The effect of hummingbird feeders on the pollen loads and diversity in nectarivorous bats (Glossophaginae) in a tropical cloud forest

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ABSTRACT

Bats are some of the most important pollinators in tropical regions. I studied the effect of hummingbird feeders on pollen loads in nectarivorous bats in the Monteverde region. I mist netted bats at two locations Selvatura Hummingbird Garden (deemed high feeder density), and the Santa Elena Reserve (low feeder density). Pollen was removed from the bat's back using clear scotch tape and placed directly onto microscope slides for examination. A Shannon-Weiner diversity index showed that there was a difference between the pollen diversities (Selvatura H'=5.47, Reserve H'= 4.63) although mean pollen diversity and overall pollen count were not different. These differences could have been attributed to the fact that *Anoura geoffroyi* was the main species caught at the Reserve while *Glossophaga spp.* was caught at Selvatura.

RESUMEN

Los murciélagos nectarivorous se encuentran entre los más importantes polinizadores en los trópicos. Yo estudié los efectos de los comederos de colibríes en el polen que encontré en los murciélagos nectarivorous en Monteverde, Costa Rica. Atrapé murciélagos en dos lugares, El Jardín de Colibríes en Selvatura, y La Reserva Santa Elena. Tomé muestras de polen con cinta transparente y lo puse en los portaobjetos inmediatamente. Un índice de diversidad Shannon-Weiner muestreó que había diferencia entre la diversidad de polen (Selvatura H'=5.47, Reserva H'= 4.63) aun promedio diversidad de polen y total diversidad de polen no produjo ninguna diferencia. Estas diferencias pueden ser atribuidas al hecho de *Anoura geoffroyi* era la mayoridad de los murciélagos capturados en La Reserva, mientras *Glossophaga spp.* fue capturado en Selvatura.

INTRODUCTION

Throughout tropical and semitropical zones worldwide, bats are some of the most important pollinators and seed dispersers of flowering plants. In the Neotropics pollination by nectarivorous bats (Glossophaginae) has arisen independently in 27 different plant families affecting more than 500 different species (Altringham 1996). Typical bat flowers are white, creamy, or greenish, open at night, often for only one night, and have deep nectaries which in some cases can hold up to 10 mL of nectar (Altringham 1996). When a bat visits a flower to drink, the flowers strategically placed anthers deposit pollen onto the animals head, neck and back.

Nectarivorous bats fill an ecological niche in the night that hummingbirds fill during the day. As a result of this similarity it is not surprising that Glossophaginae bats have been known to visit hummingbird feeders. Studies have shown that a pollinator will

leave a certain flower species when a source of higher quality nectar is found elsewhere (Bronstein 1994). The amount of liquid and the concentration of sugars in hummingbird feeders far exceed any that could be found in a natural source. It is intuitive from this information that in the presence of hummingbird feeders bats would choose them over the flowers. In studies done on the effects of hummingbird feeders on pollen dispersal by *Heliodoxa jacula*, Hayes (2003) mist-netted hummingbirds at three different locations: Monteverde Cloud Forest Reserve Hummingbird Garden, Estación Biológica (no feeders), and Bajo del Tigre (no feeders). She discovered that 21 morphospecies of pollen were found at the Estación Biológica while only 14 were found at the Monteverde Cloud Forest Reserve.

In a similar study done on nectarivorous bats, Grover (2003) mist netted bats at the Monteverde Cloud Forest Reserve and at Bajo Del Tigre, a comparison of feeders vs. no feeders. She found that the diversity of pollen morphospecies found at the Cloud Forest Reserve was higher than that of Bajo Del Tigre. A large discrepancy in elevation could have had an effect on these results.

The purpose of this study was to see if hummingbird feeders had a significant effect on the pollination behavior of Glossophaginae bats. Based on these prior studies I hypothesized there would be a difference in the pollen diversity at Selvatura and the Santa Elena Reserve. I predicted that Selvatura would have lower pollen diversity because of the increased effect of humming bird feeders on the bat's diet.

MATERIALS AND METHODS

Bats were collected at the humming bird garden at Selvatura Adventure Park, and the walkway to the office at the Santa Elena Cloud Forest Reserve between the first and the fifteenth of November. Selvatura Hummingbird gallery is a very well established energy source for all sorts of nectarivorous animals. The garden has been in existence for nearly ten years, it has a stone tiled floor, benches, and as many as 20 active hummingbird feeders at one time. The other study site, Santa Elena Cloud Forest Reserve has a much smaller concentration of hummingbird feeders. The Reserve has roughly seven feeders set up about three meters apart on the path to the main office. These two study sites are located very close to each other. The Santa Elena Reserve is less than one kilometer away from Selvatura and situated on nearly the same elevation.

