

## **Food Preference by Hummingbirds Visiting Feeders**

Johanna Juntunen  
Managing Director, Phalaropus Productions  
Culver City, California, USA

Miami University - Project Dragonfly  
Global Field Program  
Inquiry & Action: Baja I BIO 675 CA

December 3, 2023

## *Abstract*

Hummingbirds (Trochilidae) belong to the unique group of birds that feed on nectar from flowering plants but also utilize sugar water feeders provided by humans. Many species of hummingbirds take advantage of feeders in urban settings. Allen's (*Selasphorus sasin*) and Anna's (*Calypte anna*) hummingbirds, common on the West Coast of the United States, have adapted well to human provisioning. Both store-bought and homemade solutions are commonly used, but which food birds favor is not known. This experiment fills the void in research on hummingbird food preferences, and aims to answer the research question: do hummingbirds coming to feeders prefer homemade nectar or store-bought mixture? Homemade sugar water was compared to Perky-Pet hummingbird nectar concentrate at three sites in Los Angeles, California, in October 2023. The results show that hummingbirds at these sites favor homemade nectar over a commercial product of which a considerably lesser amount was consumed. This finding would not be possible if counting only visits as there were more visits to the feeder with Perky-Pet food on two days of the experiment. Therefore, using a method of accurate measurement in food preference studies is imperative. This experiment paves the way for further studies to compare homemade nectar to several commercial foods which need to be analyzed for the contents to assess the safety and accuracy of advertised ingredients.

*Keywords:* *Calypte anna*, *Selasphorus sasin*, hummingbird food preference, hummingbird diet, Trochilidae, human-bird interactions

## Introduction

Hummingbirds (*Trochilidae*) are one of the few avian pollinators (Lee et al., 2019) living in a symbiotic relationship with the plants they frequent (McCaffrey & Wethington, 2008). More than 160 native North American plants depend exclusively on hummingbirds for pollination (Kerlin, 2015). These plants have co-evolved with hummingbirds (Lang, 2020) and adapted to limit other pollinators, such as bees, visiting their flowers using color and shape as cues; red, which bees see as a non-attractive dark color, but hummingbirds see well, and a tubular shape which requires a long beak and tongue to reach the nectar at the base of the flower (Stokes & Stokes, 1989). Hummingbirds need high-carbohydrate nectar to fuel their fast metabolism (Spence et al., 2022; UC Davis, n/d; Winkler et al., 2020). Flower nectar is composed of varying amounts of sucrose, glucose, and fructose (Stiles & Freeman, 1993), and the average sugar concentration in many flowers frequented by hummingbirds is 20% (McCaffrey & Wethington, 2008), although it can be up to 26% (Stiles & Freeman, 1993). To augment their nectar diet, hummingbirds eat tiny invertebrates for protein needs (Spence et al., 2022; Strauss, 2020; The Cornell Lab of Ornithology, 2019). Based on a few studies, a hummingbird's diet consists of 90% nectar and 10% of small insects and other small arthropods (Winkler et al., 2020). Pollination and insect control are critical environmental functions hummingbirds provide (Strauss, 2020; UC Davis, n/d).

There is a clear indication of the anthropogenic effect (climate change, habitat loss, food provisioning) on the abundance of hummingbirds (McCaffrey & Wethington, 2008). Areas where sugar water feeders are present can have larger populations than areas where birds depend solely on flowers (Wethington & Russell, 2003). Feeders offer an alternative food source to nectar from flowers when only a few plants flower (McCaffrey & Wethington, 2008). Hanging feeders in their gardens people get a chance to observe these beloved birds at close range (The Cornell Lab of Ornithology, 2019) which can increase appreciation for wildlife and create a sense of wonder (Stokes & Stokes, 1989), increase well-being (Methorst et al., 2021), and inspire conservation efforts. Hummingbirds require habitats with a variety of flowering plants (McCaffrey &

Wethington, 2008; Stokes & Stokes, 1989; The Cornell Lab of Ornithology, 2019) that can be planted in yards, pots, and flower boxes on apartment balconies (Lang, 2020; Stokes & Stokes, 1989) to attract hummingbirds. Besides being a food supply for both nectar and insects, plants provide shelter and breeding places for hummingbirds. Feeders maintained by people can be an important lifeline for hummingbirds in urban areas.

There is a perception among many people who feed hummingbirds that the birds prefer homemade sugar water to commercial mixtures (e.g., Pino, 2023). Whether that assumption is correct, is not currently known (Swanson, 2023). According to Wethington (personal communication, August 31, 2023), the food preference between homemade and commercially available nectar by hummingbirds visiting feeders has not been scientifically studied. An earlier experiment studied sugar-water concentration, feeder color, feeder position preferences by hummingbirds, and the effect of adding a perch to the feeder during spring migration in California (Harris-Haller & Harris, 1991), but used only homemade nectar. More research is needed due to many commercially available food mixtures used alongside homemade solutions. There are ready-made foods in a powder form; to some, you add just sugar and/or water, and some are liquid mixes that can contain vitamins and minerals (Stokes & Stokes, 1989), but also preservatives (Swanson, 2023), and liquid food mixtures in plastic bottles can leak microplastics (Sulpizio, 2022). Users of some commercial solutions in powder form have complained that the crystals don't dissolve completely, and that the solution becomes moldy quickly (Hummingbirds Plus, 2023). Red food dyes are added to many commercial food mixtures because red flowers are especially attractive to hummingbirds offering the most nectar (Stokes & Stokes, 1989) but the birds visit flowering plants of all colors, shapes, and sizes (McCaffrey & Wethington, 2008; Stokes & Stokes, 1989). Although all red food dyes are claimed to be safe for people and animals, tests have not been done on hummingbirds, so the effects of the dyes are not known (Stokes & Stokes, 1989; The Cornell Lab of Ornithology, 2019; UC Davis, n/d). Williamson (2008) refers to studies that have linked red food dyes commonly used in hummingbird mixtures (Red No. 3 and Red No. 40) to attention-deficit/hyperactivity disorders (ADHD), allergies, and asthma in children, and to DNA damage and tumors in mice. Hummingbirds absorb some

amounts of red dye and the dye alters chemically in their bodies (Williamson, 2008). Depending on the species, hummingbirds need to eat up to two and a half times their body weight daily because of their high metabolism (Williamson, 2008), which is higher than any other warm-blooded animal (Strauss, 2020). Therefore, they can ingest red dye many times over the daily dosage, leading to DNA damage (Tsuda et al., 2001). Besides being potentially harmful, dyes are unnecessary, and so are vitamins and minerals which only add to the cost of the mixture (The Cornell Lab of Ornithology, 2019). Feeders with red features are known to be attractive to hummingbirds (Harris-Haller & Harris, 1991) even with non-colored sugar water. The sugar concentration varies among brands, although bird conservation organizations and scientists agree that the ideal ratio for feeder nectar is one part granulated cane sugar (sucrose), and four parts regular tap water (McCaffrey & Wethington, 2008; Stokes & Stokes, 1989; The Cornell Lab of Ornithology, 2019) resulting in a mixture with around 20% sugar concentration. When water is boiled it lessens the likelihood of fermentation (Stokes & Stokes, 1989), and adding sugar to the boiling water makes it dissolve completely. Nectar needs to cool down before pouring it into the feeder. It is important to keep the feeders clean and the solution fresh. The homemade nectar stays fresh in a refrigerator for up to two weeks, but bacteria and fungi grow rapidly in sweet liquid in the feeder, especially in warm temperatures (Lee et al., 2019; The Cornell Lab of Ornithology, 2019) which contributes to fermentation (Stokes & Stokes, 1989). The birds also bring microorganisms into the feeder in their bills and tongues (Lee et al., 2019; The Cornell Lab of Ornithology, 2019), so feeders should be cleaned and the nectar changed every 2 - 3 days (Stokes & Stokes, 1989; The Cornell Lab of Ornithology, 2019). Putting only the amount of nectar in the feeder that will be consumed in a few days avoids waste.

