Niche portioning in four Frugivorous Neotropical Bats: *Carollia subrufa*, *Carollia perspicillata, Sturnira ludovici*, and *Artibeus toltecus*

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Abstract

Neotropical bat diversity is high, suggesting finely partitioned niches. Mist nets were set up on edges of Premontane Moist Forest and secondary forest remnants of San Luis, Costa Rica to examine plant use by frugivorous bats there. I caught 42 frugivorous bats of four species and one nectavorous bat: *Carollia subrufa, Carollia perspicillata, Sturnira ludovici, Artibeus toltecus, and Glossophaga soricina* . The number of Piper, Solanum, and other seeds were counted and identified in fecal matter to see what each species of bats were eating. The main diet of all 4 species of bats studied consisted of similar species of *Piper*. Although *A. toltecus* is known to have a diet consisting of mainly *Solanum* (Dinerstein, 1981), I found that every A. toltecus fecal sample had only *Piper*. Though *Piper* species were not distinguished from one another, their general morphology and accessibility to bats suggest that bats are not partitioning niches. Instead, all four sympatric bat species seem to be eating the same thing. It could be that all four of these species could coexist because there is an abundance of *Piper* in the area at present. Because area plants have complex seasonal flowering and fruiting phenologies, the study might have to be repeated at a time of resource depletion to see possible niche partitioning.

INTRODUCTION

Costa Rica is the home of at least 108 species of bats, or 11% of the total number of bat species in the world (LaVal and Rodriguez, 2002). For them to coexist, the Competitive Exclusion Principle states that these bats would have to partition their resources. Indeed, the feeding guilds of Costa Rica bats include insectivores, frugivores, nectarivores, piscivores, and sanguivores (Janzen. 1983).

For example, sympatric bats within a feeding guild may prefer different habitats, like *Sturnira ludovici*, and *Artibeus toltecus* who both feed on *Piper* but prefer either primary or secondary forests, respectively. Others share habitats but feed at different vertical heights or strata in the forest, like species *Artibeus toltecus* and species *Carollia perspicillata*, feeding low and high in the forest (LaVal and Rodriguez, 2002). Sympatric frugivorous bats such as *Carollia subrufa*, *Carollia perspicillata*, *Sturnira ludovici*, and *Artibeus toltecus* all live in San Luis, Costa Rica. These bats forage in similar habitat and similar strata and appear to feed on similar fruits, though there are certain preferences (Dinerstein, 1983).

Bats are able to coexist through evolving a specific niche that allows them to compete with other bats. Frugivores bats such as the *Carollia subrufa, Carollia perspicillata, Sturnira ludovici,* and *Artibeus toltecus* have developed niches to eat certain fruits (Aguirre et al. 2003). Bats will specialize in plants that live in primary and secondary forest. Some frugivores bats will specialize in eating fruit at different canopy levels.

Fecal matter is taken from the bats to identify the fruit seeds that are in their diet. Mist nets are set up to catch bats in the forest and on the forest edges. Frugivores in this study are mainly found around *Piper* and *Solanum* plants. As stated previously, the Competitive Exclusion Principle dictates that bats sharing resources in the same way should not coexist (Ambrose et al. 2002). How, then, do *C. subrufa, C. perspicillata, S. ludovici* and *A. toltecus* do it? While Dinerstein (1983) did not find compelling evidence for competition and niche partitioning in these species, resources vary from year to year and even month to month. It is possible that his study was performed in year of unusual fruit abundance or some other anomaly. Here, I repeat Dinerstein's fecal analyses for these bats in a further attempt to study niche partitioning in these species.

MATERIALS AND METHODS

STUDY AREA AND SITE DESCRIPTION- San Luis is located in a Pre-montane Moist Forest found in Costa Rica. Mist nets were always in or near forest. One site was a cattle farm and another had a fruit garden nearby. The third study site was deep in forest. Two sites were located on trails inside the forest. All three study areas were between 1100 -1200 meters. I set up mist nets in three different areas at each site. The mist nets were set up around fruiting *Piperacea* plants that *C. subrufa, C. perspicillata, S. ludovici,* and *A. toltecus* would eat. Dinerstein (1983) shows that in the month of July, *Piper (Piperaceae*) and *Solanum (Solanaceae*) are fruiting and all four species of bats mentioned above feed on these two plants (Dinerstein, 1983). I was not able to find any *Solanum* plants around the study areas but some *Piper* was seen at two study areas.

