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Reproduction of *Besleria princeps* in Monteverde Cloud Forests

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ABSTRACT:

The purpose of this study was to show the occurrence of asexual versus sexual reproduction in lower premontane cloud forest, on the Atlantic slope and the Pacific slope of the Tilarán Mountain range near the Monteverde Biological Station. Eight hundred plants, 400 on the Atlantic slope and 400 on the Pacific side, were examined at their roots for fragmentation and seeding. The elevations of each slope and a comparison of the two slopes were examined using a chi-squared two-way contingency test.

The results showed that asexual reproduction (fragments) is more common in *Besleria princeps* than sexual reproduction (from seeds). The Atlantic slope and the highest elevations of each slope, showed a higher frequency of fragments to seeds in the windier and wetter conditions.

The chi-squared results of the Pacific slope elevations were significant, $x^2 = 29.609$; $df = 3$, and a p-value $<.0001$. The Atlantic slope elevations chi squared test had significant results, $x^2 = 21.212$, $df = 2$, and a p-value $<.0001$. The results of the Atlantic slope versus the Pacific slope showed significant chi squared results, $x^2 = 41.439$, $df = 1$, and a p-value $<.0001$.

RESUMEN

El propósito de este estudio fue mostrar la existencia de reproducción asexual versus la reproducción sexual en el bosque nuboso pre montano, en las laderas Atlántica y Pacífica de la Cordillera de Tilarán cerca de la Estación biológica de Monteverde. Ochocientas plantas, 400 en la ladera Atlántica y 400 en la ladera Pacífica, fueron examinadas en sus raíces para encontrar fragmentación y semillas. Se examinó las elevaciones para cada pendiente y la comparación de las dos pendientes utilizando una prueba de chi cuadrado de contingencia de dos colas. Los resultados mostraron que la reproducción (fragmentos) asexual es más común en *Besleria princeps* que la reproducción sexual (de semillas). La ladera atlántica y las elevaciones más comunes en *Besleria princeps* que la reproducción sexual (de semillas). La ladera atlántica y las elevaciones más altas de cada pendiente, mostraron una frecuencia más alta de fragmentos que de semillas en las condiciones más ventosas y más húmedas. Los resultados de chi cuadrado de la ladera Pacífica fueron significativos, $x^2 = 29.609$; $df = 3$, y un valor $P <.0001$. La prueba de chi cuadrado de la ladera Atlántica tuvo resultados significativos, $x^2 = 21.212$, $df = 2$, y un valor $P <.0001$. Los resultados de la ladera Atlántica versus la ladera Pacífica mostraron resultados de chi cuadrado significativos, $x^2 = 41.439$, $df = 1$, y un valor de $p <.0001$.

INTRODUCTION

Besleria princeps is an herbaceous plant with the characteristic pubescent leaves and stem of its family, as well as the ability to reproduce sexually and asexually. Its flowers are orange and tubular, like those in its genus.

Its characteristics of brightly colored and tubular flowers as well as a low growing stature are contrasting. Generally, colorful and tubular flowers are specialized for pollinator like hummingbirds, but *B. princeps* have no nectar reward and are close to the ground. *Besleria princeps* characteristics seem to be misleading considering all these findings.

The specific type of asexual reproduction of *Besleria princeps* is called fragmentation, where parts of the plant root into the ground after they have been broken off their parent plants. “In biology, (reproduction is) the process by which a living organism produces other organisms more or less similar to itself. The ways in which species reproduce differ, but the two main methods are by asexual reproduction (fragment plant) and sexual reproduction (seed plant)... offspring produced asexually are clones of the parent and there is no variation. (Hutchinson Dictionary of Science 2003)” If *B. princeps* primary form of reproduction is fragmentation, then the majority of the study group of plants are clones of one another. Is this reproduction type good for the fitness of the plant?

Areas with wet conditions, high amounts of disturbance, and an abundant source of fragments are most conducive to fragment reproduction. These are the conditions

found in the misty cloud forest of Monteverde, where a majority of shrub species in Monteverde are capable of reproduction through plant fragments (Bush 2000).

Besleria princeps has not been studied much in the Monteverde Cloud Forest (Masters, 2003, pers. comm.). I studied *B. princeps* to provide more general information that can be useful for conservationists and biologists in Monteverde.

I studied the frequency of fragment plants and seed plants at different elevations because wind, sun, moisture, are all factors that vary with altitude change, and may vary the frequency of fragment plants and seed plants.

The purpose of this study was to examine if *B. princeps* reproduces asexually in the forest of the Monteverde Biological Station. This study compared the number of fragments versus the number of seeds of the Atlantic slope to the Pacific slope, and compared the elevations on each slope to see if there was an altitudinal gradient.

MATERIALS AND METHODS:

The study was conducted in lower montane life zones, on the Sendero Principal of the Pacific slope and the Atlantic slope of the forest of the Monteverde Biological Station. *Besleria princeps* were found five to ten meters off the main trails between October 29 and November 14, 2003. I examined the roots of the *B. princeps* for fragment plants (FP) or seed plants (SP).

I carefully removed a total of 800 plants from the forest, 400 from the Atlantic slope and 400 from the Pacific slope. One hundred plants were examined in altitudinal transects at every 50 meters. I measured the elevations using a calibrated altimeter.