Warmer winters have already changed the migration strategy (Courter, 2017; Wethington et al., 2005) and distribution of many hummingbird species, namely Rufous (*Selasphorus rufus*), Anna's (*Calypte anna*) and Allen's Hummingbirds (*Selasphorus sasin*). Many Allen's hummingbirds stay on the California coast year-round, and Anna's are now surviving in snow and freezing temperatures with the help of people hanging feeders in their gardens (Juntunen, 2022). People can increase the sugar amount in

their feeders to one part sugar, and three parts water during cold and rainy weather (The Cornell Lab of Ornithology, 2019; Williamson, 2008) and migration when food consumption doubles (Bell, 2023; The Cornell Lab of Ornithology, 2019; Williamson, 2008). Hummingbirds visiting feeders benefit from our help already, but they will likely require more assistance from humans in the future. Providing hummingbirds with nutritious, fresh, and healthy food could have important implications for the well-being of the whole ecosystem.

My research question is: Do hummingbirds visiting feeders prefer homemade sugar water or store-bought nectar? The hypothesis is that there is no preference. The alternative hypothesis is that they prefer one to the other.

## **Methods**

This field experiment compares homemade sugar water to Perky-Pet Hummingbird Liquid Nectar Concentrate, which is one of the best-selling commercial hummingbird foods on Amazon. Perky-Pet concentrate was chosen for the experiment because it is widely used, clear, and closest to homemade food, but besides sucrose, it includes preservatives like all commercial mixtures. Instructions on Perky-Pet direct to mix one part concentrate with four parts water. The same tap water was used for homemade (Feeder A) and Perky-Pet (Feeder B) solutions. The Perky-Pet label says that the sugar content is no less than 40%. But when I mixed the Perky-Pet according to the package directions and measured the sugar concentration (Brix) with a refractometer (Aichose, portable optical refractometer 0–80% Brix) it was only 10% while the homemade nectar was 20%. I added enough of the concentrate to feeder B (Perky-Pet) to make the sugar concentration 20%. I measured the sugar content of the nectar in both feeders with the refractometer before and after the 2-hour sampling time. Hummingbirds have been shown to prefer higher sugar concentrations (Sandlin, 2000; Stiles, 1976), so both food types needed equal sugar concentrations to answer the research question in this experiment.

To make the results statistically significant, I found three locations where at least 30 hummingbirds visit feeders. I could not use randomization for the site selection because there are very few feeding sites in the Los Angeles area in the fall with 30 or more hummingbirds. Sites are spatially far away from each other at elevations of approximately 155 – 300 meters. Two of the sampling sites are in the gardens of private homes (Site 1: La Cañada Flintridge, Los Angeles, and Site 2: the Gottlieb Native Garden, Beverly Hills), and the third one is in a public park (Site 3: The Hummingbird Garden in Kenneth Hahn Park, Los Angeles). All gardens have native and non-native plants with varying flower production throughout the year. Hummingbirds visit both flowers and feeders at all sites. Depending on the time of the year, hummingbird species observed at these sites include resident Anna's (*C. anna*) and Allen's hummingbirds (*S. sasin*); migratory Costa's (*Calypte costae*), Calliope (*Selasphorus calliope*), Black-chinned (*Archilochus alexandri*), and Rufous hummingbirds (*S. rufus*), which are very rare in the fall after September. The samplings were done between October 3 – 28, 2023 when only Anna's and Allen's hummingbirds were around. Both feeders were put up at the same time near each other to reduce travel costs for the birds (Sandlin, 2000) using either existing feeders or those (First Nature, 32 oz, no. 993055-001) I borrowed from Ann and Eric Brooks who feed birds at Site 3. All feeders had 8-10 ports. Only additional feeders closest to the experiment location were removed. There were enough birds at Sites 1 and 2 that additional feeders were needed. Site 3 had the fewest birds, but existing feeders were not removed except for the closest one to keep the external conditions of the experiment uniformly controlled. I did 2-hour sampling periods at each site, switching the placement of feeders randomly after hour one to minimize a placement bias. I replicated the experiment three times at different times of the day to get enough data points.

The feeders used cannot be opened and emptied without spilling if there is still leftover liquid inside, so I weighed the feeders with a kitchen scale at the beginning of sampling 1) with 300 ml of food, and 2) after the 2-hour sampling time to get the amount consumed in grams. I decided to use 300 ml of nectar in each feeder after doing a pre-test with 150 ml of nectar. It was consumed in one hour at Site 1 which had several hundred hummingbirds in early October.

Instead of trying to count individual birds, a more practical way to get data on abundance at feeders is to estimate the visits per feeder (Bell, 2023). I recorded six 3-minute videos at random times during each sampling (total = 162 min) with a cellphone camera, counted the number of visits, and calculated the species distribution per feeder. A visit was measured from when the bird inserts its bill in the feeder and sips from it to the time it leaves the feeder (see Lee et al., 2019; Harris-Haller & Harris, 1991; McCaffrey & Wethington, 2008) completely. There were times when all birds got flushed for a second or two, backed out a couple of centimeters, but returned to feed, sometimes at a different port. Those instances were not counted as separate visits, neither were those when a bird had to move to a different port because of bees or harassment from other hummingbirds. At times, counting the number of visits from the recordings in slow motion (0.25x) was challenging. The backsides of the feeders are not visible when taking video clips, and when there are hundreds of fast birds buzzing around, it is impossible to get exact numbers. It is also hard to know which birds are repeats, because individual birds appear by the feeder every 10 – 60 minutes (Bell, 2023). According to Wethington (personal communication, September 2, 2023), if there are a hundred visits per hour at a feeder, the number of individual birds is 20 – 30.

I described feeder behavior and recorded the ambient weather temperature at the beginning and end of the sampling day. I used descriptive and inferential statistics to analyze data and determine the significance of my findings.

## **Results**

The birds consumed a total amount of 1,845 g of food; 1,328 g of homemade food (Feeder A), and 517 g of Perky-Pet nectar (Feeder B). The mean amount of homemade food consumed was 147.56 g (range = 16 – 302 g) with a standard deviation of 98.5 g. The mean amount of Perky-Pet food consumed was 57.44 g (range = 13 – 114 g) with a standard deviation of 38.98 g. Because there is high variation in the data set and some outliers (Table 1) I did the Shapiro-Wilk test (Statistics Kingdom, n/d) to check if the



normal distribution model fits the observations and it showed that data is normally distributed.

Table 1. Food consumed in grams (g) on each sampling day, and total amounts.

Day	Feeder A (homemade)	Feeder B (Perky-Pet)
1	302	114
2	187	112
3	53	13
4	167	81
5	145	39
6	16	22
7	235	73
8	26	20
9	197	43
<b>Total</b>	<b>1, 328</b>	<b>517</b>

Note: 300 ml of nectar weighs 323 g.

Therefore, setting alpha ( $\alpha$ ) at 0.05 to indicate statistical significance, I proceeded with the paired, 2-tailed t-test which calculated the p-value to be 0.004. It is smaller than the alpha ( $0.004 < 0.05$ ), so the null hypothesis that there is no preference between homemade and store-bought nectar will be rejected. There is a significant difference in food preference (Figures 1 and 2) that is not due to chance alone.

Site 3, sampling days 3, 6, and 8 (Figure 1), had relatively a smaller number of birds than at other sites, but also an abundance of bees. They frequented both feeders and prevented birds from utilizing them which impacted the results.

