

Epiphytes and deforestation in the tropics

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Abstract. The rapid conversion of tropical forests poses the question as to the fate of the rich epiphyte communities of these forests. This paper presents results of our recent investigations on deforestation and epiphytes along disturbance gradients in mountain forest areas in Bolivia, Ecuador and Costa Rica. Species losses following disturbance vary considerably among the different groups of epiphytes and are particularly severe among orchids, bromeliads and filmy ferns. Moreover, shade epiphytes of the forest understory are more strongly impacted than sun epiphytes of the forest canopy. Species turnover along the disturbance gradient is high in all epiphyte groups and recovery of the epiphyte communities in the regenerating secondary forests is very slow. Canopy closure and microclimate are principal factors predicting epiphyte diversity changes along the disturbance gradient. In addition, changes in tree species composition and host tree characteristics play an important role. The lichen / bryophyte species ratio is a powerful indicator of the degree of human disturbance in tropical moist forests.

1 Introduction

Tropical moist forests, especially montane forests, are very rich in epiphytes, including orchids, bromeliads, aroids, ferns, bryophytes, lichens, etc. (Fig. 1). In the Reserva Biológica San Francisco, a mountain forest hotspot in the Andes of southern Ecuador with more than 2000 species of plants, about one on every two plant species is an epiphyte (HOMEIER & WERNER 2008, GRADSTEIN et al. 2008).

Unfortunately, these epiphyte-rich forests are now disappearing rapidly due to the growing human pressures on the natural resources. By the early 1990s it was estimated that almost 90% of the tropical montane forests of South America had been converted into pastures or other land use types (HENDERSON et al. 1991) and conversion is continuing at an alarming pace in spite of efforts to slow down the process of deforestation (MOSANDL & GÜNTER 2008). The rapid conversion of these forests poses the question as to the fate of the rich epiphyte communities. Can they survive in the degraded, logged forests, in plantations or on remnant trees in pastures? Are they able to re-establish in the regenerating secondary forests and if so, how fast is their recovery?

The impact of deforestation in the tropics on epiphytes has been little investigated and most studies focus on vascular epiphytes (flowering plants, ferns). Some authors reported a marked impoverishment of epiphyte diversity following forest clearance (TURNER et al. 1994, DUNN 2000, BARTHOLOTT et al. 2001), others found little or no change (HIETZ-SEIFERT et al. 1996); reasons for these contrasting results have remained unclear. This paper presents some results of our recent investigations on deforestation and epiphytes along disturbance gradients in Central and South America. By comparing epiphyte diversity and (micro)climatic conditions in differently impacted habitats, we tried to obtain insight into the responses of epiphytes to forest alteration and their ability to recover after deforestation. In addition to vascular epiphytes we included bryophytes and lichens in our studies, which had hitherto been neglected.



Fig. 1: Prof. J-P. Frahm in the interior of a tropical montane forest rich in epiphytes. Above Chachapoyas, Peru, 3200 m. Photograph by the author.

2 Methods

Fieldwork was carried out in mountain forest areas in Bolivia, Costa Rica and Ecuador. In Bolivia, we sampled vascular epiphytes and bryophytes on selected trees in natural forest and adjacent young, 10-15 yr old secondary forest on the eastern slope of the Andes near La Paz, at 600 m and 1600 m (KRÖMER 2003, BACH 2004). In Costa Rica, we studied epiphytic bryophyte and macrolichen diversity in primary and secondary (15 and 40 yr old) oak forests at ca. 3000 m in the Cordillera de Talamanca (HOLZ 2003, KAPPELLE 2006). In Ecuador, we sampled vascular epiphytes, bryophytes and lichens at ca. 1900 m in natural forest, 50 yr old secondary forest and on isolated trees in pastures in the Reserva Biológica San Francisco area between Loja and Zamora, fieldwork site of Research Units 402 and 816 of the German Research Foundation (NÖSKE 2005, WERNER 2007, BECK et al. 2008, Nöske et al. 2008, GRADSTEIN et al. 2008a). In all locations, trees were ascended by means of the single-rope climbing technique and epiphytes were collected from trunk bases to the outer portions of the crowns using a standard protocol for representative sampling of epiphytes (GRADSTEIN et al. 2003; Fig. 2).



Fig. 2: PhD student Christine Gehrig ascending into a tree by means of the single-rope climbing technique for the study of epiphytes. Reserva Biológica San Francisco, Ecuador, 1900m. Photograph: Florian Werner.

3 Results and discussion

Bolivia. We collected almost 500 species of vascular epiphytes and 100 of epiphytic bryophytes on selected trees in natural forest and fallows, indicating that these forests rank among the richest worldwide in terms of epiphyte diversity. Deforestation resulted in major losses of epiphytes: young secondary forests (fallow) had on average 60-70% fewer epiphyte species than neighbouring natural forests (ACEBEY et al. 2003, KRÖMER & GRADSTEIN 2004). Losses were particularly severe in orchids (90%), bromeliads (70-80%) and filmy ferns (Hymenophyllaceae; 100%). Among bryophytes, species reduction was much lower (ca. 30%) and no reduction was observed in the fern families Asplenaceae and Polypodiaceae. Species composition in the fallows, however, differed considerably from that in the natural forest indicating that turnover was high and that many forest species had become lost. Especially vulnerable were the species of the shaded forest understory, the drought-intolerant "shade epiphytes". Those of the high canopy of the natural forest, the drought-tolerant "sun epiphytes", however, were less impacted and many had re-established on the secondary forest trees. We also recorded a significant vertical shift of epiphytic species towards lower relative heights on the trees in the secondary forests. The latter phenomenon had been observed earlier by plant collectors but had never been demonstrated in a rigorous manner.

