

Daily consumption of sugar syrup by Rufous Hummingbirds at feeders in Clearwater, British Columbia, 2013–2020

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Abstract: Sugar-syrup consumption, primarily by Rufous Hummingbirds (*Selasphorus rufus*), was monitored May 12 to August 12 over eight years, 2013–2020. Data show wide variation in consumption, often with large changes during the hummingbird season. Consumption decreased, which is a presumed indicator of decline in hummingbird numbers over time. The method of measuring syrup consumption by weight worked well and could be used to monitor hummingbird populations at other locations. This technique is well suited to a citizen science program to track hummingbird populations across the continent.

Key words: Rufous Hummingbird, *Selasphorus rufus*, daily syrup consumption, nectar, British Columbia.

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Introduction

Monitoring population changes of birds is a key need for conservation action. Fluctuations in populations are variable, in some cases cyclic and in others increasing or decreasing (Koenig 2016). Monitoring hummingbird populations is particularly difficult because of their small size and low detectability (Wethington and Finley 2009). Though never informed of the results, participation in a 2013 university degree project designed by Michael Hoebel, in which people weighed sugar syrup consumption by hummingbirds at their location in B.C. one day per week, left me wondering what more frequent measurement would show. Expectations were that consumption would be moderately level one day to the next with increased consumption during migration, hatching, and fledging.

Methods

Syrup was made at a concentration of 1 part sugar in 4 parts water (20%). Each feeder was filled, weighed in grams, hung outside and, 24 hours later, weighed again. The difference in mass was calculated to determine the amount of syrup consumed. The same procedure was used for each subject feeder. Occasionally, all syrup was consumed before the scheduled weighing time. In these cases, a replacement feeder was erected or more syrup was added,

and the total 24 hour consumption was the combined amount from both feeders (or filling sessions). Care was taken to ensure calculations reflected the amount consumed; if a feeder got wet, it was dried prior to weighing. The weigh scale was a non-commercial one (Escali P115WR), but in comparison to a commercial one (Avery Berkel FX 220) seemed $\pm 2\%$ accurate.

After an extensive Internet search, a research paper, Holroyd and Finlay (2016), became the basis for calculating the consumption by one Rufous Hummingbird (*Selasphorus rufus*). It concluded that a Rufous Hummingbird would consume an average of 4.8 ml of syrup per day at a concentration of 1 part sugar in 3 parts water (25%). A conversion of their result, 4.8 ml/bird/day at 25% concentration, was made for the lower 20% concentration I used, resulting in a consumption of 6 ml/bird/day, $(4.8 \times 0.25 \div 0.2 = 6)$.

That result required conversion from milliliters to grams by multiplying it by a 20% sucrose solution's molecular density (Lane, Les, website, *Table - sucrose solutions, composition, viscosity, density @20°C.* <<https://lclane.net/text/sucrose.html>>) of 1.081g (6 x 1.081 = 6.496). The result was a rounded estimate that one Rufous Hummingbird might consume 6.5 grams per day. I also changed the calculation to volume to more easily relate this study to others, 1 bird consumes about 6 ml/day or 42 birds consume 250 ml.

Feeders at my home were monitored May 12 to August 12, for eight years, 2013–2020. The first full year, 2014, started with measuring every other day, but soon became

