

# **Sugar Preferences of Hummingbirds**

Rachel Schmid

July 1st, 2008

BIO 320

Dr. Elliott & Dr. Szczys

*Abstract.* Nectar contains the sugars fructose, glucose, and sucrose, among other substances. Hummingbirds tend to consume nectars that contain a higher concentration of sucrose. In order to test my hypothesis that hummingbirds display a preference towards sucrose, I loaded flowers from a *Heliconia rostrata* plant with 25% concentrations of glucose, fructose, and sucrose and water to measure the frequency and length of visitation to each manipulated flower. My results showed that hummingbirds do not show a sugar preference, but my lack of data most likely affected my results.

## **Introduction**

Many flowers produce nectar in order to attract pollinators such as hummingbirds. Floral nectar is used as the main source of energy for these organisms and is primarily composed of various concentrations of the disaccharide sucrose and the monosaccharides fructose and glucose (Stiles and Freeman 2003) as well as small amounts of amino acids and electrolytes (Martinez del Rio 1990; Chalcoff et al. 2008). In the Americas, the nectars associated with plants pollinated by hummingbirds predominately contain higher concentrations of the sugar sucrose than both fructose and glucose (Stiles and Freeman 1993; Fleming *et al.* 2004; Chalcoff2008).

Because all of these sugars (sucrose, fructose, and glucose) contain about  $16.48 \times 10^3$  Jig of energy (Martinez del Rio 1990), the questions remain why hummingbird nectars contain higher concentrations of sucrose and if the birds actually prefer this sugar. Although several studies concerning this topic have been performed under artificial

conditions, only the study conducted that was performed in the field was by Chalcoff et al. (2008) but this was with the use of feeders. Because hummingbirds' preference can be affected by various conditions not found in the laboratory, such as territoriality, this study was conducted mimicking natural conditions as closely as possible with the use of *Heliconia rostrata*.

## Materials and Methods

This experiment was conducted in the botanical garden of Selva Verde Lodge located in Chilamate, Sarapiquí, Costa Rica (10°27'N, 84°4'W, elevation ~76 m) on May 23-24 and 27-28, 2008. The garden had a path running along its border which led into the rain forest. A frequently visited *Heliconia rostrata* plant located about a meter from the walkway was used for this experiment. The most frequent visitor was the *Chalybura urochrysa*, who appeared to claim this plant as his territory.

I offered approximately a 25% concentration of each of fructose, glucose, and sucrose as well as a control of distilled water on two separate bracts of flowers on the heliconia plant. Each day I observed, I chose the two healthiest looking bracts with the most inflorescences and each day I used different bracts located on various sides of the plant.

I began by diluting previously made mixtures of both fructose and glucose to a 25% concentration and then by making the sucrose solution from distilled water and table sugar. I then used a 20  $\mu$ L pipette to remove the nectar from each flower and loaded 20  $\mu$ L of each sugar solution and water into eight different flowers, varying the height and order of solutions to avoid biases that could be made by the feeding hummingbirds. I

observed the flowers from 530 to 730 and then from 900 to 1100. During each observation period, I recorded the duration of each visit using a stopwatch and number of visits to each flower by any hummingbird that fed there, noting the species.

*Statistical analyses* - I analyzed the data using a chi square test for the number of visits and a mean comparison for the duration of visit.