The changes in the epiphyte flora towards the secondary forest seemed to be influenced by several factors. The most important factor seemed the drier microclimate in the fallows, caused by the more open canopy. Furthermore, the secondary forest trees were generally smooth-barked and of a different architecture than those in natural forest, having less-branched crowns and oblique (instead of horizontal) branches. This type of bark and crown architecture is unfavourable for the establishment of many species of epiphytes. A third factor, finally, was the lack of a dense bryophyte cover on the secondary forest trees. In mature montane forests, trunks and branches are usually covered by thick moss layers, providing a suitable substrate for the germination of epiphytic ferns and flowering plants (NADKARNI 1984). The lack of such bryophyte layers on trees in the fallows may have hampered the re-establishment of at least some vascular epiphyte species.

Costa Rica. We recorded 168 cryptogamic epiphyte species, including 108 bryophytes and 60 macrolichens, on just 15 trees in early secondary, late secondary and primary oak forest (five trees in each forest type). As opposed to the Bolivian study, we found no significant differences in species richness in the different successional stages of the forest (HOLZ & GRADSTEIN 2005). Apparently this was due to the closed canopy in all three forest types, resulting in similarly high atmospheric humidity. In the Bolivian forests investigated, young secondary ones had much more open canopies than natural ones and were therefore much drier. However, like in the Bolivian study species composition in primary and secondary forests differed markedly, indicating that turnover along the gradient was high. Apparently, long time is needed for the recovery of the microhabitats and the associated epiphyte communities of the primary forest (see also NADKARNI 2000). No less than 40% of the species recorded were only found in the secondary forest, indicating the important contribution of these forests to biodiversity.

Ecuador. We collected over 250 species of vascular epiphytes, 115 of epiphytic lichens (micro- and macrolichens), and almost 100 of epiphytic bryophytes on selected trees in natural forest, 50 yr old secondary forest and in meadows. As in Bolivia and Costa Rica, we recorded major floristic changes along the disturbance gradient (WERNER et al. 2005, NÖSKE et al. 2008). We also observed the characteristic shift of canopy species towards lower parts of the tree in open habitats, recorded earlier in Bolivia. The changes in species richness were very different among the various groups of epiphytes, however. Total species numbers towards open vegetation declined dramatically (over 80%) in bromeliads and orchids, less so (ca. 30%) in bryophytes, and increased in lichens, especially among the tiny microlichens (10-15%). The abundance of lichens on isolated trees in pastures was striking (Fig. 3); in the dense forest they were much scarcer and largely restricted to branches and twigs in the relatively dry outer portions of the tree crowns. The preference of epiphytic lichens for relatively dry habitats has also been observed elsewhere and is apparently due to their ability to withstand long periods of desiccation (LANGE 1992, FRAHM 2003). Interestingly, we found a good correlation between air humidity and the species ratio of bryophytes vs. lichens (NÖSKE 2005). A 2 : 1 ratio of lichen vs. bryophyte species was characteristic for the relatively dry forest canopies and isolated trees; in the humid forest understory, however, the ratio was reversed.



Fig. 3: Abundant growth of epiphytic lichens on an isolated tree in pasture land. Reserva Biológica San Francisco, Ecuador, 1900 m. Photograph: Florian Werner.

As in Bolivia and Costa Rica, we found that canopy closure and microclimate were important parameters predicting the responses of epiphytes to habitat alteration. The very different species composition of the natural forest and the recovering secondary forest, again, indicated that regeneration of the rich epiphyte communities following disturbance is slow. Among the various groups of epiphytes, bryophyte species were the best indicators of disturbance (NÖSKE 2005, WERNER & GRADSTEIN in press). About 40% of the bryophyte species sampled along the disturbance gradient in the Reserva Biológica San Francisco area occurred with high fidelity in only one of the three habitat types studied, as compared with ca. 10% of the lichen species.

4 Conclusions

Our work on the impact of forest disturbance on epiphyte diversity revealed the paramount importance of canopy closure and microclimate. Disruption of the forest canopy leads to microclimatic changes which in turn affect the epiphyte communities. In addition, changes in tree species composition and host tree characteristics play an important role. Species losses following disturbance vary considerably among the different groups of epiphytes and are particularly severe among orchids, bromeliads and filmy ferns. Moreover, shade epiphytes of the forest understory are more strongly impacted than sun epiphytes of the forest canopy. Species turnover along the disturbance gradient is high in all epiphyte groups and recovery of the epiphyte communities in the regenerating secondary forests is very slow. As a result, the epiphyte flora of secondary forests may be very different from that of the natural forest. The lichen / bryophyte species ratio, finally, appears to be a powerful indicator of microclimatic conditions and degree of human disturbance in tropical moist forests.

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