THE EFFECT OF SUGAR CONCENTRATION ON HUMMINGBIRD FEEDING AND AGGRESSION

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Abstract (T.Y.)

This study focused on the effects of sugar concentration at artificial bird feeders on feeding rates and aggression of hummingbirds. Our results indicate that there is a significant positive correlation in hummingbird visitations between feeders containing no sugar and feeders containing increasing concentrations of sugar. This result signifies an ability of hummingbirds to detect sugar content. There was also a significant positive correlation between the sugar concentration and the amount of aggression exhibited by hummingbirds. This suggests that hummingbirds are more likely to establish a hierarchy around a more valuable nectar resource.

Introduction (G.G.)

The interaction between hummingbirds and certain species of plants is an example of mutualism. Plants provide hummingbirds nectar, a source of energy, and hummingbirds act as vehicles of cross pollination for the plants. Plants produce sugar rich nectar in their flowers in order to attract pollinators. It has been documented that hummingbirds are attracted to red, orange, and yellow flowers (Kricher, 1989). We found a variation in nectar sugar concentrations and similar nectar volumes across several flower species within this color spectrum. Barring morphological incompatibility, it seems that hummingbirds would prefer flowers containing richer nectars because they are able to meet their diets more efficiently at the more concentrated sites. In order to obtain significant amounts of hummingbird feeding data we conducted our study using the three birdfeeders outside the hummingbird gallery at Monteverde, Costa Rica. Because artificial feeders were used, morphological differences of flowers could not be taken into account, but were controlled for because all feeding ports were identical. We hypothesized that as the sugar concentration of the feeders' increases, the number of hummingbird visits should increase.

It is well known that hummingbirds defend nectar sources (Janzen, 1983). There is an energy cost associated with each aggressive interaction undergone to protect or gain access to nectar. Our second hypothesis was that as the sugar concentration of the feeders increases, the number of aggressive interactions should increase.

Methods (T.Y.)

We performed our study at the "Hummingbird Gallery" in Monteverde, Costa Rica on 31 January 1991 from 11:00 - 17:00 and on 1 February from 0900 - 1100. Three preexisting feeders at the gallery were used. The sugar content of the preexisting mixture was found (17.5%) using a refractometer. We based our solutions on this concentration and mixed up batches of 0%, 20%, and 40% sugar solutions by weight (using sugar-sucrose and water) (This represents a range of 5% - 35% sugar concentrations found in nature). The feeding locations at the gallery were dubbed location "a" (under shelter), location "b" (middle of field), and location "c" (under tree). To test hummingbird visits as a function of sugar concentration, feeder of 0.20% and 40% concentration was placed singly at one of the 3 locations along with an individual observer. A lag time of 30 min. was allowed before data recording in order to allow the birds to readjust their feeding patterns. Twenty, two-minute trials were performed for each feeder (0%, 20%, 40%) at each location. The trial began with a handswipe at the feeder to clear the birds, and then every landing (either perch or in flight feed) was recorded during the two minutes. After the 20 trials, the feeders were rotated to a new location. A 30 min. lagtime was allowed between each twenty trial set to give the birds time to readjust their feeding patterns. In order to account for locational bias by the birds, we compared visitation rates at each feeder at teach of the three locations. We also measured the volume of liquid withdrawn over the feeding periods by marking the initial volumes and the final volumes of each feeder.

The aggression hypothesis was tested by removing two feeders and leaving one at the "sheltered" location. A lag time of twenty minutes was allowed between sets of trials. Five two-minute trials were performed for each feeder. In each trial, three observers simultaneously counted aggressive interactions that occurred with 0.5 meter of the feeder. An aggressive interaction was identified by physical contact, a chase, or a displacement of one bird by another. The counts were then averaged and recorded.

Results (G.G.)

The sugar concentrations of the four species of hummingbird pollinated flowers sampled were as follows: Hansteinia blepharorhachis, 12.5% (Mattoon et al. Dartmouth FSP '91), Razisea spicata, 20.5%; Centropogon solanifolius, 21%; and Impatiens wallerana, 32%. All concentrations are by weight.

Over a three hour period we found that the hummingbirds consumed 32ml of the 0% sugar solution, 366ml of the 20% solution, and 331ml of the 40% solution.

We ran three ANOVA tests comparing the visitation data obtained for a particular feeder (0, 20 or 40% sugar) at all three locations (i.e. 20% location A vs. 20% location B vs. 20% location C). However, the number of visits to the 20% feeders was significantly greater than those of the 0% feeders ($P < 0.01$, $n = 120$ x0% = 6.23 x 20% = 24.50). T-test results also confirmed a significant difference in number of visits to 0 and 40% feeders ($p < 0.01$ $n = 60$, $t = 9.18$, x0% = 6.23, x40% = 25.23).

A linear regression plotting all aggression data revealed a strong positive correlation between sugar concentration and the # of aggressive interactions ($p < 0.01$, $r = 0.75$, $r^2 = 0.56$ $n = 15$).