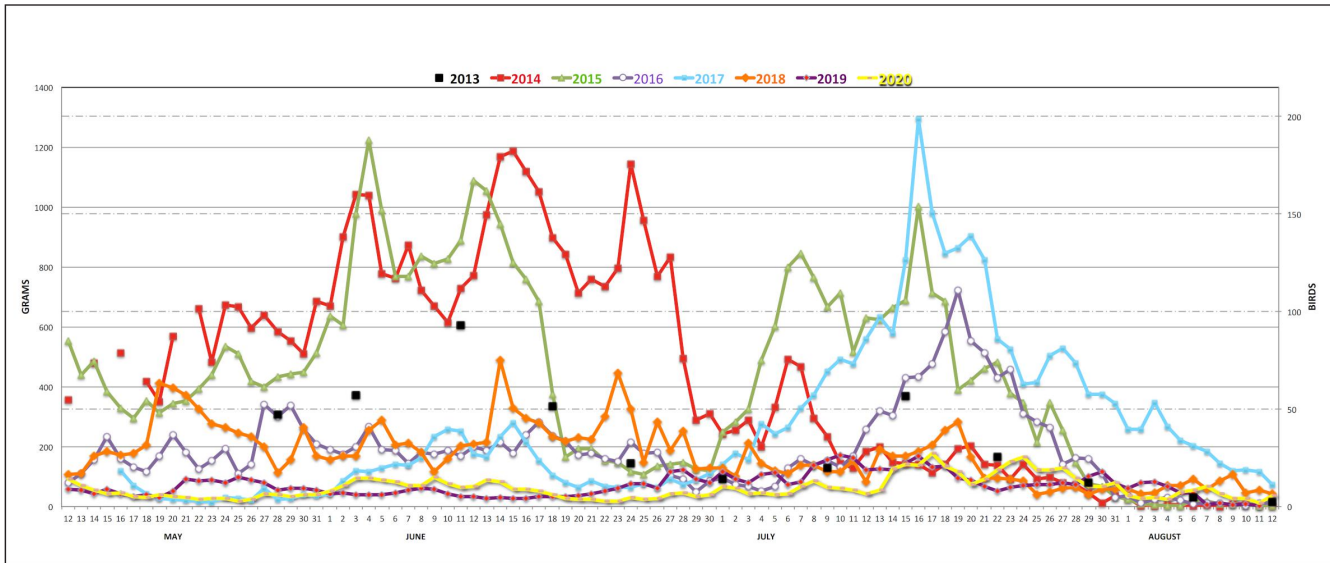


Figure 1. Grams of syrup consumed daily by Rufous Hummingbirds and number of birds (estimated at 6.5 g/bird) 2013–2020 at Clearwater, B.C.

every day from about mid-May to about mid-August and continued daily each year up to 2020. The first few years, three feeders were used and for a short while four, however the fourth feeder did not result in increased consumption. The last few years only two were used due to reduced hummingbird activity. The feeder in the shade under the north eave was usually the most frequented though this was not as prevalent in 2019 and 2020 with fewer birds.

Results

Syrup consumption

The daily amount of syrup consumed by Rufous Hummingbirds is presented in Figure 1. Blanks in lines are due to days when consumption was not measured. No line is used for 2013 as measurement was only once per week, but included so data on those dates can be compared each

year. Estimate of numbers of birds is based on 6.5 grams per bird per day (Holroyd and Finlay 2016, adjusted for the present study).

Consumption appears to follow a pattern of northward migration influx and subsidence: increase in June; a low point near the end of June; an increase at fledging and start of migration in July; and final decrease coinciding with southward migration in August. A similar seasonal pattern occurred through nearly all the years, with slight variation for warmer/early springs and cooler/late ones. Even the low consumption years of 2019 and 2020 generally followed the same pattern. Based on that pattern, monthly average consumption was calculated to better see the variation among years (Figure 2, Table 1). The months May and June trended strongly downward with July moderately so, while August’s trend rose slightly.

At my location in Clearwater, Rufous Hummingbirds predominate, with occasional sightings of Calliope (*Selasphorus calliope*), rare sightings of Black-chinned (*Archilochus alexandri*), and even rarer sightings of Anna’s (*Calypte anna*). Therefore, this study is basically about the sugar syrup consumption by Rufous Hummingbirds.

Observations

On rainy 2015 June 4, the most frequented north eave feeder, which did not have a dominant male, had about eight birds around it all day, often with two sharing a perch or port so that six were feeding at the same time from the four ports. 215 grams were consumed at that feeder and only 22 grams for the other two feeders combined. Though not as strong, this imbalance continued until the dramatic drop June 17 when an extremely aggressive male overwhelmed the birds at the north eave feeder, chasing most

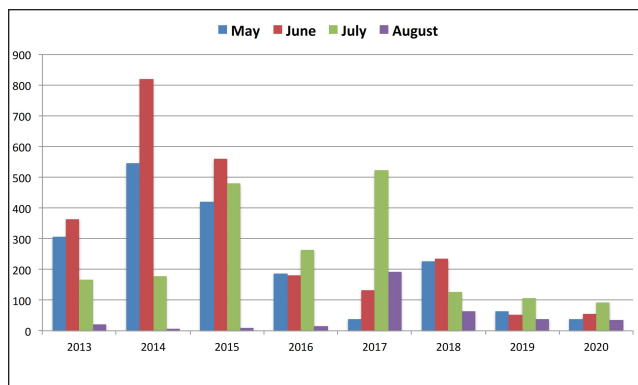


Figure 2. Average grams of syrup consumed monthly by Rufous Hummingbirds 2013–2020 at Clearwater, B.C.

Table 1. Grams of syrup consumed daily by Rufous Hummingbirds (mean±SE and sample size) May–August 2013–2020 at Clearwater, B.C.

