Nosotros investigamos la relacin entre algunas plantas epfitas especficas y troncos de helechos. Solamente algunas epfitas son frecuentes o muy frecuentes en helechos. La mayora de las especies de epfitas no son especficas de estos troncos. *Blechnum grafile* son las nicas encontradas exclusivamente en helechos. Tambin hemos observado diferentes comunidades de epfitas que dependen de la especie de helecho y la morfologa del tronco del helecho.

1 Introduction

In Costa Rican montane rainforest, many species of epiphytes grow on all substrates. Research results about the ecology, diversity, and significance of epiphytes in the rain forests have been published recently (Ingram et al. (1993), Johansson (1974), Nardkarni (1985, 1986), Wolf (1993 a,b)). But there are few reports on studies of the host specificity of epiphytes (Johanson et al. (1972)). Beaver (1984) showed the differences of most epiphytes on diferent tree fern species in New Zealand. Medeiros et al. (1993) compared the colonization of native and invaded tree fern species in Hawaii. In the present study an analysis has been made of the frequency of vascular epiphytes on four tree fern species. Correspondence analysis is well suited for this kind of data, since it can give a synthetic representation of the multidimensional behavoir of the frequency data.

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2 Methods

2.1 Study site

The study of tree ferns was undertaken on a one hectare plot in the "Reserva Biológica de Alberto Brenes". The site is located on the Atlantic slope of the Cordillera de Tilarán in Costa Rica. The geographical coordinates are 10^o 12' N, 84^o 36' W. The study site is at 1000 m over sea level in the vicinity of the field station of this area.

2.2 Inventory

We inventoried all tree ferns with trunk height from 1.0 to 5.0 m in the one hectare plot. For each tree fern, all vascular plant epiphytes species were listed as well as the location where this epiphyte is growing on the trunk. After this, we analysed the epiphyte communities on every tree fern species using a correspondence analysis.

2.3 Statistical method: Correspondence Analysis

Correspondence Analysis is a statistical method (Benzécri 1982, Greenacre 1984, Lebart 1985) based on algebraic and geometrical properties for the analysis of contingency tables. It can be viewed as finding the best symultaneous representation in few dimensions of two data sets that define a contingency table. Classical methods for the analysis of contingency tables, like tests of the chi-square, only give an index that measures the association between the two qualitative variables crossed in the table, but they are unable to give an explanation of "how is this association", that is to say, which categories in the rows are associated with which categories in the columns.

In our case, we want to measure the associations between the presence and frequency of epiphytes on tree ferns, and moreover, how is this association. That is to say, which epiphytes are present (or absent) in which kinds of tree ferns, and what are the relations latent to these associations.

Our basic information is contained on a contingency table that describes the presence of 53 epiphytes on 4 tree ferns (first part of Table 1, at the end of this article). This presence is divided in 5 levels: from 0% to 20% of the tree fern height, from 20% to 40%, from 40% to 60%, from 60% to 80% and from 80% to 100% (second part of Table 1).

Correspondence analysis deals with the "profiles" of the rows and columns, that is, the histograms formed by the frequencies of each category. Then, it compares all the row-profiles by means of an euclidean distance -the chi-square distance- and searches for a space (as in multidimensional scaling or principal component analysis) of reduced dimension where all the distances between the projections of the row-profiles are the more similar to the original distances. The same analysis can be made with the categories in the columns of the tables. It can be proved (Lebart 1985) that the solutions of the two problems are related by the so-called transition equations. Hence, the projections of the row-categories and the projections of the column-categories can be plotted in the same principal plane, which is the plane where the original distances are the less deformed.

Proximity between row-points x and x' (respectively columns-points) is interpreted as similar profiles: the column-categories (resp. row-categories) that are important for x are also important for x', and the ones that are not important for x are not important for x'. Analogously, proximity between a row-point x and a column-point y means that, between all the column-points, it is for y that x is one of the important categories in the histogram of y.

As in principal component analysis, the solution of correspondence analysis is obtained by the diagonalization of a matrix, and the eigenvalues of this solution show the importance of the axis they define. This importance is interpreted as the part of the total variance that can be explained by the axis.

3 Results

We have found in the study site four species of tree fern with a different number of individuals for each species. The tree fern species *Alsophila erinacea* ($n = 5$), *Alsophila polystichoides* ($n = 17$), *Cyathea delgadii* ($n = 17$) and *Cyathea nigripes* ($n = 21$) are unspecifically distributed in the plot. All plants are covered by epiphytes. A total of 52 vascular epiphyte or hemiepiphyte species was found on the trunks of tree ferns. 24 species are pteridophtes in 9 families and 28 spermatophytes from 12 families. The cover by epiphytes and the frequency is very different for each tree fern species. *Alsophila erinacea* showed twenty-eight different epiphyte species. Half of these species are observed on 25% of the trunks. Eight species were found on more than 50% of the trunks. *Alsophila polystichoides* were covered by thirty-eight vascular epiphyte species. 27 species were found on less than 25% of the trunks. Four species were observed on more than 50 % of the trunks and Asplenum pteropus on more than 75% of the trunks from *Alsophila polystichoides*. *Cyathea delgadii* showed very unspecific epiphytes. Most of the twenty-five species that were found are on less than 25% of all trunks of *Cyathea delgadii*. Only three species covered up to 50 % of all trunks. Thirty-seven species covered *Cyathea nigripes*, the most epiphytes in this study. 65% of the species are only on 25% or less of the trunks of this species. Five species are frequent on 50% or more of the trunks of *Cyathea nigripes*. The comparison of the epiphyte species for all four tree ferns, showed that the following epiphyte species are very frequent on tree fern trunks: Marcgravia spec., Schradea costaricensis, Asplenium pteropus, *Blechnum fragile* and Trichomanes capillaceum. It should be added that no orchids were observated on the trunks of tree ferns.