Discussion (A.B., G.G.)

Variation of sugar concentration in flower nectar is common between species of hummingbird pollinated flowers (Mattoon, et al., Dartmouth SIFP, Monteverde, 1991). Production of nectar containing higher sugar concentration involves more energy investment by the plant. However, the birds may prefer these higher concentrations. In fact, there is evidence that hummingbirds defend favored feeding sites (Kricher, 1989). Therefore, it may be beneficial for a plant to invest the extra energy in order to attract more pollinators. However, it may also be advantageous for a plant to produce more flowers, but with lower sugar concentration. In this situation, hummingbirds must visit more flowers in order to obtain sufficient amounts of sugar. This results in an increased chance of cross pollination for the plant.

We tested whether number of hummingbird visitations increased as sugar concentration in a feeder increased. We found a large difference in the number of visits to a feeder with no sugar as compared to feeders with 20 or 40% sugar. This result, in conjunction with the volume consumption data, shows that hummingbirds are able to distinguish between plain water and water with 20-40% sugar concentration. The birdfeeders used were all colored red, indicating that color alone will not attract more than a minimum number of hummingbird pollinators; the plant must also produce nectar containing some minimum concentration of sugar.

The finding that there was no strong correlation between visits to feeders with 20 and 40% sugar concentrations does not necessarily indicate that the birds were unable to distinguish between the two concentrations. Since these birds are accustomed to water containing a sugar concentration of 17.5%, the 20% sugar concentration provided sufficient nutrition. Also, the birds studied in this experiment have been conditioned to forage from feeders which are accessible 24 hours a day and refilled regularly. Therefore, the hummingbirds are not so pressured to forage efficiently. Under natural conditions, one would expect hummingbirds to

prefer more highly concentrated sugar sources because richer nectar enables the birds to meet their sugar needs more efficiently.

A significant positive correlation was found between the sugar concentration in each feeder and number of aggressive interactions between visiting hummingbirds. By limiting food resources to the birds, we created a situation where there was increased competition for food. Each aggressive interaction represents an energy cost for the bird. Accordingly, there is more to gain by behaving aggressively at a feeding site of higher sugar concentration because there will be a higher reward for the energy cost.

There were a few potential sources of error in our study. The first was feeder location. We accounted for this by rotating the feeders every 20 trials and leaving adjustment time for the birds. However, these rotations may not have been enough to account for previous conditioning to the feeders. Also, trials were run on two consecutive days, at different times and under different weather conditions. We noticed a decline in the total number of visits on the second day, which may have been a result of harsher conditions. Other factors contributing to error were a resident olingo attempting to feed on the hummingbird feeders, as well as people walking by and taking photographs during the course of the study.

Figure 1 Hummingbird visits vs. sugar concentration in feeders per 2 minute interval.

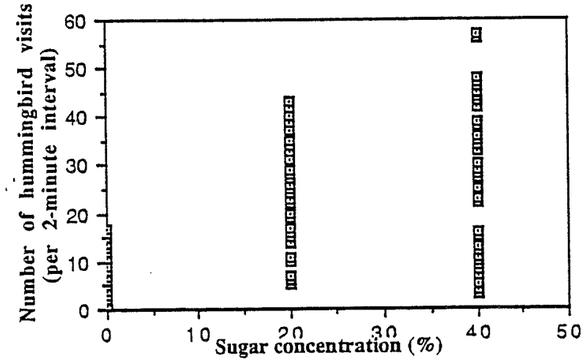
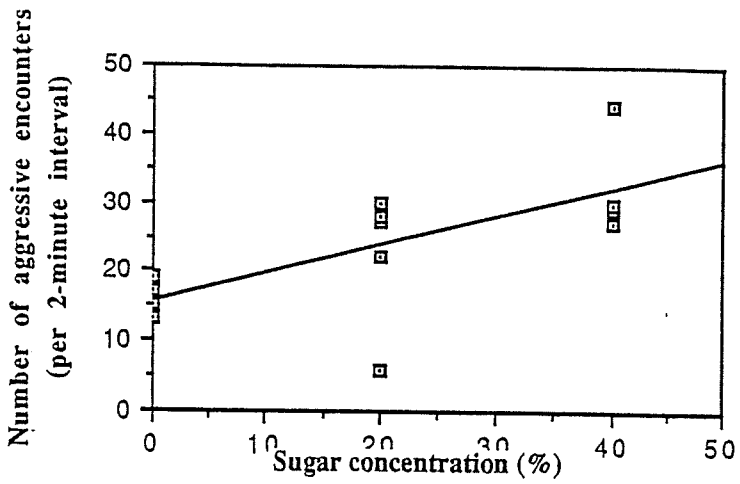


Figure 2 Aggressive encounters vs. level of sugar concentration in feeders per 2 minute interval.



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