The entire study was conducted over 13 nights in July. At two sites I set up three mist nets that were attached to two poles. The nets were set up in the trails in the forest because the bats would use the relatively open trails as flyways. In the second site, I placed two mist nets on the edge of the forest. The nets were only set up on nights when it was not raining. After two to three nights I would move the bat nets 20-40yards in each study area because the bats would start to avoid the nets if they were left in the same area every night. I would open the nets at 5pm and close them at 10pm. After opening them I would check each net every 15 minutes to check to see if any bats flew into them. I would take each bat out of the net with gloves and place the bat into a bat bag for 15 minutes to allow the bat to defecate. About 70% of the time the bat would defecate on the glove when the bat was taken out of the net. I placed the fecal matter in a vile and put some alcohol into the vile to preserve the fecal matter. After catching bats I looked at the fecal matter underneath a microscope and used a dissecting kit to examine the fecal matter. I used Richard LaVal's seed library in order to identify the seeds in the fecal matter.

RESULTS

Samples were taken from a total of 47 bats that consisted of five different species of bats, not just the four I expected. I obtained samples from three *Carollia subrufa*, twenty seven *Carollia perspicillata*, six *Sturnira ludovici*, seven *Artibeus toltecus*, and four *Glossophaga soricina. G. soricina* is a nectarivorous bat, but with fruit seeds in its droppings.

All species preferred to eat *Piper* than *Solanum* as you can see in figure one with the total seed counts of each species. I found a difference in the total number of seeds per bat species ($\mathcal{X}^2$ = 32.31,DF = 8, P< 0.05; Ambrose et al. 2002). *C. perspicillata* had many more seeds overall, even after accounting for the relative number of individuals in my sample.(FIGURE: 1)

TABLE 1. All species preferred *Piper* over other fruit plants. *C. subrufa* and *A. toltecus* did not eat any *Solanum. A. toltecus* only ate *Piper* plants while *C. perspicillata* and *S. ludovici* consumed *Piper, Solanum*, and other fruits.

	C. perspicillata	*C. subrufa*	*S. ludovici*	*G. soricina*	*A. toltecus*
Piper	26	3	4	3	7
Solanum	4	0	2	1	0
Other	4	1	2	0	0