	May	June	July	August	Total
2013	306.0 (1)	363.8±94.35 (4)	166.8±52.50 (5)	22.0±8.00 (2)	219.9±51.10 (12)
2014	546.1±27.33 (16)	820.4±40.75 (30)	177.2±19.97 (31)	6.6±2.07 (12)	437.3±37.32 (89)
2015	418.8±16.76 (20)	560.2±68.74 (30)	480.1±44.62 (31)	9.6±2.21 (12)	432.0±32.03 (93)
2016	187.2±17.05 (20)	179.7±9.10 (30)	263.8±33.04 (31)	16.4±2.97 (11)	190.1±14.26 (92)
2017	37.5±6.62 (16)	130.7±12.34 (30)	522.4±48.02 (31)	191.9±23.26 (12)	258.6±27.31 (89)
2018	227.6±20.55 (20)	234.5±15.76 (30)	126.3±11.11 (31)	64.4±6.06 (12)	175.0±10.13 (93)
2019	62.4±4.59 (20)	52.3±4.59 (30)	105.7±6.09 (31)	37.8±9.42 (11)	70.8±3.97 (92)
2020	39.3±3.76 (20)	55.3±4.67 (30)	92.1±7.22 (31)	35.8±4.33 (12)	61.6±3.80 (93)

away in two days. Male aggression, or lack of it, appears to be a strong factor affecting consumption.

Generally, consumption increased around July 16 to 19, which seems to be the peak for southward migration. Regarding the record 199 birds on 2017 July 16, weather was likely a contributing factor as the high, 20°C, was just after midnight, dropping to 13°C much of the day and down to 11°C at 21:00h, with strong-smelling smoke throughout the day. Perhaps the flowers were not producing much nectar and the hummingbirds went just to the feeders. Therefore, each bird may have consumed more feeder syrup than usual, thus exaggerating the numbers. Perhaps a pulse of migrants travelled through at the same time.

Another July 16, but in 2015, was a cool day with a high of 16°C and low of 7.5°C and had a spike similar to the one in 2017. It followed strong winds with heavy rain a day earlier. A spike 2016 July 19, was cloudy with some rain while a spike on the same date in 2018 was hot, 30°C, with a severe thunderstorm warning. Comparison of weather and spikes for other dates did not show any definitive relationship.

Six of the eight years had the First Of Year (FOY) arrival of a male within a five-day period, April 21 to 25, with exceptions of 2015 April 17 and, the earliest, 2016 April 10, when both years had warmer April temperatures. Averaging 4.9 days later, FOY females arrived within a four-day period, April 26 to 29. Again, there were exceptions in 2015 and 2016.

Some interesting observations were unrelated to the data. One day in May of 2015 the six-port dish-shaped west feeder was switched with the four-port north eave feeder because more birds were feeding at that location. The switch seemed to result in the male owner of the dish-shaped feeder moving with it to the north eave and chasing many others away. Reversing the situation for the next day seemed to result in that male continuing his ownership of the six-port feeder back at the west location.

One other day, the pole feeder was not put up as there was little action at it. Its owner seemed to take over the north eave feeder for the day. The situation was resolved by replacement of the pole feeder for the next day.

Usually the final observation of an adult male Rufous occurred in mid-July. The latest final sighting was 2017

July 21, while one was much earlier, 2014 July 8. The final departure of an adult female or juvenile varied considerably with the earliest being 2020 August 12. Outside of this study's timeframe an Anna's was the last hummingbird in 2018 and 2019 staying well into September.

Discussion

Syrup consumption

An original use of 5.16 g/bird/day calculated for denser sugar syrup (25%) used by Holroyd and Finlay did not feel sound. My current figure of 6.5 g/bird/day for my less dense syrup (20%) feels more plausible since, in 2020 when overall syrup consumption was low, the calculated number of birds expected to be present was in close agreement with the number of individual birds actually seen at the feeders. Four days in August had Rufous Hummingbird numbers identical for calculated/observed birds (three days at 4/4; one day with 2/2). On two other days (4/4; 5/4) a Black-Chinned Hummingbird was observed along with Rufous. Four days in May had one more Rufous calculated than observed (5/4; 5/4; 4/3; 4/3).

Weighing syrup consumption could be utilized to monitor hummingbirds anywhere. Though the method does not require much time, I do not expect many people would make it a daily habit, but might be willing to be engaged every few weeks. Coordinated dates for calculating syrup consumption over a very large area by many "citizen scientists" would give a valuable estimate of the population and readily show fluctuations.

The potential is indicated by participation 2020 June 10, when seven households weighed syrup consumption at their location; 6 near Clearwater, B.C., and one in Errington, B.C., on Vancouver Island. The rounded, estimated number of hummingbirds was 12, 11, 7, 5, 0, and 0 at Clearwater locations and 4 in Errington. One of those locals weighed syrup most of the season recording similar numbers to mine less than one kilometre away.

Use of grams rather than milliliters as the measure almost eliminates the problem of spillage, certainly easier to use, and weighing takes little time. Preferred time was in the evening just after the hummingbirds stopped feeding and can be done at night if the usual time was missed.