I pulled out the plants, digging around the roots, keeping them as intact as possible. The roots of each plant were checked from the bottom of their tips to the stem, in search of incomplete roots, and signs of fragmentation. Fragmentation was fairly obvious to see, generally there were brown pieces of half or semi dead fragments that could be traced down to the roots or on the roots.

The data were analyzed using chi squared, two way contingency tests. FP versus SP were tested from the elevations on the Pacific and Atlantic slopes. FP versus SP were tested from the elevations on the Pacific slope versus the Atlantic slope. I calculated the individual chi square significance of each cell to compare the values at each elevation, and of each cell result.

The elevations I worked at, on the Pacific side, began at 1650 meters and ended at 1850 meters. The elevations I worked at, on the Atlantic side, began at 1750 meters and ended at 1850 meters. The number of SP and FP were counted and recorded every 50 meters and 100 plants per transect were examined. The Atlantic slope trails lead to a pasture at about 1700 meters, so I took the counts of 200 plants from two trails at 1700 meters to get a count of 400 plants on each slope to compare Atlantic versus Pacific SP and FP.

RESULTS:

The overall chi-squared results of the Pacific slope elevations were significant. The results were $x^2 = 29.609$; $df = 3$, and a p-value $< .0001$. The individual chi squared cell values of elevations 1750m and 1800m showed results with the strongest significance.

At 1750 meters, the expected value for the number of seeds, 29.25, was lower than the observed value, 47. The expected number of fragments, 70.75, was higher than the observed value, 53.

At 1800 meters, the expected value for the number of seeds, 29.25, was higher than the observed value, 12. The expected number of fragments, 70.75, was lower than the observed value, 88.

The Atlantic slope elevations chi squared test, overall, had significant results, $\chi^2=21.212$, $df = 2$, and a p-value $<.0001$. The individual chi squared cell values of elevation 1700m showed results with the strongest significance.

At 1700 meters, the expected value for the number of seeds, 88, was higher than the observed value, 76. The expected number of fragments, 12, was lower than the observed value, 24.

The results of the Atlantic slope versus the Pacific slope showed significant chi squared results. The results were $\chi^2 = 41.439$, $df = 1$, and a p-value $<.0001$.

The Atlantic slope expected value for the number of seeds, 80.5, was higher than the observed value, 44. The expected number of fragments, 319.5, was lower than the observed value, 356.

The Pacific slope expected value for the number of seeds, 80.5, was higher than the observed value, 117. The expected number of fragments, 319.5, was higher than the observed value, 283.

DISCUSSION:

This study showed that fragmentation is the common form of reproduction of *Besleria princeps* in the forest of the Monteverde Biological Station.

Exposure to the intense northeast trade winds seems to favor regeneration through fragmentation (Bush 2000). The effects of the northeast trade winds can be seen in the comparison of the Atlantic slope versus the Pacific slope results, where there is a far greater number of FP on the Atlantic slope compared to the Pacific slope. The northeast trade winds keep the Atlantic slope consistently wetter, windier; therefore the Atlantic slope has favorable conditions for fragmentation.

The Pacific slope elevation results had significance at the highest altitude, 1800 meters, where there were a low number of plants by seeds and a high number of fragments. Higher elevations tend to have windier conditions, which would explain why the highest altitudinal transect of the Pacific side had the greatest number of fragments and the lowest number of seeds.

The Atlantic slope had significant results at the lowest elevation, 1700 meters. The results showed a smaller number of fragments and a higher number of seeds versus the two higher elevations. There may be a correlation between this elevation and its placement on the Atlantic slope. The end of this transect was where the forest ended and became a pasture. It is possible that the open pasture allows for pollinators and dispersers to reach the plants more easily.

Fragments are prone to rotting and many fall directly below their parent plant, where there are greater amounts of seedling predation, and competition (Heyn 1996). Fragmentation might decrease the fitness of a plant species; since the fitness of a plant is influenced by the distance it can disperse its seeds. *Besleria princeps* is mostly relying on fragmentation to reproduce, and could possibly be creating a bottleneck effect where “few genotypes (are) producing most offspring (Aldrich and Hamrick 1998). A future consequence to bottlenecking is genetic deterioration (Masters 2003) and reduced fitness of *B. princeps*.

Hummingbirds are the suggested pollinators of *B. princeps* (K.L. Masters, 2003, pers. comm.) but have not been seen pollinating the flowers. The location and stature of *B. princeps* makes it seem an unlikely candidate for hummingbird pollination. The results in this paper show that *B. princeps* may not have a consistent pollinator because it reproduces mostly from fragments.

Future studies need to be done on *B. princeps* pollinator(s), to find if it is in fact a hummingbird. Who are the dispersers of *B. princeps*? Seed plants have been found of *B. princeps*, but the pollinators and dispersers are unknown. Further studies would be helpful to increase the general knowledge about *B. princeps* in the Monteverde Cloud Forests.

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TABLE 1. *Plants produced by seeds (SP) and fragments (FP) on the Pacific slope.*

Elevation (m)	SP	FP
1650	29	71
1700	29	71
1750	47	53
1800	12	88

TABLE 2. *Plants produced by seeds (SP) and fragments (FP) on the Atlantic slope.*

Elevation (m)	SP	FP
1700	24	76
1750	4	96
1800	8	92

TABLE 3. *Plants produced by seeds (SP) and fragments (FP) on the Atlantic and Pacific slopes.*

Origin	Pacific	Atlantic
SP	117	44
FP	283	356