## Results

### Visitation

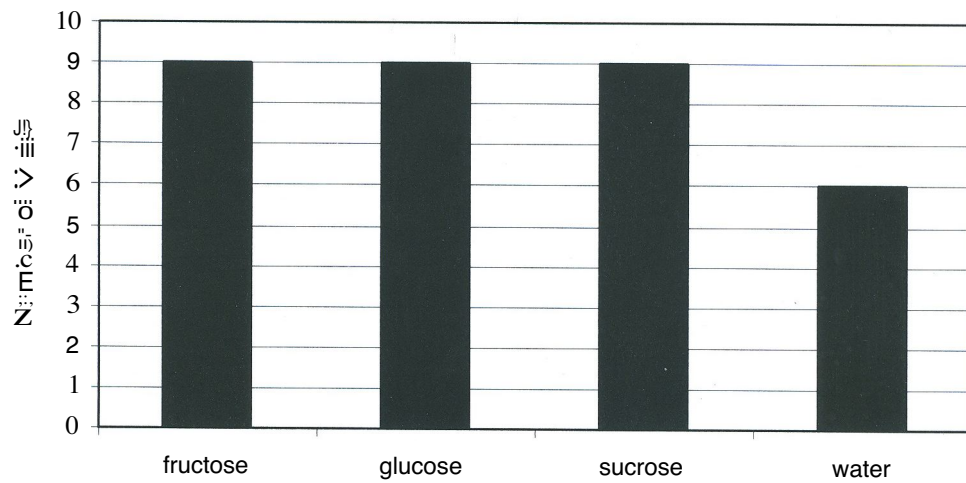


Fig 1. The total number of recorded visits by hummingbirds to *Heliconia rostrata* flowers containing each solution.

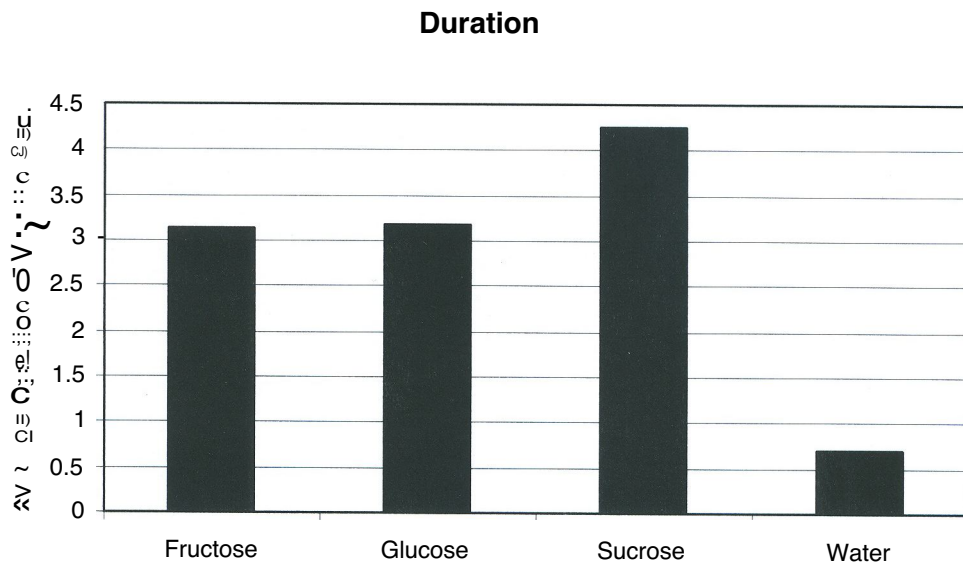


Fig. 2 The average duration of each visit by a hummingbird to a specific type of treatment.

I recorded 32 total visits by a plumeleteer (*Chalybura urochrysis*) and 1 by a long tailed hermit (*Phaethornis superciliosus*). The hummingbirds did not show a significant preference for any specific sugar [number of visits  $\chi^2=.82$ ,  $df=3$ ,  $p=.84$  and duration  $\chi^2=$   $df=3$ ,  $p=.49$ ]. They visited the flowers containing fructose, glucose, and sucrose the same number of times and water only slightly less frequently (Fig 1). Although the mean length of visitation was the longest for sucrose, there was no significant difference found among all treatments (Fig 2). The length of visitation for fructose and glucose were the closest, being 3.13 sec. for fructose and 3.19 sec. for glucose.

## Discussion

The hummingbirds did not show a significant preference for sucrose over fructose, glucose, or water in this experiment. Although similar experiments trying to indicate a sugar preference in hummingbirds have been performed over the past several years, there have been no conclusive answers. Experiments, such as those done by Stiles (1976), Martinez del Rio (1990), and Chalcoff et al. (2008) indicate a significant preference for sucrose over glucose and fructose by hummingbirds; whereas, Hainsworth and Wolf (1976) did not find a profound preference towards any sugar, as my results agree with.