Evaporation was determined to be a negligible factor. Sample feeders isolated from faunal consumption in a greenhouse over 24 hours had no loss of mass on one test with the temperature just over 20°C, while another test at 29°C had a 0.003% loss of mass. More rigorous testing of evaporation should be done, taking into account the need for a more accurate weigh scale, and the effect of humidity and temperature, in combination.

Consumption by other species was not much of a factor here. In 2014 an explosion of wasps may have consumed a measurable amount of syrup, but not afterward (fewer around and perhaps removal of the yellow florets on feeders helped). A Downy Woodpecker (*Dryobates pubescens*) consumed some syrup a few times in 2009, but not during the years of measurement. A Bullock's Oriole (*Icterus bullockii*) was seen on the property in 2017, but never at a feeder. A few bats reside under the shakes on the west gable end, but have never been seen at a hummingbird feeder. An ant moat was necessary in earlier years, but not during this study.

Hummingbird Declines

As early as 2004, declines of Rufous Hummingbirds were identified as of concern by Partners in Flight (Rich *et al.* 2004). The Audubon Society in 2007 estimated the decline at 2.7% per year (Rich *et al.* 2004). In 2018, the IUCN Red list raised Rufous Hummingbirds from Least Concern to Near Threatened (BirdLife International 2018). Some potential reasons for declining Rufous Hummingbird numbers include: climate change-related alteration of flowering times; fires and extreme weather events; widespread pesticide use; and habitat loss on both breeding and wintering grounds.

A ten-day period of July high temperatures (over 30°C) in 2014 may have prompted migrants to choose a different route south and possibly chose the cooler alpine meadows. Perhaps some resident hummingbirds may have moved to the cooler alpine meadows as well. When the heat wave began July 7, consumption was rapidly rising only to drop 29% over four days. Without a heat wave, the next three years showed much higher consumption in July.

Regarding climate change-related fires, the sharpest drop in hummingbird numbers followed the B.C. wildfire season in 2015, which lasted from early May through August with extensive smoke almost all season. The two worst wildfire seasons in B.C.'s history, 2017 and 2018 (B.C. Wildfire Service 2019), probably caused a further reduction in hummingbird numbers. Fires and smoke extended July through mid-September in 2017 and mid-July through August in 2018. Generally, it appears the number of local birds dropped following a major fire season as evident by reduced consumption in May and June, but there was little effect on the July southward migrations until 2018 through 2020. Coastal hummingbirds are known to

migrate south through the interior of B.C. along with those from the northern interior. If those populations are still vibrant, they must have chosen a different route south. It is not difficult to see how wildfire seasons would impact the success of migration, from poor air quality to limited nectar availability because of reduced photosynthesis.

Along with major forest fire events, an added constant stressor is the contamination of insects from agricultural pesticides in soil and water courses which represent a dietary source of neurotoxins that could affect hummingbird migration and spatial orientation; imidacloprid has been shown to affect migration and stopover in passerines (Eng *et al.* 2017). Some water sources near agriculture in the Fraser Valley have had pesticides at levels toxic to aquatic invertebrates and honey bees (Bishop *et al.* 2020). This is of importance because insects are a vital source of protein, fat, and minerals for migrating and breeding hummingbirds, and flying insects with aquatic larval stages form the majority of the diet of Rufous Hummingbird nestlings (Moran *et al.* 2019). Although the full effect of these agricultural practices remains unknown, it is clear that in B.C. pesticides from agriculture are making their way through the food chain into hummingbirds, as they have been found in the urine of hummingbirds in the Fraser Valley, Similkameen, and Okanagan (Bishop *et al.* 2018, 2020). So, hummingbirds migrating through those areas intent on reaching this study site could be affected by pesticide use in those locales and elsewhere.

Conclusion

With many factors affecting syrup consumption, such as weather, other food sources, increased energy needs for male displays and aggression, increased energy needs for breeding females, etc., the method I used can provide only an estimate of numbers, although it corresponds well with my observations when numbers were very low. The data indicate this method provides a worthwhile estimate of the population over time. Of benefit, no physical handling (or related stress) occurs and sampling is unaffected by avoidance issues, which may occur with a banding/mark-recapture program, and no organized, highly-trained participants are required.

The expected day-to-day stability of syrup consumption rarely occurred except when daily consumption was very low, as was evident in 2019, 2020, and much of 2017. The seasonal consumption rates associated with important life-cycle events were apparent. More concerning was the general year-over-year decline in overall consumption and the likely corresponding decline in hummingbird numbers at the study site.

My study demonstrates that tracking syrup consumption could be used to monitor hummingbird populations as proposed by Holroyd and Finlay (2016). Monitoring syrup

use would be a more widely acceptable citizen science program than the current technique of trapping hummingbirds by skilled people in the Hummingbird Monitoring Network (Wethington and Finley 2009).

In 2020, with reports of many deaths of several bird species and severe forest fires in the western United States during migration time, I will continue monitoring in 2021.

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