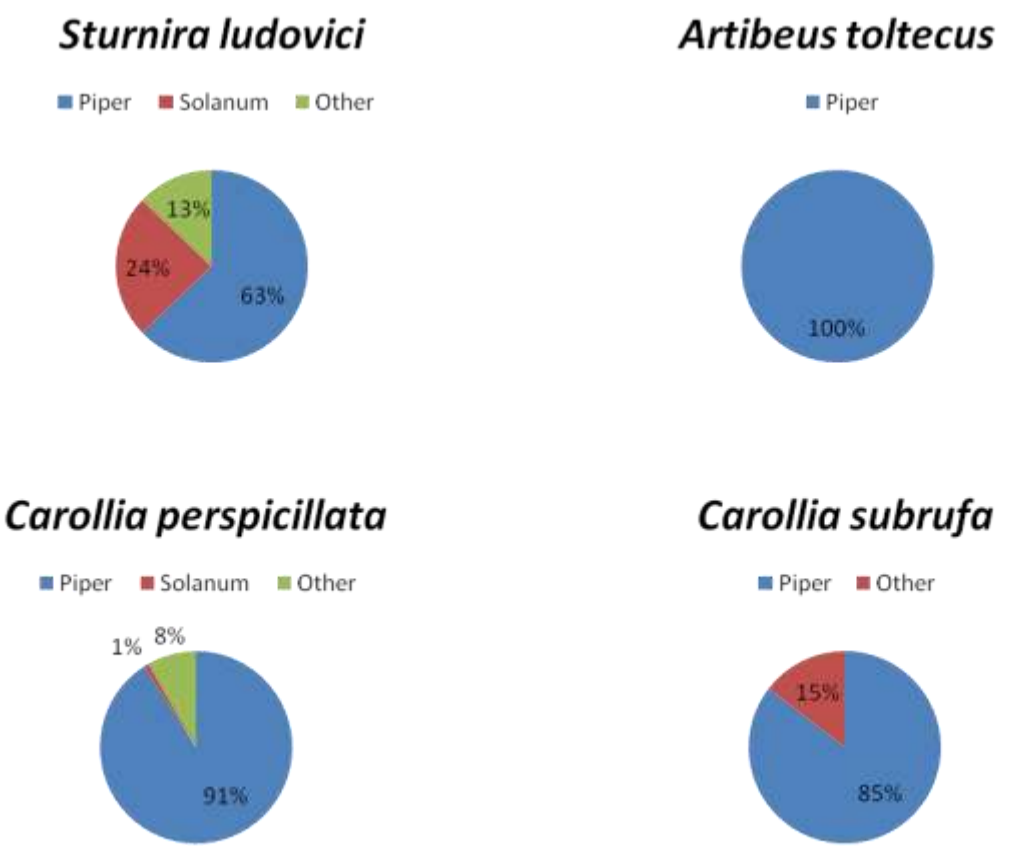

FIGURE 1. This figure shows that a total of three *S. ludocici* ate 39 *Piper* seeds, 15 *Solanum* seeds, and 8 other seeds. Twenty seven total individuals of *C. perspicillata* ate 1,179 *Piper* seeds, 12 *Solanum* seeds, and 107 other seeds. Seven total individuals of *A. toltecus* ate only *Piper* seeds in their diet consisting of 81 seeds total. A total of three *C. subrufa* ate 47 *Piper* seeds and 8 other seeds. All four species preferred to eat more *Piper* than *Solanum* or other fruits.

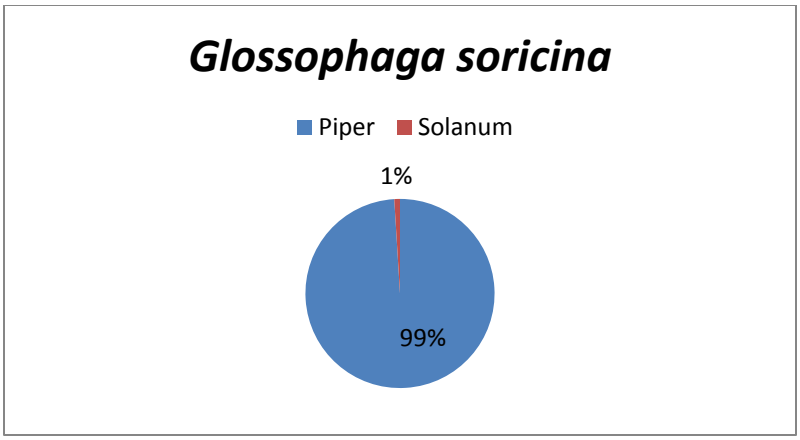

FIGURE 2. The fecal matter of 4 *G. soricina* consisted of 102 Piper seeds and 1 Solanum seed. G. soricina is a nectavorous bat that preferred mainly *Piper* plants.

Additional Observations

G. soricina was the only non frugivores bat that I caught and obtained a fecal sample from. *G. soricina* is a nectavorous bat and I obtained 4 fecal samples from 4 individuals. The *G. soricina* preferred more *Piper* over *Solanum* as seen in figure 6.

DISCUSSION

Piper and Solanum were both present in all the study areas but I do not know which study areas contain higher concentrations of *Piper* plants or *Solanum*. I know that *Piper* and *Solanum* were present in each study site because both species of plants were found in the fecal matter at all three study areas. *Piper* and *Solanum* are both normally fruiting during the study in July (LaVal, 2003). It is unknown why all species preferred *Piper* over *Solanum* or other fruits. Dinerstein (1983) shows *S. ludovici*, *C. perspicillata*, and *C. subrufa* all consume more *Piper* than *Solanum* (Dinerstein, 1983). Dinerstein does show that each of these three species eats *Solanum* as well, and all three of these species did consume small quantities of *Solanum* in this study. *A. toltecus* is shown to eat mostly *Solanum* and very small amounts of *Piper* according to Dinersteins results (Dinerstein, 1983). On the contrary, my study shows that *A. toltecus* consumed only *Piper* (Figure 1). This could mean that more *Piper* was in the area and very little *Solanum* was around. This could also suggest that *Solanum* plants are preferred and, hence, depletd in the area. Perhaps *A. toltecus* are adapting to consume more *Piper* in their diet

The fact that a nectarivorous bat had seeds in its droppings is interesting. *G. soricina* could be feeding on fruits when flowering plants are not blooming. The *G. soricin*a's main diet is nectar. Since four individuals were captured and retrieved samples from that had fruit seeds in their fecal matter, could suggest that *G. soricina* are changing their diet. Studies have shown that *G. soricina* will occasionally eat insects and fruits while there are low numbers of flowers in the area (Patterson et al. 2003).

I am assuming that all four species that I studied do not have the same niche because they are coexisting together. Different species of bats were caught at different times of the night which can suggest that different species are feeding at different times. Perhaps different species of bats are eating different species of *Piper* in order to coexist with one another. I only looked to see if the seeds were in the family of *Piper* and did not identify which species of *Piper*. These bats may be acquiring niches for specific species of *Piper*. The bats could be feeding only in certain areas of forest or feeding at different times of night.

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