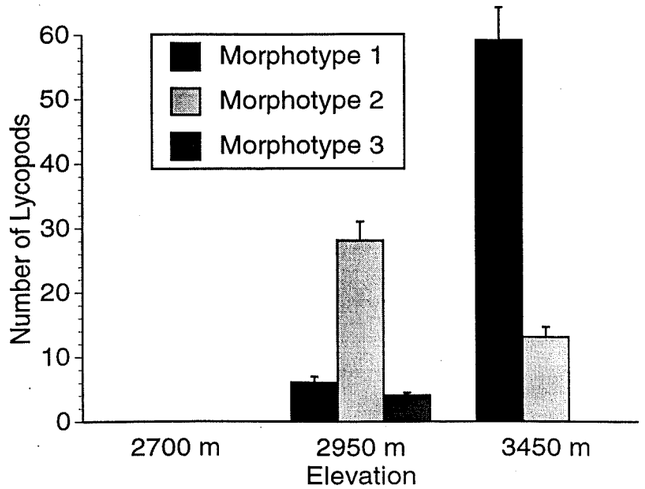

FIG. 3. Abundance and distribution of three different lycopod morphotypes at three elevations.

MONOCHAETUM REPRODUCTION IN OPEN AND CLOSED CANOPIES

SARA C. GOODWIN, PHUONG T. X. HANG, AND JAMES P. ZAK

*Abstract.*Individual plant size and local resource availability control the onset of reproductive activity in many plants. A plant will not allocate resources to reproduction if the investment compromises growth and maintenance or threatens survival. We studied flowering and non-flowering *Monochaetum* plants in high elevation oak forest to determine the effects of size and resource availability on reproductive status. We examined 1) the relationship between size and reproductive effort, 2) the difference in reproductive status between closed canopy forest and open, second growth habitats, and 3) the interaction between individual plant size and habitat on reproductive status. A significant correlation was shown between size and reproductive effort. There was no correlation between percent cover and reproductive effort. When we removed the effects of size, we found that individual *Monochaetum* shrubs in open habitats began reproduction at a smaller size than their counterparts in the forest habitat.

Key Words: reproductive status, reproductive size, reproductive effort

INTRODUCTION

To maximize fitness, plants must not only reproduce, but they must survive to reproduce again. A plant will not allocate resources to reproduction if the reproductive investment threatens survival. Size and available resources will determine the reproductive status of a plant. To understand the factors that regulate the flowering and reproductive status of understory shrubs, we examined the reproductive patterns of a tropical shrub, *Monochaetum sp.* These melastome plants are abundant in tropical forest understories and secondary growth at high elevations We proposed that the flowering in this plant would be greatly affected by the habitat in which it was found, since resource availability should, theoretically, be very different in closed canopy forest and open secondary growth habitats. Only when a plant has a high resource input, will it be able to allocate resources to growth, maintenance, and reproduction. Therefore, we predicted that reproductive *Monochaetum* shrubs would be either larger plants with greater access to resources or plants in open habitats where resource availability is probably greater. We also expected *Monochaetum* shrubs in open habitats to achieve reproductive status and flower at a smaller size than the shrubs in closed forest habitats.

METHODS

Data were collected on 27 January 1997 on the west and east trails of the Estación Biológica Cuericí, Costa Rica, in a high elevation oak-dominated forest. We sampled *Monochaetum* shrubs in two habitats. The open habitat was of thick secondary growth without any overgrowth. The closed habitat was the understory of an established forest. Within each habitat, the individuals were sampled in a single 275 m transect along a trail. Two *Monochaetum* individuals, 18 - 212 cm in height, were randomly selected every 25 m along the transect. This size class was chosen because shrubs that are below 18 cm are too immature for reproduction, and those that are above 212 cm were too high for us to measure the canopy cover over the plant from the ground. No *Monochaetum* trees above 212 cm in height occurred in the closed forest habitat; in the open habitat, however, there were many trees above 212 cm in height, all of which were flowering. For each selected individual we measured the height, diameter, length and width of the live crown of the shrub. As an estimate of Total Reproductive Effort (TRE), we counted the total number of flowers and buds on each *Monochaetum.* Percent cover above each shrub was measured using a spherical densiometer held directly above each plant. As an indication of shrub size, we described a leaf area index, defined as (lengthLEAF CANOPY x widthLEAF CANOPY)/2. We used this index as an indication of shrub size.

We used an ANCOVA to test for a relationship between TRE (dependent variable) and plant size (independent variable) and habitat (independent variable).