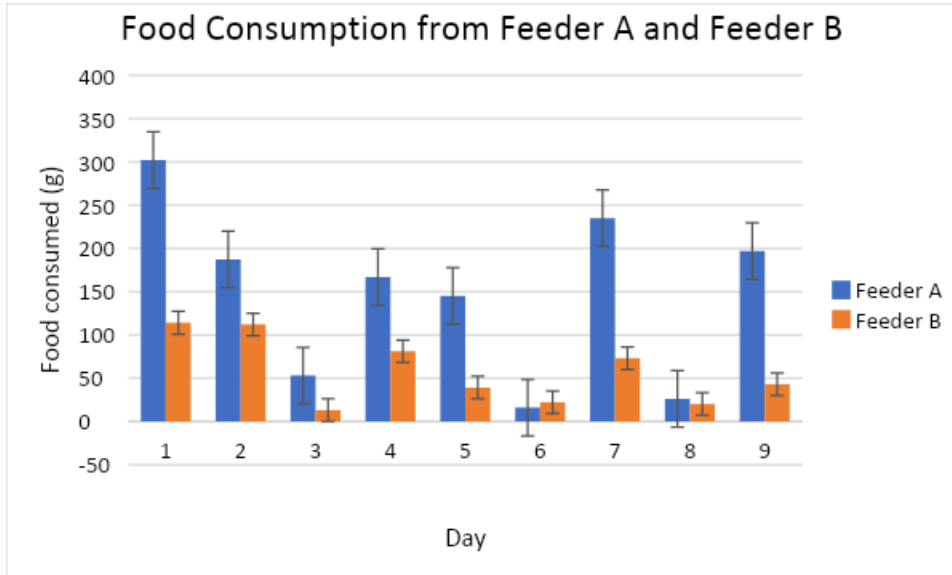


Figure 1. Food consumed in grams (g) from Feeder A (homemade) and Feeder B (Perky-Pet) during the nine sampling days at three sites. Site 1. La Cañada Flintridge, L.A. (Days 1, 5, and 9), Site 2. The Gottlieb Native Garden, Beverly Hills (Days 2, 4, and 7), and Site 3. Kenneth Hahn Park, L.A. (Days 3, 6, and 8).

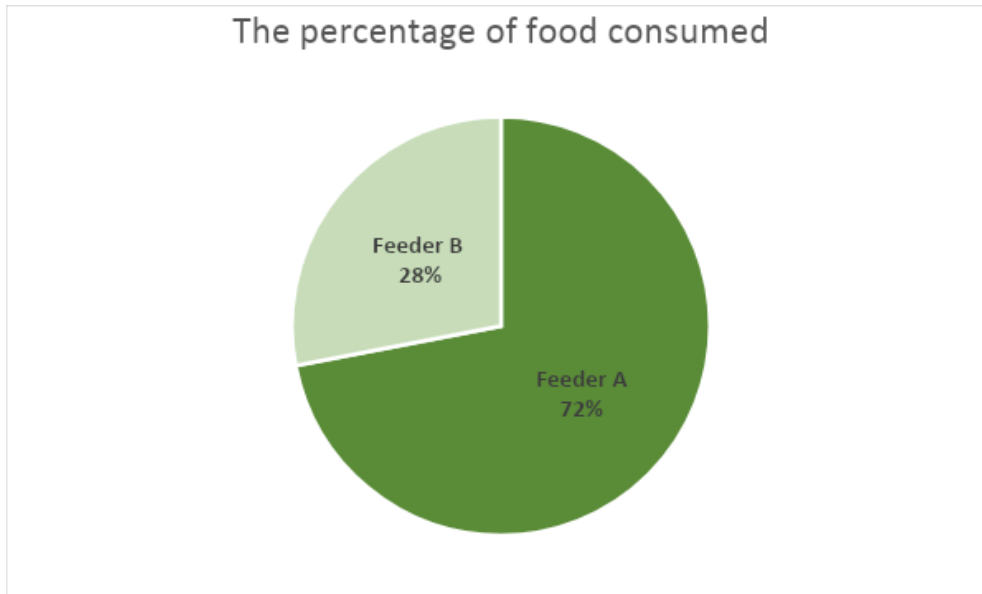


Figure 2. The percentage of food consumed between homemade sugar water (Feeder A) and Perky-Pet nectar (Feeder B).

Figure 2 shows that the birds consumed more food from Feeder A (72%) than from Feeder B (28%). Feeder A had 798 total visits, and Feeder B had 671 visits during 162

minutes of video footage (Table 2). Hummingbird visits varied throughout the study from a mean of 89 visits ( $n = 798$ , range = 11 - 240) to Feeder A with a standard deviation of 8.49 and a mean of 75 visits ( $n = 671$ , range = 0 - 163) to Feeder B with a standard deviation of 2.12.

Table 2. Total visits per feeder and visits by species (AN = Anna's hummingbird, AL = Allen's hummingbird) as estimated from 162 minutes of video footage.

Species	Feeder A (Homemade)	Feeder B (Perky-Pet)
AN	507 (64%)	453 (68%)
AL	291 (36%)	218 (32%)
<b>Total visits</b>	<b>798</b>	<b>671</b>

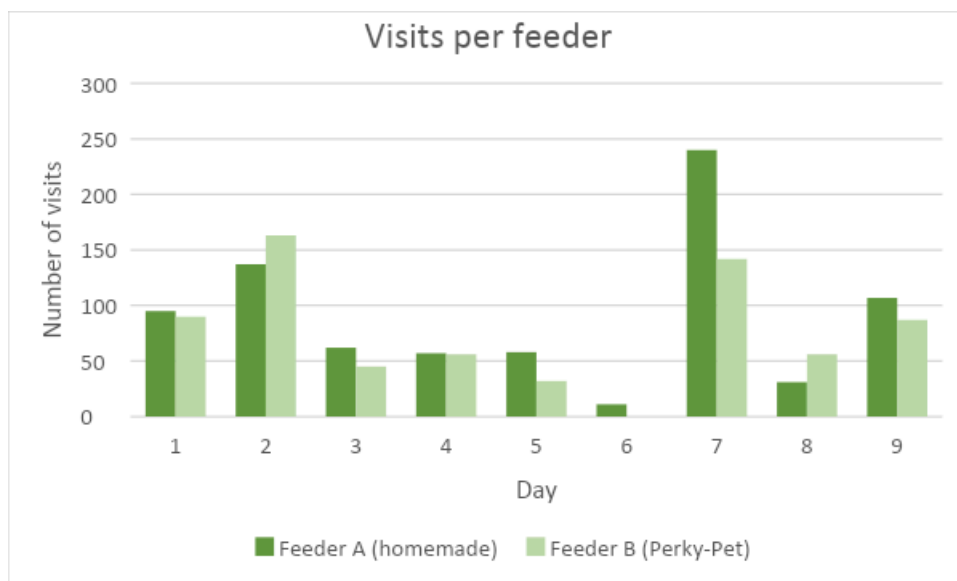


Figure 3. Visits per feeder (Feeder A = homemade, Feeder B = Perky-Pet) during 18 minutes

per site on nine sampling days at three sites. Site 1. La Cañada Flintridge, L.A. (Days 1, 5, and 9), Site 2. The Gottlieb Native Garden, Beverly Hills (Days 2, 4, and 7), and Site 3. Kenneth Hahn Park, L.A. (Days 3, 6, and 8). Visits were estimated from 162 minutes of video footage.