We have performed different kinds of correspondence analysis. Firstly, an analysis over the table crossing the frequency of the 53 species of epiphytes on the 4 species of tree ferns gives us a raw idea of the relation between epiphytes and tree ferns. The data are in the first part of Table 1. In the principal plane (Fig. 1) we have plotted with a star the tree ferns and with a bullet the epiphytes, but only the most important are highlighted with a circle and their name is indicated. These important epiphytes are: *Marcgravia spec.*, *Peperomia emerginella*, *Asplenium holophlebium*, *Asplenium pteropus*, *Blechnum fragile*, *Polybotrya alfredii*, *Grammitis lehmanniana* and *Trichomanes capillaceum*.

The configuration of the points in Fig. 1 shows that the epiphytes of our interest are not the responsible of the major statistical deviations. However, it can be observed that there are two clear clusters: one cluster around *Cyathea delgadii*, composed by *Polypodium loriaceum*, *Trichomanes reptans*, *Solanum evolulifolium* and *Oleandra articulata.* The rest of the epiphytes form a second cluster around *Cyathea nigripes*, *Alsophila polystichoides* and *Alsophila erinacea*; in this cluster are the eight epiphytes of our interest. The dots without label are the other epiphytes of the analysis.

In order to determine whether the five levels show significant differences in the frequency of epiphytes, we have performed a second correspondence analysis in the table crossing the epiphytes and their frequency on the levels (second part of Table 1). Results in Fig. 2 show some important features: the height plays an important role, since the five levels follow the direction of the first axis. There is an specialization of epiphytes among the levels and it can be seen that lower levels are associated with some kind of epiphytes and higher levels with other epiphytes.

This analysis can be refined in order to investigate the relations between the levels and the tree ferns. Indeed, we have applied correspondence analysis to a table crossing epiphytes and tree ferns, level per level. Unfortunately, apart from the factor of "height" already observed, the results are very difficult to elucidate since we have now 73 points in a plane that only explains 32.7% of the total inertia. Thus, we decided to perform analyses tree-fern per tree-fern and level per level. The analyses over the tree ferns showed the following results: for *Cyathea delgadii* (Fig. 4) *Blechnum fragile* and less importantly *Grammitis lehmanniana*, *Polybotrya alfredii* and *Marcgravia spec.* are associated with lower levels, *Peperomia emerginella* with middle levels, and *Asplenium holophlebium* with higher levels. On the other three tree ferns (Figs. 3, 5 and 6) *Trichomanes capillaceum* and *Polybotrya alfredii* are highly correlated with the lower levels, *Asplenium pteropus* and *Grammitis lehmanniana* are on intermediate levels, and *Peperomia emerginella* and *Asplenium holophlebium* (this one except for *Alsophila erinacea*) are clearly in the higher levels. *Asplenium holophlebium* is rather on intermediate levels for *Alsophila erinacea.* Analyses of the data crossing the epiphytes and each level confirm the preceding results.

4 Discussion

The represented results of the correspondence analysis showed that we found some correlation between epiphyte species and tree fern species. Also we can establish that there is a relation between epiphyte communities and the level of these comunities on the tree fern trunk. The occurrence of different epiphyte species on different tree fern is related with the tree fern morphology and the age of the tree fern trunk. Older parts of the trunks have more possibilities for colonization from epiphytes. This is a very important aspect for the differences that we observed between *Cyathea delgadii* and the other tree fern species. *Cyathea delgadii* shows a very fast growing (Bittner et al. 1995) and the colonization of the youngest part needs time. In contrast, *Alsophila erinacea* or *Cyathea nigripes* shown in the top part of the trunk the pioneers of epiphytes. This parts of the trunk are up to four times older than the same part of *C. delgadii.* Another aspect is that the morpholgy of the trunks is very different . *Cyathea delgadii* shows a lot of long smooth scales. The colonization of these parts is difficult. After the losing of the scales, we can find more epiphytes on the trunks. Specially, the development of adventive roots can be observed. In the parts with adventive roots it is possible to find large numbers of epiphytes. *Alsophila erinacea*, *Alsophila polystichoides* and *Cyathea nigripes* do not have these extreme scales. The morphology of the trunks is another reason for the differences in epiphyte quantities and one more example of the relation between substrate morphology and epiphyte colonization, that was discussed by Benzing (1990) or Johansson (1974). Both the morphology of trunk and the micro climate explain the kinds of epiphyte communities observed in this study. An example is the observation of small ferns of the Hymnophylaceen in the base of the trunks. Normally, adventive roots are found in this part. Also this part is normally shady and wet, which is very important for this group of plants. The other extreme is found on the top of the trunks, where small fast climbing species (*Peperomia emerginella* or *Polypodium*) grow. These plants are normally more succulent and adapted to dry biotopes.

A preliminary list of the epiphytes was listed in Bittner's (1994) study in the same investigation area. A comparison with the present study shows that only *Blechnum fragile* is found exclusively on tree ferns. This observation and also the result that no orchids are growing on tree ferns is possibly due to chemical substances that we found in the trunk of tree ferns (Soeder, per.com.). Johansson (1974) and Medeiros et al. (1993) mention similar observations. Summarizing, we can establish that tree fern trunks are specific hosts, only for some species. The trunk is unspecific for most of the epiphytes and settlement depends on the morphology and microclimate factors found. The importance of chemical substances will be an interesting aspect of future studies.

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