Bats were caught at each site using one twelve meter mist net. When a bat was caught it was removed from the net and identified using *A Field Key to the Bats of Costa Rica* by Robert M. Timm and Richard K. LaVal (1998). Once identified the forearm length in millimeters and mass in grams was recorded with a Pesola 50 g scale. Pollen was removed from the bat with using clear scotch tape on the head, neck, and back of the bat for a total of ten pats per bat. The tape containing the pollen was then stuck to a blank microscope slide and labeled with the number of the bat and the location of capture. Slides were then set aside for later examination.

The slide was scanned on the 10x lens to detect the presence or absence of pollen. When a pollen grain, or group of pollen grains was found it was examined on the 40x lens to determine which morphospecies it belonged to. Morphospecies were drawn and given a letter for identification ranging from A through EE (letters were doubled once A-Z was seen).

The diversity of pollen was analyzed using a Shannon-Wiener diversity index, and a T-test was used to look for significance. I also calculated s-marg and evenness for the same data.

RESULTS

For both locations there were a total of thirty one different pollen morphospecies discovered. The Selvatura Hummingbird Garden yielded twenty six morphospecies while the Santa Elena Reserve had only twenty. An equal number of bats (19) were caught at each site however there was only a limited amount of species overlap. Seventeen of the nineteen individuals caught at Selvatura were identified as *Glossophaga spp,*. two were fruit bats of the genus *Sturnia spp.*. At the Santa Elena Reserve five of the nineteen bats were identified as *Glossophaga spp.* two were *Loncophylla robusta* and the remaining twelve were *Anoura geoffroyi*.

The pollen diversity found on bats in the Selvatura Hummingbird Garden (H'= 2.76) was significantly higher than the pollen diversity at the Santa Elena Reserve (H'= 2.41) ($t = 2.58$, $df = 181.8$, $p = 0.01$). I found more morphospecies at Selvatura (26) than the Reserve (20). Morphospecies C was found in every pollen sample at both locations, morphospecies G was extremely common as well found in 33 of the 38 samples. Eleven morphospecies were unique to the Selvatura Hummingbird Garden, while only five were distinctive at the Santa Elena Reserve. Pollen morphospecies L found in 27 of the total 38 pollen slides was later identified as a lepidopteron wing scale

The Selvatura Hummingbird Garden had higher values for all three numbers calculated H', E, and S'marg. A t-test was done using these values and concluded that the differences were indeed significant with a p-value of $\approx 0.01 < 0.05$. The mean morphospecies count per bat was calculated and tested for significance using a t-test. The mean for Selvatura was 5.47 while the mean for the Reserve was 4.63. The t-test yielded a p-value of 0.0974 at 36 degrees of freedom and a t-value of 1.701. The p-value of 0.0974 is insignificant because it is greater than the desired p-value of 0.05 (see Figure 1).

In all different morpho types were seen a total of 107 times at Selvatura and 86 at the Santa Elena Reserve. A Chi-square test resulted in a chi-value of 2.285 with one degree of freedom. This yielded an insignificant p-value of 0.131 (see Figure 2).

DISCUSSION

My data showed that although there was a difference in the amount and abundance of pollen morpho types between the two sites, this difference was not significant. The Shannon-Wiener diversity index did find a significant result, but the difference in mean pollen count, and total pollen count were insignificant. This data did agree with my hypothesis that there would be a significant difference in pollen at the two sites; the pollen abundance however did not differ. Many factors could have had an effect on these trends.

Although it was originally thought that the Selvatura Hummingbird Garden would have more of an effect on the bat's feeding, observations seemed to point otherwise. At Selvatura the hummingbird feeders were often empty, or had fallen on the ground. Time

spent observing the feeders by moonlight showed that visitors were few and far between. The Santa Elena Reserve on the other hand, although there were fewer feeders, and the feeders were spaced farther apart, always had plentiful solution available. Feeder observations at the Reserve were also very different. There was hardly a moment when a bat wasn't feeding or flying low and fast along the trail. This difference in feeding activity could explain why the Reserve had slightly lower pollen diversity than Selvatura.

The difference in species caught could have also had an effect on the results. Only *Glossophaga spp.* was caught at Selvatura, while *Anoura geoffroyi* was the most commonly captured species at the Reserve. Hajduczek (1997) studied the pollen carried by *Anoura geoffroyi*. She found only thirteen different morphospecies on thirty-two individual bats (I found only 16 morphospecies on *A. geoffroyi*). It is possible that *A. geoffroyi* is merely more of a specialist pollinator and the hummingbird feeders themselves have little effect.

The fact that morphospecies L is a lepidopteron wing scale is intuitive because like hummingbirds, nectarivorous bats must supplement their diet of nectar with insects for protein. Soto-Centano and Kurta (2006) studied the diets of two Puerto Rican nectarivorous bat species and concluded that 75% of fecal matter examined contained insect material.

Unlike the results found by Grover (2003), my data showed a difference between the pollen found at my two locations. I eliminated the altitudinal differences found in Grover's study and as a result found significant results. My two study sites unlike Grover's both had hummingbird feeders in high and low concentrations. In order to make a more detailed study, a comparison of forest to hummingbird garden on the same elevation would be more descriptive. I did not have time enough to search for a suitable netting site on the same elevation as Selvatura that was entirely out of range of hummingbird feeders.