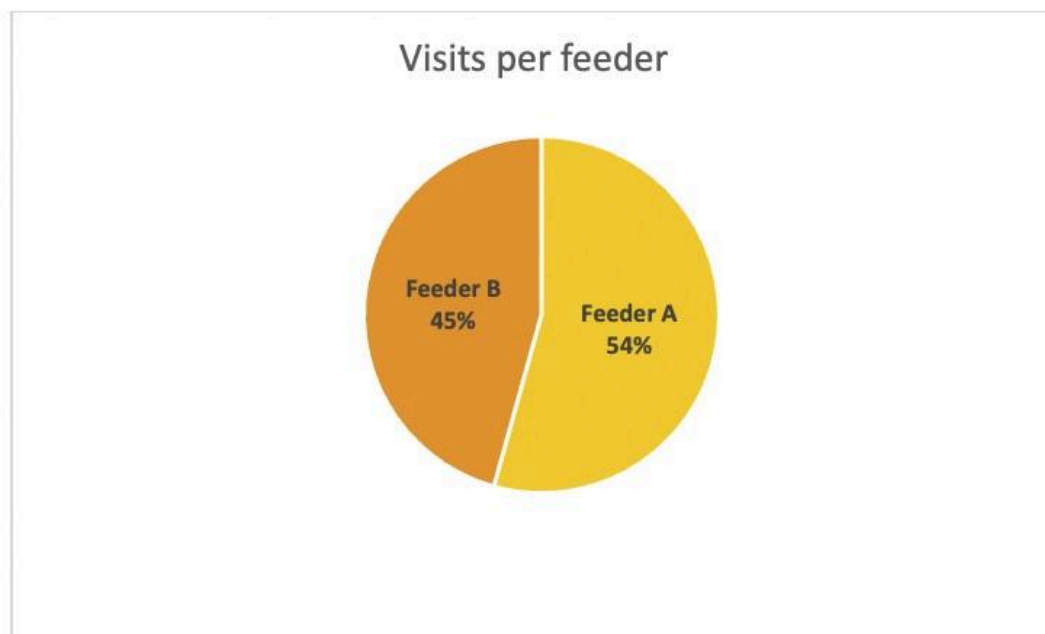


Figure 4. The percentage of visits between Feeder A (Homemade) and Feeder B (Perky-Pet) as estimated from 162 minutes of video footage taken for 18 minutes per site, per sampling.

Of the total visits estimated from 162 minutes of video clips taken during this experiment, Feeder A had 54% of visits and Feeder B had 45% (Figure 4). Visits increased at both feeders on two sampling days during hour 2 and decreased on other days. I counted more visits to Feeder B (163, 56) than to Feeder A (137, 31) during days 2 and 8 (Figure 3), but more food was consumed from Feeder A (183 g, 112 g) than from Feeder B (26 g, 20 g). Hummingbirds feed on average 5 – 8 times in an hour regardless of the weather, but only 30 – 60 seconds at a time (Stokes & Stokes, 1989), and my observations revealed that some birds stayed longer at feeders, taking breaks, but not leaving and continuing feeding later. Female birds visited Feeder B more than Feeder A on days 2 (45 vs 72 visits) and 8 (6 vs 25 visits). There were more visits by male birds to Feeder B on days 4 (38 vs 47 visits) and 8 (25 vs 31 visits). Hummingbirds are active from morning till evening, and I counted the maximum number of visits ( $n =$

382) in the morning (day 2), and also the minimum number of visits ( $n = 11$ ) in the morning (day 6) that had a high number of bees. If that sampling is excluded, bird activity was highest in the mornings, and lowest in the evenings. Many birds had pollen on their beaks at all sites, which shows that they were also feeding on flowers. The availability of feeders didn't deter them from utilizing natural nectar sources which were numerous at all sites.

Anna's hummingbird (*C. anna*) was the most frequent visitor at both feeders and visits by Allen's hummingbirds (*S. sasin*) were about half as frequent (Table 2) which is not surprising considering the differences in relative abundance of the species at sampling sites. Birds were utilizing feeders actively regardless of the ambient temperature. The ambient temperature was unusually high during two sampling days, 30 C and 26 C. Depending on the site, the feeders were either in the sun, partly in the sun for some, or the whole time of the sampling. I measured the Brix after samplings to explore whether the heat influenced the sugar concentration in the food. Perky-Pet food had 18% Brix after sampling at Site 2 during the heatwave on October 6, 2023. Both foods had a 20% sugar concentration before and after the sampling at all other sites and dates.

## **Discussion**

This experiment compared homemade sugar water to a widely used commercial brand (Perky-Pet) to answer the research question: do hummingbirds visiting feeders prefer homemade or store-bought nectar? The results indicate that there is a preference for homemade sugar water. Hummingbirds take a long time to try different feeders as they get used to going to the same spot (D. Bell, personal communication, September 20, 2023). They might just go to the feeder because of the familiar location, not depending on what kind of food is inside. This observation by Bell (2023) supported the research plan to replicate the experiment three times at each site. Hummingbirds are being fed homemade food (20% Brix) at all sites in this study, which could explain their preferences. Hummingbirds have only a few taste buds (UC Davis, n/d), but my experiment suggests that taste matters. During the sampling, I saw birds going to

Feeder B, and after taking a sip or two, some individuals switched to Feeder A. This behavior seemed to happen more often the longer the sampling time went on. Birds also switched to Feeder A when too many bees swarmed on or around Feeder B. Switching from A to B happened when all feeding stations were taken at Feeder A or when there were too many bees enjoying homemade nectar. Bees affected feeder visits negatively at Site 3. On day 6 no birds visited Feeder B during the 18 minutes of filming while bees consumed some of the food. Bees have a good sense of smell (Stokes & Stokes, 1989), but the strong smell of the Perky-Pet liquid did not deter them from enjoying it beside the homemade food. Hummingbirds have no sense of smell (UC Davis, n/d), so the odor of Perky-Pet nectar did not affect them. I found out towards the end of the experiment that one feeder (Feeder B on day 6 and Feeder A on day 8) had a tiny crack on the side. Even though it was not leaking, the bees smelled the sugar water inside and formed a large swarm on the side of the feeder. Birds could not get to the feeder when it was full of bees as they didn't want to risk getting stung with potentially lethal consequences.

The birds spent more time feeding at A than at B. As this experiment shows, measuring consumption is a more accurate method to test food preference than counting visits alone. The amount consumed suggests there were more visits to Feeder A than to Feeder B, but the number of visits was inverse to the amount consumed on two sampling days. Therefore, counting only visits can give inaccurate information on food preferences, which need to be considered when designing follow-up experiments. Interestingly, when more females visited Feeder B than Feeder A, the amount consumed from Feeder B was less than from Feeder A. The results indicate that female birds ate less and/or spent less time at the feeder even though they can weigh more than males (West, 2015).

The reasons for the high variance (Table 1) in the consumption can be explained by the number of birds at different sites. It varied between 30 – 40 at site 3 to 300 – 400 at sites 1 and 2. At Site 3 which had the lowest abundance of hummingbirds, all birds flocked to the same feeder or feeders regardless of the number of feeders on the site which supports Bell's (2023) notion about trap-lining. If a bird was alone at one of the

feeders and the other feeder had many birds, the loner often changed to the more popular feeder. I observed this behavior at Site 3 which has 9 feeders spread around the Hummingbird Garden where birds favor one or two feeders depending on the day. Do they all crowd to the same feeder which was also popular with bees while other feeders were empty and free of bees because of trap-lining or are there other factors that explain this behavior?

Because of the small sample size ( $n = 9$ ), it would be beneficial to repeat the experiment in additional sites and increase the number of sampling days and/or hours. My observations suggest that hummingbird activity peaks in the morning with the peak of flower nectar availability (Stiles, 1975). Many birds had pollen on their bills, but hummingbirds can extract more food faster from a feeder than flowers that don't always have a consistent amount of nectar (McCaffrey & Wethington, 2008). Utilizing feeders saves energy and time, so feeders can be valuable to birds, especially in cold and rainy weather. Preference for nectar with higher sugar concentration before and during migration has been shown (Bell, 2023; The Cornell Lab of Ornithology, 2019), but the last larger study was done in 1972 (Harris-Haller & Harris, 1991), and it needs to be repeated. Bell (2023) suggests that rather than the sugar concentration, the placement of the feeder seems to be a bigger factor in the food preference in the short term. This is an additional question to explore.