RESULTS

All sampled *Monochaetum* in the closed forest habitat were shaded (>60% canopy cover; Fig. 1a). In

open habitats, *Monochaetum* had greater sun exposure (< 60% cover; Fig. 1b). When both habitats were combined, there was an overall positive relationship between plant size and TRE (F=12.55, df=46, P=0.001). There was, however, no correlation between habitat and TRE (F=0.966, df=46 , P=0.331). The relationship between size and TRE was different in areas with different amounts of canopy cover (Finteraction=11.03, df=46, P=0.0012).

To determine the relationship between TRE and plant size at different levels of canopy openness, we separately assessed this relationship blocking by habitat, and thereby controlling for canopy cover. TRE and shrub size in the open habitat were strongly related (F =25.212, df=47, P<0.001; Fig. 2). In the closed forest habitat, however, size showed no relation with TRE (F=0.905, df=47, P=0.352; Fig. 2). To examine the effect of habitat on reproductive status separate from the effects of size, we ran two contingency analyses separating the shrubs into two size classes: larger shrubs above 100 cm and those smaller than 100 cm. The open habitat had more small reproductive individuals than expected given the overall distribution of reproductive and non-reproductive individuals across the two habitats (G=15.73, df=30, P<0.001); 6 out of 11 small plants and zero out of 21 small plants were reproductive in the open and the closed forest habitat, respectively.

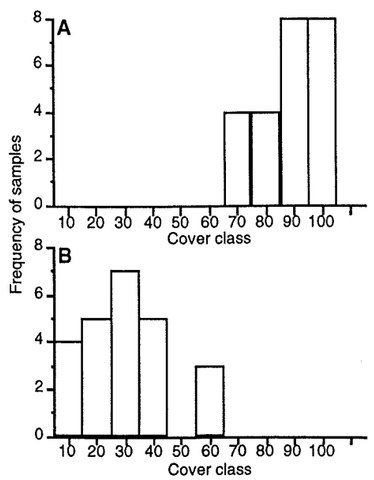

Fig. 1. Distribution of cover classes from a single 275 m transect in a) closed habitat and b) open habitat. Data were collected from the east and west ends of the forest trails at Biological Station Cuerici. Cover was measured at 24 sites in each habitat.

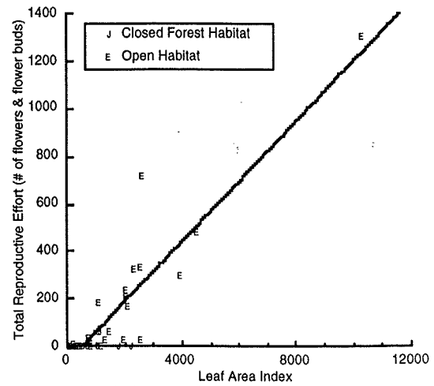

Fig. 2. Relationship between total reproductive effort (TRE = # of flowers + flower buds) and leaf area index. Data were collected from Biological Station Cuerici. Samples were taken from 24 sites in each habitat. The regression line is the best fit for the open habitat only.

Discussion

The positive relationship between size and reproductive effort was expected because reproduction can only begin once the shrub has reached a size that increases its access to resources. Limiting our samples to individuals < 212 cm in height focused our study to plants of a size which may or may not be reproductive. Every individual we saw >212 cm was flowering, and all of these were in the open habitat. Only in the open habitat did shrubs get large enough that a large reproductive effort was observed; reproductive effort in the closed forest habitat was limited to a few flowers or buds. In the closed habitat the effect of size on reproductive effort is not as clear. Although the reproductive shrubs were among the largest plants sampled in the closed habitat, their numbers and reproductive effort were too low to show a strong effect.

Canopy cover reduces resource availability and consequently affects growth rate and plant size. Therefore, the effect of canopy cover on reproductive effort is not direct. The relationship between light availability of the two habitats and reproductive effort can not be analyzed without removing the effects of size. When individual shrubs in the open habitat were compared with their same-size counterparts in the closed habitats, we found that plants flowered at a smaller size in the open habitat. When greater light resources are available, a plant can attain sufficient energy to reproduce with a smaller leaf area (lower access to resources). In a habitat with a consistently high input of energy, shrubs do not compromise their

growth or maintenance by beginning reproductive activity at a smaller size. In the closed forest with low resource availability, an individual must wait until it has reached a size that allows it sufficient resource access to attain the energy necessary for reproductive effort. For *Monochaetum* shrubs, the resource limiting reproduction seems to be light. Further studies might examine the limiting effects of other resources such as water or minerals on the reproductive status of other plants.