Seedling establishment on fallen logs versus forest floor in a high elevation tropical oak forest

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Abstract: Fallen logs may provide a substrate for seedling establishment in forests. We examined the distribution of seedlings on fallen logs and on the forest floor of an oak-dominated forest, at Estacíon Biologica Cuerrici, Costa Rica. Seedling density and richness were higher on logs than on the forest floor, but there was no difference in evenness. Epiphytes may account for the increased density and richness, because they are adapted to the low moisture and nutrient environment on logs. Logs do not appear to provide a favorable habitat for *Quercus copayensis* but may allow other canopy and subcanopy species to maintain themselves in an oak dominated forest.

Key Words: disturbance, epiphytes, Quercus copayensis

INTRODUCTION

One aspect of natural disturbance in primary forest systems that may create microhabitats for the establishment of seedlings is the production of fallen logs in various stages of decay. The floor of oak-dominated forests is covered by a thick layer of oak leaves which decompose slowly because of their high concentration of tannic acid. Thick leaf litter may restrict establishment of seedlings on the forest floor. Thus, fallen logs may provide an important alternative substrate for seedling establishment. However, shallow or absent organic mats on logs may result in moisture constraints and low nutrient availability. These stresses may require specialized physiological adaptations in seedlings and therefore determine which species can utilize the log microhabitat. In tropical oak forest, we compared seedling density, richness , and evenness between fallen log and forest floor habitats.

METHODS

On January 30, 1999, we sampled seedlings on 8 logs and 8 forest floor areas in primary montane oak forest at Estación Biologica Cuericci, Costa Rica. We established a 10 m x 30 m sample area offset 15 m from a trail in a flat area at 2840 m elevation. We measured the area of all fallen logs in the sample area to estimate the proportion of area occupied by fallen logs. In 3 randomly chosen 0.02 m^2 areas, we collected and separated all recognizable leaf litter into oak and non-oak categories to determine the percentage by weight of oak leaf litter. Finally, to estimate percentage basal area of oak, we recorded all trees in the sample area in three DBH classes: 5-10 cm, 10-25 cm, >25 cm. In the analysis trees within the >25 cm class were counted as 30 cm.

We sampled seedlings in three randomly chosen areas (1m x log width) on each log > 4 m long that extended into the sampling zone. We matched each log sampled to a forest floor plot (1 m x log length) offset 3-10 m from the log and along the same azimuth as the log. We varied the area (3 - 4.5 m^2) for each sample of forest floor, estimating in each case the area required for a similar number of seedlings to the paired log sample. We recorded the height, morphotype and substrate (moss, litter, soil, wood) for each seedling in both the log and forest floor plots.

RESULTS

Quercus copayensis contributed 98.8% of total basal area and 90.2% of total leaf litter. Fallen logs comprised 9.1% of the available substrate for seedling establishment.

A total of 401 seedlings were morphotyped on 32.5 m^2 of forest floor and 8.6 m^2 of log substrate. These included 183 seedlings (20 morphotypes) on the forest floor and 218 seedlings (16 morphotypes) on logs. 13 morphotypes occurred on both logs and forest floor.

Seedling density was approximately five times higher on logs than on the forest floor (Fig. 1; Wilcoxon Test, X^2=11.29, df=1, P=0.0008). Furthermore, there were approximately three times as many species per unit area on logs as on the forest floor (Fig. 2; Wilcoxon Test,

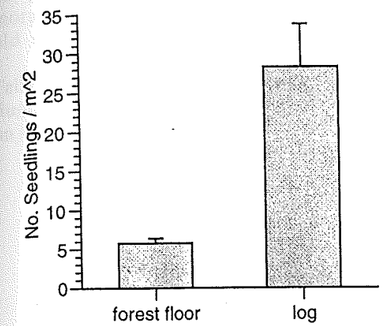

Fig. 1. Mean seedling densities ± SE by substrate, in *Quercus* dominated forest at 2900 m elevation, Estación Biologica Cuerici, Costa Rica (Wilcoxon Test, n=8, P=.0008).

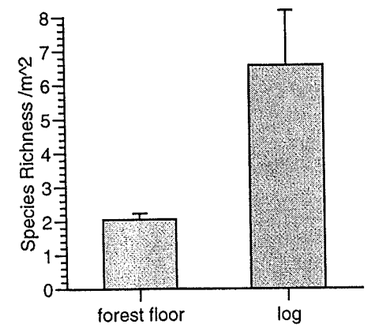

Fig. 2. Mean species richness ± SE per m^2 of seedlings on forest floor and logs, in *Quercus* dominated forest, Estación Biologica Cuerici, Costa Rica (Wilcoxon Test, n=8 P=0.016).

X^2=5.86, df=1, P=0.016). Evenness was similar between forest floor and logs (Wilcoxon Test, X^2=1.93, df=1, P=0.16). Substrate associations differed among the five most abundant morphotypes. One, morphotype 2 was over one hundred times as dense on logs as on the forest floor (Fig. 3; Wilcoxon Test, X^2=11.67, df=1, P=0.0006). Morphotypes 3 and 18 showed a similar, but not significant, trend (Wilcoxon Test, X^2 =2.36, df=1, P=0.125; Wilcoxon Test, X^2=2.10, df=1, P=0.148), while morphotype 7 showed no trend. Bamboo was negatively associated with log substrate (Fig. 3; Wilcoxon Test, X^2=5.51, df=1, P=0.019).

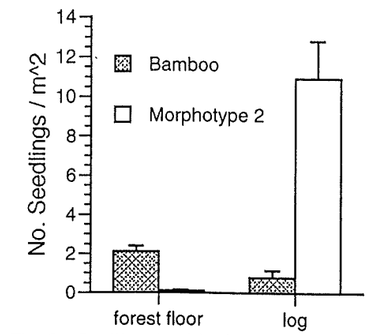

Fig. 3. Seedling densities between log and forest floor substrates (means ± SE) in *Quercus* dominated forest, at 2900 m elevation, Estación Biologica Cuerici, Costa Rica. Bamboo was positively associated with forest floor substrate. Morphotype 2 was positevely associated with log substrate.

DISCUSSION

For all species combined, the fivefold higher density of seedlings on logs indicates that logs provide more favorable substrate for seedling establishment than the oak dominated litter of the forest floor. The greater species richness on logs may be due to the establishment of many epiphyte species there (morphotypes recognized by Carlos, pers. comm.). The morphological characteristics of epiphytes (succulent leaves, swollen stems, tubers), evident on many of the seedlings on logs, may provide epiphytes with an advantage in establishing in the low moisture and nutrient conditions on log substrate.

However, the suitability of log habitat for establishment depends on species characteristics. Bamboo does poorly on log substrate, perhaps because its small seed and plant body lack adaptations to the low moisture and nutrient conditions on logs. Also, rhizomatous growth could be limited by the thin surface layer of detritus on logs.

Logs do not appear to provide a favorable habitat for the dominant species, *Q. copayensis*, since all oak seedlings were found on the forest floor. However, the 9% of area covered by logs may provide a favorable microhabitat for other canopy and subcanopy species that occur in low densities to maintain themselves in this oak dominated forest.