## **Conclusions**

This experiment compared homemade sugar water to a commercial brand (Perky-Pet) to test the food preferences of hummingbirds visiting feeders in Los Angeles, California. Homemade nectar was consumed more during each sampling day, even though there were more visits to the Perky-Pet feeder on two days, but the visits were shorter. Birds often took just a sip or two at Feeder B (Perky-Pet) and switched to Feeder A (homemade food). The results suggest that there is a difference in taste that birds detect which can be due to preservatives, water type, or other ingredients in the concentrate not on the label. The preference for homemade food can also be explained

by the fact that the birds visiting feeders at the sampling sites are used to the homemade nectar.

Following the directions on Perky-Pet liquid nectar bottle yields sugar water with only 10% Brix, not 20% as the homemade food. This is misleading to people if they think that they are feeding hummingbirds food that has the recommended 20% sugar concentration which can only be reached by doubling the amount of concentrate. Birds need to come to the feeder more often to meet their nutritional needs when the solution is only 10%. Consumers end up paying double for the product because of inaccurate information, and can't be even sure what they are getting. The label also claimed that the undiluted contents are 'no less than 40% sugar', but the refractometer revealed it to be 38%. This experiment paves the way for further studies to compare homemade nectar to several commercial foods which need to be analyzed for the contents to assess the safety and accuracy of advertised ingredients.

Bees affected this experiment unexpectedly at Site 3, Kenneth Hahn Park, and consumed some of the contents of both feeders during two sampling days. One solution is to attach bee guards onto the feeding ports, but they might not deter the determined bees from trying to get to the sugar water. Some feeders come with bee guards attached to them, but these are not used at Site 3. Additional feeders at Site 1, Beverly Hills, have smaller feeding ports, and have less bees around them. Using bee guards or different feeders should be considered in follow-up studies at sites with an abundance of bees.

Hummingbirds live solitary lives outside breeding and nesting season (Strauss, 2022), but feeders force them to be social and tolerate others. They have adapted to form alliances and social bonds, and they have enemies and friends they prefer to eat with (S. Logan, personal communication, September 15, 2023). I observed some of this feeder behavior, but analyzing it from the video footage which can be viewed at slow-motion can reveal more about the group dynamics and hierarchies of these speedy birds.



Rising temperatures change the chemical structure of both nectar in flowers and feeder solution (M. Lanan, personal communication, September 1, 2023) that birds need to adapt to but at what cost, is not known. Plant phenology is also closely related to climate; even small changes affect food availability and blooming dates, desynchronizing the symbiotic relationship between hummingbirds and the plants they pollinate (Bazzaz, 1998; Waser, 1979). This can influence the hummingbird reproductive cycle and change migration times further, causing losses for both flora and fauna. Exploring these questions can direct future feeding protocols, ensure the best outcome of the human-hummingbird relationship, and offer guidance on how to compensate for some of the harm people are inflicting on our environment.

## References

- Amazon (2023). *Best Sellers in Hummingbird Food*.  
<https://www.amazon.com/Best-Sellers-Hummingbird-Food/zgbs/lawn-garden/13402001>
- Bazzaz, F. A. (1998). Tropical forests in a future climate: changes in biological diversity and impact on the global carbon cycle. *Climatic change*, 39(2-3), 317-336.
- Bell, D. (2023, October 17). Attracting (more) hummingbirds to your yard. L.A. Birders webinar. [Video] YouTube. <https://www.youtube.com/watch?v=oJ7TFjtkcvo>
- Baker, H. G. (1983). Floral nectar sugar constituents in relation to pollinator type. *Handbook of experimental pollination biology*, 117-141.
- Courter, J. R. (2017). Changes in spring arrival dates of rufous hummingbirds (*Selasphorus rufus*) in Western North America in the past century. *The Wilson Journal of Ornithology*, 129(3), 535-544.
- Harris-Haller, T., & Harris, S. W. (1991). Experiments with Allen's and Anna's Hummingbirds at sugar water feeders in spring. *Western Birds*, 22. 175 – 188.
- Hummingbirds Plus (2023). *10 Best Hummingbird Food: Picks for Attracting and Nourishing Your Feathered Friends*. <https://www.hummingbirdsplus.org/food/>
- Juntunen, J. (2022, June 22). Amerikkalaislinnuista on kadonnut liki 30 prosenttia, mutta kolibrit sinnittelevät – maailman pienimmät linnut ovat sopeutumisen mestareita. Yle. <https://yle.fi/uutiset/3-12460234>
- Kerlin, K. (2015, April 21). *Hummingbird health: Appreciating the little things*. UC Davis. <https://www.ucdavis.edu/news/hummingbird-health-appreciating-little-things>
- Lang, J. W., (2020). *The Gottlieb native garden. An intimate wildlife journey*. G2 Books, Los Angeles.
- Lee, C., Tell, L. A., Hilfer, T., & Vannette, R. L. (2019). Microbial communities in hummingbird feeders are distinct from floral nectar and influenced by bird visitation. *Proceedings of the Royal Society B*, 286(1898), 20182295.  
<http://dx.doi.org/10.1098/rspb.2018.2295>
- McCaffrey, R. E., & Wethington, S. M. (2008). How the presence of feeders affects the use of local floral resources by hummingbirds: A case study from southern Arizona. *The Condor*, 110(4), 786-791.

Methorst, J., Rehdanz, K., Mueller, T., Hansjürgens, B., Bonn, A., & Böhning-Gaese, K. (2021). The importance of species diversity for human well-being in Europe. *Ecological Economics*, 181, 106917. <https://doi.org/10.1016/j.ecolecon.2020.106917>

Myers, C. (1997). The art and science of investigation. The webs we weave. *Dragonfly teacher's companion*. May/June 1997, 8 – 9.

Myers, C., Smart, T., Haynes, C., Bercaw, J., Cummins, H., Myers, L.B., & Wolfe, C. (n/d). *Dragonfly QUEST Leaders Guide*. Dragonfly.

Pino, M. (2023, June 20). Easiest hummingbird food recipe: Ideal ratio plus handy tips. *Planet Natural*.

<https://www.planetnatural.com/hummingbird-food/#:~:text=The%20hummers%20will%20prefer%20homemade,means%20of%20attracting%20more%20birds>.

Sandlin, E. A. (2000). Cue use affects resource subdivision among three coexisting hummingbird species. *Behavioral Ecology*, 11(5), 550-559.

Spence, A. R., Wilson Rankin, E. E., & Tingley, M. W. (2022). DNA metabarcoding reveals broadly overlapping diets in three sympatric North American hummingbirds. *Ornithology*, 139(1), 1–14. <https://doi.org/10.1093/ornithology/ukab074>

Statistics Kingdom (n/d). <https://statskingdom.com/index.html>

Stiles, F. G. (1976). Taste preferences, color preferences, and flower choice in hummingbirds. *The Condor*, 78(1), 10-26.

Stiles, F. G., & Freeman, C. E. (1993). Patterns in floral nectar characteristics of some bird-visited plant species from Costa Rica. *Biotropica*, 191-205.

Stokes, D., & Stokes L., (1989). *The Hummingbird Book. The Complete Guide to Attracting, Identifying, and Enjoying Hummingbirds*. Little, Brown & Company (Canada) Limited.

Strauss, E. G. (2020). *Hummingbirds of the Gottlieb Native Garden*. G2 Books, Los Angeles.

Sulpizio, J. (2022, August 26). *Microplastics in our Waters, an Unquestionable Concern*. PennState Extension.

<https://extension.psu.edu/microplastics-in-our-waters-an-unquestionable-concern#:~:text=Yes..Mason%2C%20a%20Penn%20State%20researcher>.

Swanson, J. (2023, May 9). Do Hummingbirds prefer homemade nectar? DIY or Buy? *WildBirdScoop*.