Martinez del Rio (1990) provides a possible explanation for the discrepancies based on the experimental differences among the tests. The results show that hummingbirds that have been exposed to the sugar variations for long periods of time, (4-48 hours) show significant sucrose preferences, but those where the sugars are alternated frequently (Hainsworth and Wolf, 1976) show no preference toward sucrose. This may indicate that hummingbirds need several hours, and thus numerous feeding sessions, to acclimate to the differences among the sugars and indicate a preference. Because I did not alternate the position of my sugar solutions throughout the day, I should have found a significant preference towards sucrose, based on previous tests. The fact that I did not perform my experiments continuously and that I rotated the position of the sugars each morning may have affected the significance of my results. Also, none of the aforementioned experiments were conducted with real flowers and the one performed by Chalcoff et al. (2008) was the first to be located in a natural setting, offering all choices at the same time. Many of the other experiments were performed in artificial conditions

where the hummingbirds were offered the various sugars in pairs (Hainsworth and Wolf, 1976; Martinez del Rio, 1990). Because I manipulated relatively few flowers on the entire plant, this could have affected the frequency of visitation because of the vast choices of flowers the hummingbirds had. Given that I was only able to collect a minimal amount of data, the quality of my results may be skewed based on the quantity of data I was able to collect.

Although my results show that hummingbirds do not show a preference towards any sugar, it is confounding why the nectars these birds ingest most frequently have higher concentrations of sucrose than fructose or glucose (Freeman et al., 1984; Stiles and Freeman, 1993; Chalcoff, 2008). Martinez del Rio (1990) hypothesizes that hummingbirds prefer sucrose because they are taught to, not because it is more easily digested or more energetically beneficial than glucose and fructose. He proposes that "food imprinting," where, in this case, a hummingbird prefers the taste of the nectar given to it early in its life by its mother later in life, plays a dominant role in hummingbird nectar choices.

The ecologically accepted "ornithocentric explanation" provides that over time, plants develop different sugar concentrations in their nectars based on the digestive preferences of specific birds in order to increase its chance of pollination (Fleming et al., 2004; Chalcoff, 2008). The explanation contradicts Martinez del Rio's hypothesis and the results that Fleming et al. (2004) found. The contrast to the "ornithocentric explanation" is the "plant-centered explanation" (Chalcoff, 2008) that suggests that plant physiology and floral morphology are the key factors that affect sugar concentrations in

nectar, thus causing birds species to adapt (Fleming et al., 2004; Chalcoff, 2008). None have been proven.

## Literature Cited

- Chalcoff, V.R., M.A. Aizen, and L. Galetto. 2008. Sugar preferences of the green-backed firecrown hummingbird (*Sephanoides sephaniodes*): A field experiment. *Auk* 115:60-66.
- Fleming, P.A., B. Hartman Bakken, C.N. Lotz, and S.W. Nicolson. 2004. Concentration and temperature effects on sugar intake and preferences in a sunbird and a hummingbird. *Functional Ecology* 18:223-232.
- Freeman, C.E., W.H. Reid, J.E. Becvar, and R. Scogin. 1984. Similarity and apparent convergence in the nectar-sugar composition of some hummingbird-pollinated flowers. *Botanical Magazine* 145:132-135.
- Hainsworth, F.R., and L.L.WOLF. 1976. Nectar characteristics and food selection by hummingbirds. *Oecologia* 25:101-113.
- Martinez del Rio, C. 1990. Sugar preferences in hummingbirds: The influence of subtle chemical differences on food choice. *Condor* 92: 1022-1 030.
- Stiles, F.G. 1976. Taste preferences, color preferences, and flower choice in hummingbirds. *Condor* 78:10-26.
- Stiles, F.G., and C.E. Freeman. 1993. Patterns in floral nectar characteristics of some bird-visited plant species from Costa Rica. *Biotropica* 25:191-205.