Future studies should look at the pollen diversity of a single species over a wide range of habitats comparing not only feeders vs. no feeders but also altitudinal differences, and changes in life zones.

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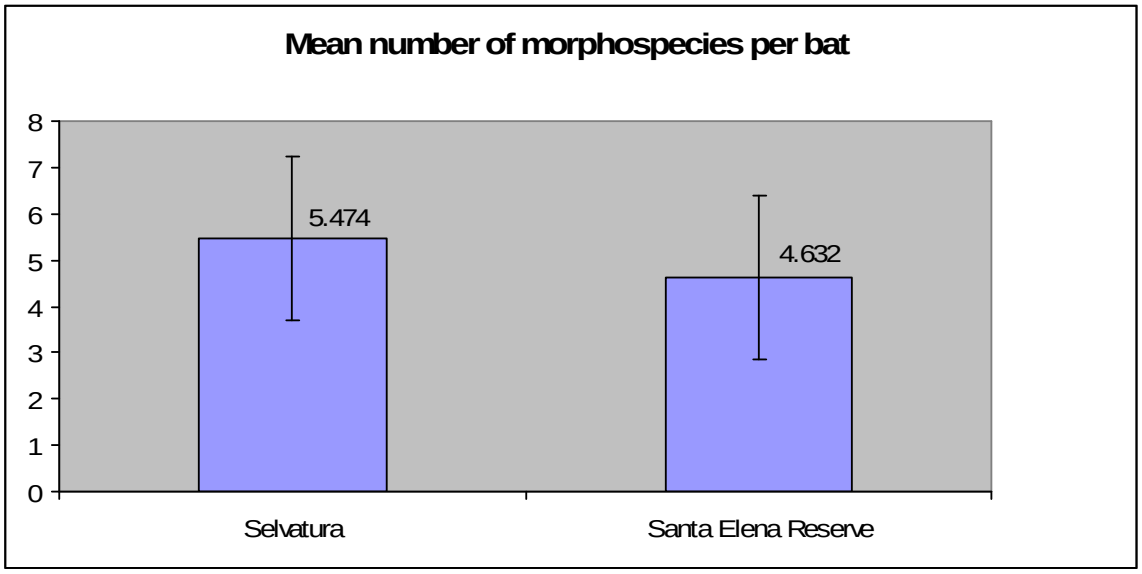

Figure 1. Mean number of morphospecies per bat: the mean number of different morphospecies of pollen found on each bat.

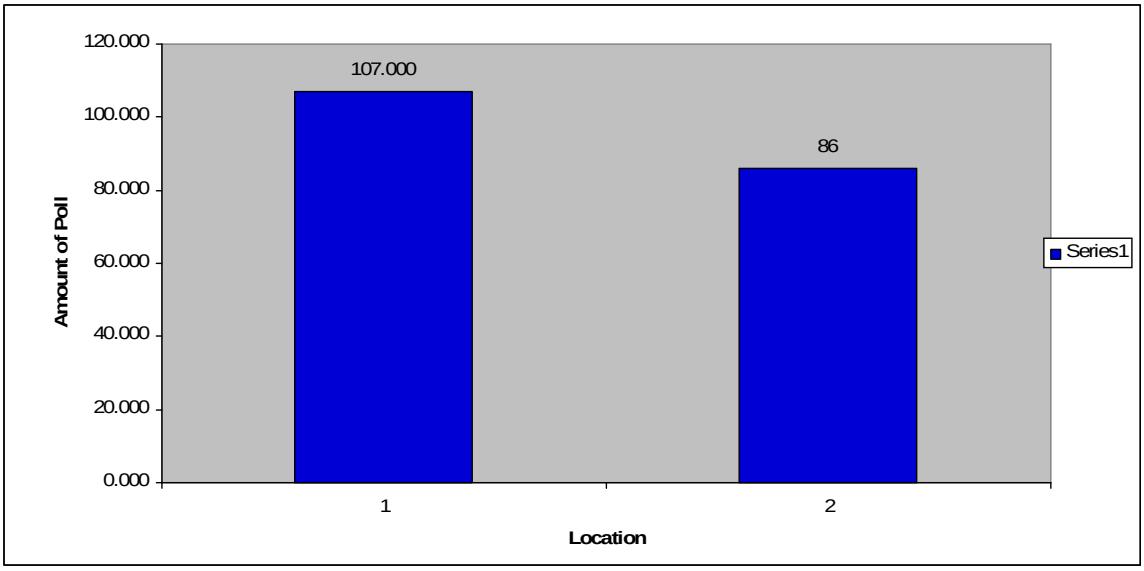

Figure 2. Total pollen count: The number of different morphospecies on each bat was added up to give total pollen count. ***107 at Selvatura vs. 86 at the Reserve.***