<https://www.wildbirdscoop.com/do-hummingbirds-prefer-homemade-nectar.html>

The Cornell Lab of Ornithology (2019). *Attracting Hummingbirds*. Bird Notes 2.

<https://www.birds.cornell.edu/home#>

The Gottlieb Native Garden (2022). *Bird Day LA*.

<https://thegottliebnativegarden.com/projects-partners/bird-la/>

Tsuda, S., Murakami, M., Matsusaka, N., Kano, K., Taniguchi, K., & Sasaki, Y. F. (2001). DNA Damage Induced by Red Food Dyes Orally Administered to Pregnant and Male Mice, *Toxicological Sciences, Volume 61, Issue 1*, May 2001, 92–99,

<https://doi.org/10.1093/toxsci/61.1.92><https://academic.oup.com/toxsci/article/61/1/92/1615305>

UC Davis (n/d). *Hummingbird health and conservation program*. UC Davis Veterinary Medicine. <https://hummingbirds.vetmed.ucdavis.edu/about>

Waser, N. M. (1979). Pollinator availability as a determinant of flowering time in ocotillo (*Fouquieria splendens*). *Oecologia*, 39, 107-121.

West, G., C. (2015). *North American hummingbirds. An identification guide*. University of New Mexico Press. Albuquerque.

Wethington, S. M., & Russell, S. M. (2003). The seasonal distribution and abundance of hummingbirds in oak woodland and riparian communities in southeastern Arizona. *The Condor*, 105(3), 484-495.

Wethington, S. M., Russell, S. M., & West, G. C. (2005). Timing of hummingbird migration in southeastern Arizona: implications for conservation. Bird conservation implementation and integration in the Americas. *USDA Forest Service General Technical Report*, 1, 646-651.

Williamson, S. (2008). *Feeding Hummingbirds: The dangers of red dye*.

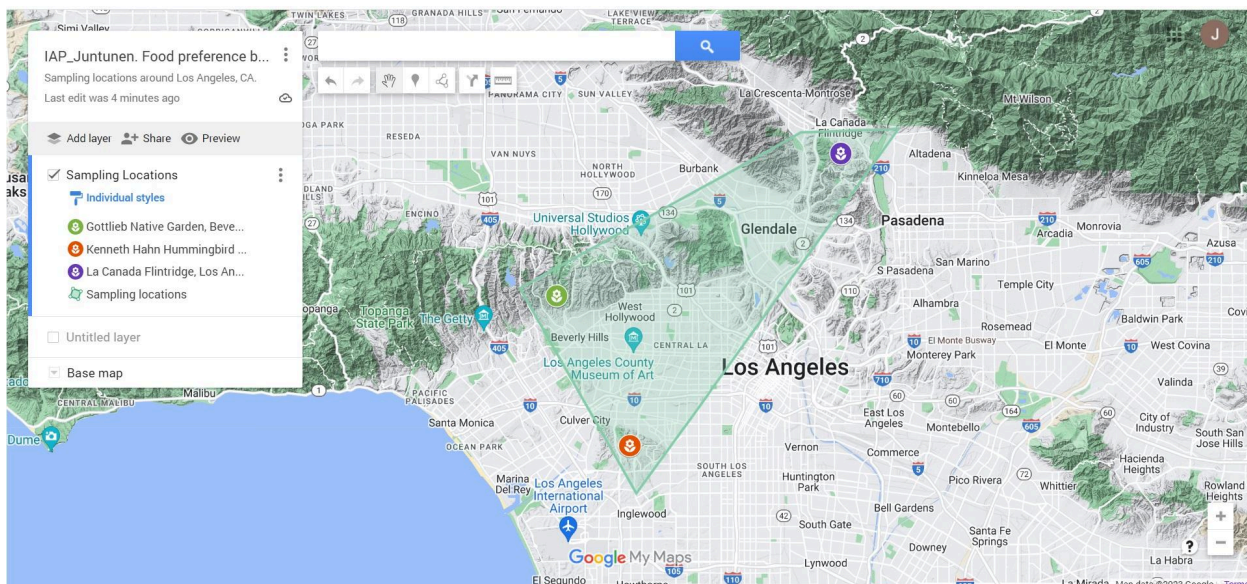
<https://fieldguidetohummingbirds.com/hummingbirds/feeding-hummingbirds-dangers-red-dye/>

Winkler, D. W., S. M. Billerman, and I. J. Lovette (2020). *Hummingbirds (Trochilidae)*, version 1.0. In *Birds of the World* (S. M. Billerman, B. K. Keeney, P. G. Rodewald, and T. S. Schulenberg, Editors). Cornell Lab of Ornithology, Ithaca, NY, USA.

<https://doi.org/10.2173/bow.trochi1.01>

## Appendix A

Map of the sampling locations in Los Angeles.



## Appendix B

Aichose 0-80% Brix Meter Refractometer for measuring sugar content in sugary drinks.



## Appendix C

Data sheets with observation notes:

### IAP Data from Hummingbird Food Preference Experiment

#### Sampling 1.

**Date:** October 3, 2023

**Time:** 11:40 – 13:40

**Sampling Site:** La Cañada Flintridge (Site I)/1

**Weather:** 25 C – 27 C with 43 – 35% humidity, sunny, NW wind 5 km/h

**Observation notes:** Pretest with Perky Pet (B) 10% solution\* (made according to the directions on the bottle) and homemade (A) 20% for 1 hour. At first, both feeders were equally popular. After 30 min many birds that visited feeder B took a sip and flew to feeder A. If there was no room at A, they stayed at B. Both feeders have 10 feeding stations with a perch.

The species observed were Anna's Hummingbirds (60%) and Allen's Hummingbirds (40%).

\*) For the actual sampling, another 1/4 of PP concentrate was added to feeder B, so both foods had 20% sugar concentration (Brix).

There were 3 additional feeders on the property, but the closest one to A and B, which were next to each other, was 8 m away. There were ~600 birds divided between the feeders, which were all full of birds most of the time. Many birds had pollen, so they were feeding on flowers as well.

About 20 minutes into hour 1, the birds started to move to feeder A after visiting B, but both feeders were still popular.

Two dogs were running outside some of the time. They did not chase the birds, but their close presence by the feeders scared them as they scattered and returned after a few minutes.

The observation was done from 15 meters away from feeders A and B. Cell phone video was taken for 3 min x 6 (3 times during hour 1; and 3 times during hour 2 after rotation of feeders) to estimate visits and species distribution.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	527 g	531 g
<b>Weight after sampling</b>	225 g	417 g
<b>Amount consumed (g)</b>	<b>302 g</b>	<b>114 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 68% AL 37%	AN 74% AL 26%
<b>Visits</b>	<b>95</b>	<b>90</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

### Visits per feeder. Site 1, Sampling 1.

Site and date La Cañada, 10/3/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	44	AN: 33 AL: 11	Females: 12 Males: 32
Hour 2.	51	AN: 32 AL: 19	Females: 25 Males: 26
<b>Feeder B</b> Hour 1.	60	AN: 42 AL: 18	Females: 25 Males: 35
Hour 2.	30	AN: 25 AL: 5	Females: 11 Males: 19

**Total visits: Feeder A = 95, Feeder B = 90.**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits were calculated from 6 x 3 minutes of video recording from each sampling.

### Sampling 2.

**Date:** October 6, 2023

**Time:** 10:00 – 12:00

**Sampling site:** Beverly Hills, Gottlieb Native Garden (Site II)/1



**Weather:** 26 C – 28 C with 34 % humidity, sunny and hot, NW wind 2 km/h

**Observation notes:** The naturalist at the private garden, **Scott Logan**, noted that birds at sampling sites where people use homemade food are used to that taste which can affect results. He said that hummers have a very accurate sense of taste.

There is only one other feeder close by. We removed others that were next to the test feeders. 7 feeders were much further away and were not used by birds. Just 20 min in A feeder is 2x more popular than B. There are a few bees around that disturb the birds. Hour 2: A is still more popular than B but both are utilized. Some birds have pollen and I see them going to the flowers. There are plenty of native flowers around. Aggressive Allen's were often chasing the Anna's away from the feeders.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	994 g	981 g
<b>Weight after sampling</b>	807 g	869 g
<b>Amount consumed (g)</b>	<b>187 g</b>	<b>112 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	18%
<b>Species and distribution</b>	AN 66% AL 34%	AN 77% AL 23%
<b>Visits</b>	<b>137</b>	<b>163</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

### Visits per feeder, Site 2, Sampling 2.

Site and date Beverly Hills, 10/6/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	74	AN: 51 AL: 23	Females: 22 Males: 52
Hour 2.	63	AN: 40 AL: 23	Females: 23 Males: 40
<b>Feeder B</b> Hour 1.	103	AN: 86 AL: 17	Females: 32 Males: 71
Hour 2.	60	AN: 39 AL: 21	Females: 40 Males: 20

Total visits: **Feeder A = 137, Feeder B = 163**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits were calculated from 6 x 3 minutes of video recording from each sampling.

### Sampling 3.

**Date:** October 11, 2023

**Time:** 13:17 – 15:17

**Sampling site:** Kenneth Hahn Park – Hummingbird Garden (Site III)/1

**Weather:** From 22 C with 62 % humidity, sunny and warm, SW wind 16 km/h

**Observation notes:** Bees are a big issue here. There are fewer birds than at other sites, only about 40 and there are 10 feeders total in the garden. One of them close to mine was covered with bees the whole time. Only mine and another one closer to them were visited during the sampling. The birds were not going to the feeder if there were so many bees that there were no empty feeding spots open, and they were annoyed by them. Some birds had quite a bit of pollen, so they were visiting flowers too and visits to the feeders were more sporadic, not used non-stop like at other sites. There are also feeders with seeds, a log with peanut butter on top of it, and a squirrel pulling one feeder and drinking from it (spilling most on the ground). Just before switching the places between the feeders, A was becoming very popular. Feeders were in the shade for the duration of the sampling.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	525 g	506 g
<b>Weight after sampling</b>	472 g	493 g
<b>Amount consumed (g)</b>	<b>53 g</b>	<b>13 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 45% AL 55%	AN 60% AL 40%
<b>Visits</b>	<b>62</b>	<b>45</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

### Visits per feeder. Site 3. Sampling 3.

Site and date Kenneth Hahn Park 10/11/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	32	AN: 8 AL: 24	Females: 9 Males: 23
Hour 2.	30	AN: 20 AL: 10	Females: 15 Males: 15
<b>Feeder B</b> Hour 1.	26	AN: 13 AL: 13	Females: 10 Males: 16
Hour 2.	19	AN: 14 AL: 5	Females: 6 Males: 13

**Total visits, Feeder A = 62, Feeder B = 45**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

### Sampling 4.

**Date:** October 13, 2023

**Time:** 15:10 – 17:10

**Sampling site:** Beverly Hills, Gottlieb Native Garden (Site II)/2

**Weather:** 24 C with 48 % humidity, sunny and warm, SW wind 10 km/h

**Observation notes:** Lots of juveniles, especially male Allen's, just one other feeder close by because of the number of birds. They are feeding on flowers as well, with quite a bit of pollen on their beaks. It seems like Anna's are more okay with Feeder B than Allen's. A couple of bees are bugging the birds and they move to another feeder if the bees harass them too much. Both feeders were in the sun for hour 1. Feeder B was not in the sun for the most part of hour 2. There are 8 feeding stations/spots in both feeders.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	1041 g	1041 g
<b>Weight after sampling</b>	874 g	960 g
<b>Amount consumed (g)</b>	<b>167 g</b>	<b>81 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 60% AL 40%	AN 59% AL 41%
<b>Visits</b>	<b>57</b>	<b>56</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

Site and date Beverly Hills, 10/13/2023	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	24	AN: 15 AL: 9	Females: 6 Males: 18
Hour 2.	33	AN: 19 AL: 14	Females: 13 Males: 20
<b>Feeder B</b> Hour 1.	32	AN: 22 AL: 10	Females: 3 Males: 29
Hour 2.	24	AN: 11 AL: 13	Females: 6 Males: 18

**Total visits: Feeder A = 57, Feeder B = 56**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

## Sampling 5.

**Date:** October 15, 2023

**Time:** 16:13 – 18:13

**Sampling Site:** La Cañada Flintridge (Site I)/2

**Weather:** 31 C – 30 C with 20 % humidity, sunny and unusually hot, SSE wind 11 km/h

**Observation notes:** There were about 50 % less birds than during the first sampling. After taking the first video, Feeder A got a lot of visits. Feeder B had visits as well. Both feeders were in the shade as the sun was behind the house. It looked like Feeder B was getting more visits than A 45 minutes into the sampling. The birds were feeding on flowers as well. After switching the places of the feeders after hour 1, I noticed that Feeder A was leaking. I don't know what happened, but some food had spilled on the ground. I estimated the amount lost, replaced it quickly in the feeder, and put it back. To compensate for the time lost, I let it stay for 2 minutes longer than Feeder B after

finishing the sampling. The big family dog was outside, walking by the feeders occasionally, and the birds scattered.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	561 g	587 g
<b>Weight after sampling</b>	416 g	548 g
<b>Amount consumed (g)</b>	<b>145 g</b>	<b>39 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 76% AL 24%	AN 72% AL 28%
<b>Visits</b>	<b>58</b>	<b>32</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

**Visits per feeder. Site 1. Sampling 5.**

Site and date La Cañada, 10/15/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	40	AN: 29 AL: 11	Females: 11 Males: 29
Hour 2.	18	AN: 15 AL: 3	Females: 6 Males: 12
<b>Feeder B</b> Hour 1.	11	AN: 10 AL: 1	Females: 6 Males: 5
Hour 2.	21	AN: 13 AL: 8	Females: 11 Males: 10

**Total visits: Feeder A = 58, Feeder B = 32**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

**Sampling 6.**

**Date:** October 20, 2023

**Time:** 8:54 – 10:54

**Sampling site:** Kenneth Hahn Park – Hummingbird Garden (Site III)/2

**Weather:** 19 C – 24 C, with 88 % humidity, sunny and warm, wind 0 km/h

**Observation notes:** There are even more bees than last time. The openings at the feeding stations/ports are big enough for bees to squeeze halfway inside and get the nectar. Feeders at other sites have smaller openings to keep bees away. They work better. Both feeders are in a semi-shaded area. Feeder 3 close by is the most popular today. Birds and bees are also feeding on the bottle-brush tree and other blooming plants, more than during the last sampling. Feeders 1 & 2 had no bees, but neither did



they have any birds. It's the same thing with feeders 7 & 8 on the other side of the bottle brush tree; they were barely visited by birds or bees. Hummers were also fighting a lot today. It looks like when there are not that many birds like here, around 40, and many feeders, they all want to go to the same one(s). They really tried to go to feeders A and B, but there were just too many bees, especially on feeder A.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	517 g	511 g
<b>Weight after sampling</b>	495 g	495 g
<b>Amount consumed (g)</b>	<b>16 g</b>	<b>22 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 55% AL 45%	AN 0% AL 0%
<b>Visits</b>	<b>11</b>	<b>0</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

**Visits per feeder. Site 3. Sampling 6.**

Site and date Kenneth Hahn 10/20/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	11	AN: 6 AL: 5	Females: 7 Males: 4
Hour 2.	0	AN: 0 AL: 0	Females: 0 Males: 0
<b>Feeder B</b> Hour 1.	0	AN: 0 AL: 0	Females: 0 Males: 0
Hour 2.	0	AN: 0 AL: 0	Females: 0 Males: 0

**Total visits, Feeder A = 11, Feeder B = 0**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

Note: Columns with zeros; Birds kept hovering around the feeders looking for an open station but there were so many bees that it was impossible. There was also an aggressive Allen's male that chased each bird away from Feeder B when they got closer to it during hour 2. Perhaps the birds showed more aggression toward each other because they were frustrated by the bees. During hour 2, bees swarmed on the side of Feeder A which had a tiny crack, but it was not leaking.

**Sampling 7**

**Date:** October 23, 2023

**Time:** 7:58 – 9:58

**Sampling site:** Beverly Hills, The Gottlieb Native Garden (Site II)/3

**Weather:** 16 – 18 C with 68% humidity, mostly to partly cloudy, SW wind 7 km/h

**Observation notes:** It is a very busy morning! Some bees start coming to my feeders, but there are so many more birds that they don't stand a chance. Gottlieb's feeder ports are too small for bees. Cloud cover cleared at 8:25, and both feeders were in the sun. There is not as much pollen on birds as before, but there are still plenty of blooming flowers around. Feeder A is clearly more popular during the 1<sup>st</sup> hour. After switching: B is popular in the beginning, but it starts to balance out quickly. These are the most popular feeders besides the one nearby and along the path towards the kitchen. There are 6 other feeders on the property. The housekeeper told me that they go through 75 lbs. of sugar a week during the spring migration.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	503 g	508 g
<b>Weight after sampling</b>	268 g	435 g
<b>Amount consumed (g)</b>	<b>235 g</b>	<b>73 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 63% AL 37%	AN 59% AL 41%
<b>Visits</b>	<b>240</b>	<b>142</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

### Visits per feeder. Site 2. Sampling 7.

Site and date Beverly Hills, 10/23/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	125	AN: 76 AL: 49	Females: 35 Males: 90
Hour 2.	115	AN: 75 AL: 40	Females: 44 Males: 71
<b>Feeder B</b> Hour 1.	64	AN: 36 AL: 28	Females: 33 Males: 31
Hour 2.	78	AN: 48 AL: 30	Females: 30 Males: 48

**Total visits, Feeder A = 240, Feeder B = 142**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

### Sampling 8.

**Date:** October 26, 2023

**Time:** 16:18 – 18:18

**Sampling site:** Kenneth Hahn Park – Hummingbird Garden (Site III)/3

**Weather:** 20 C – 18 C, with 63 % humidity, sunny, SE wind 14 km/h

**Observation notes:** Feeders were in partial shade and after hour 1 in complete shade. There were not as many bees as last time, but they were still coming to my feeders. Feeder 3 on the left of my feeders was the most popular one. Again, there were no visitors on feeders 1 & 2, and 7 & 8. Feeder A has a crack on the side where bees are gathering/swarming even though it is not dripping or leaking at all. I put clear tape around the cracked area after the sampling.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	523 g	524 g
<b>Weight after sampling</b>	497 g	504 g
<b>Amount consumed (g)</b>	<b>26 g</b>	<b>20 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 55% AL 45%	AN 61% AL 39%
<b>Visits</b>	<b>31</b>	<b>56</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

**Visits per feeder. Site 3. Sampling 8.**

Site and date Kenneth Hahn Park 10/26/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	25	AN: 14 AL: 11	Females: 6 Males: 19
Hour 2.	6	AN: 3 AL: 3	Females: 0 Males: 6
<b>Feeder B</b> Hour 1.	30	AN: 23 AL: 7	Females: 11 Males: 19
Hour 2.	26	AN: 11 AL: 15	Females: 14 Males: 12

**Total visits, feeder A = 31, Feeder B = 56**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.

**Sampling 9.**

**Date:** October 28, 2023

**Time:** 8:01 – 10:01

**Sampling Site:** La Cañada Flintridge (Site I)/3

**Weather:** 12 C – 18 C with 62 % humidity, sunny and chilly, NE wind 5 km/h

**Observation notes:** Chilly morning; hummers started coming to the feeders as soon as I set them up. The number of individuals has decreased from the earlier samplings, but there are still a few hundred birds. Pollen on many Allen's especially. Feeder B is in the sun from 8:20 on, and A from 8:30 on until 9. There are a couple of bees around, especially at B after hour one. There are 2 other feeders around, but none close by. It looks like the longer the sampling goes, the more popular A becomes.

	<b>Feeder A (homemade)</b>	<b>Feeder B (Perky Pet)</b>
<b>Weight with 323 g of food (300 ml)</b>	507 g	507 g
<b>Weight after sampling</b>	310 g	464 g
<b>Amount consumed (g)</b>	<b>197 g</b>	<b>43 g</b>
<b>Brix after sampling (both 20% at the start of sampling)</b>	20%	20%
<b>Species and distribution</b>	AN 66% AL 34%	AN 69% AL 31%
<b>Visits</b>	<b>107</b>	<b>87</b>

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL), Black-chinned Hummingbird (BC), Rufous Hummingbird (RU), Calliope Hummingbird (CA), Costa's Hummingbird (CO)

Species distribution and visits are estimated and calculated from 6 x 3 minutes of video recordings of each sampling.

**Visits per feeder. Site 1. Sampling 9.**

Site and date La Cañada, 10/28/23	Number of visits	Visits by species (AN/AL)	Visits by females/males
<b>Feeder A</b> Hour 1.	58	AN: 35	Females: 27
		AL: 23	Males: 31
Hour 2.	49	AN: 36	Females: 22
		AL: 13	Males: 27
<b>Feeder B</b> Hour 1.	54	AN: 39	Females: 27
		AL: 15	Males: 27
Hour 2.	33	AN: 21	Females: 18
		AL: 12	Males: 15

**Total visits, Feeder A = 107, Feeder B = 87**

Species and codes: Anna's Hummingbird (AN), Allen's Hummingbird (AL).

Species distribution and visits are estimates calculated from 6 x 3 minutes of video recording from each sampling.



### Appendix C

T-test comparing sugar water consumption (g) in feeders by hummingbirds.

T-test: comparing consumption of sugar water (g) in feeders						
Day	Feeder A (homemade)	Feeder B (Perky Pet)				
1	302	114			alpha	0.05
2	187	112			p-value	0.004452479203
3	53	13				
4	167	81				
5	145	39				
6	16	22				
7	235	73				
8	26	20				
9	197	43				
AVERAGE	<b>147.56</b>	<b>57.44</b>				
STDEV	<b>98.05</b>	<b>38.98</b>				
MEDIAN	<b>167</b>	<b>43</b>				

### Appendix D

## Estimated visits per feeder

	Visits per feeder		
Day	Feeder A (homemade)	Feeder B (Perky-Pet)	
1	95	90	
2	137	163	
3	62	45	
4	57	56	
5	58	32	
6	11	0	
7	240	142	
8	31	56	
9	107	87	
<b>Total visits</b>	<b>798</b>	<b>671</b>	
AVERAGE	89	75	
STDEV	8.49	2.12	
MEDIAN	62	56	

## Appendix F

Examples of feeder positioning during hour 1 and hour 2 at site 2, Beverly Hills, October 23, 2023.



Hour 1.



Hour 2.

## Appendix G

Links to sampling photos and videos:

[Sampling 1. Photos and Videos](#)

[Sampling 2. Photos and Videos 2](#)

[Sampling 3. Photos and Videos](#)

[Sampling 4. Photos and Videos.zip](#)

[Sampling 5. Photos and videos.zip](#)

[Sampling 6. Photos and videos.zip](#)

[Sampling 7. Videos and photos.zip](#)

[Sampling 8. Photos and videos.zip](#)

[Sampling 9. Photos and videos.zip](#)