Assessing the relationship between garden bird feeding patterns and weather in Vancouver, Canada

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Abstract

A recent increase in garden bird feeding by the public has provided birds with a novel food source, impacting ecosystem interactions, ecological niches, and migration of facultative migratory birds. The larger implications of garden bird feeding are not well understood and require further research. This study assesses the relationship between weather and feeding patterns in Vancouver, Canada in order to determine the optimal environmental conditions for studying garden birds in the future. Artificial nectar and seed feeders located in an urban setting were observed for 15 minutes (n=22) in the morning (09:00-11:00) and afternoon (15:00-17:00). Total feeding time and the number of feeding events were recorded, along with data on environmental temperature, wind speed, and brightness. A one-tailed paired t-test revealed a significant difference in nectar and seed feeding times (p=0.002) so data from the two feeders were analyzed separately. A second one-tailed paired t-test revealed insignificant differences between morning and afternoon total seed feeding time (p=0.27), number of seed feeding events (p=0.10), total nectar feeding time (p=0.38), and number of nectar feeding events (p=0.43), so the AM and PM data were combined, plotted, and a regression model was developed. While brightness did not impact feeding patterns, linear regressions showed an inverse relationship between wind and total feeding time or number of feeding events for both seed- and nectar-feeders. A 2^{nd} order polynomial regression showed minimum nectar feeding occurs at 10ºC, while seed-feeding is unaffected by temperature. The study concludes that future analyses on garden birds should occur in less windy weather, below 7ºC or above 12ºC for maximal observations.

Introduction

British Columbia, Canada is an ecologically diverse province that is home to more than 290 known species of birds (Campbell, 1997). Vancouver, the largest city in British Columbia, has a highly diverse biogeography with multiple different habitats. The uniquely dense concentration of marine, forest, mountainous, and urban settings accommodates an array of bird species. This paper assesses the feeding patterns of garden birds in an urban environment in Vancouver.

While some birds migrate southward in the fall to access warmer temperatures and increased food availability, many garden birds (birds that feed in urban greenspaces) do not migrate (Mayntz, 2020). Larger, soaring birds tend to be obligate migrators, travelling large distances beginning in the fall (Newton, 2012; Watanabe, 2016). In contrast, smaller birds such as those found in urban environments are more likely to be facultative migrators, meaning they only migrate when environmental conditions stretch outside their ecological niche (Newton, 2012; Watanabe, 2016). A recent increase in intentional bird feeding by the public in cities has provided many bird species with a novel food source, altering biotic interactions in urban spaces and impacting the migration patterns of facultative migrators (Reynolds et al., 2017). The effect of supplemented feeding on garden bird species is not well understood. This paper aims to further the scientific literature on garden feeders by determining the optimal conditions for observing birds for future ecological studies.

Intentional garden bird feeding in Northern Europe and North America is particularly common in colder months, as seeds and artificial nectar are provided by the public to supplement birds' dwindling food supply (Reynolds et al., 2017). For example, the only non-migrating hummingbird species in British Columbia, Anna's hummingbird (*Calypte anna*), relies entirely on supplementary food throughout the winter (Jones, 2018). To understand how garden bird feeding patterns change under increasingly harsh seasonal conditions in Vancouver, I measured bird feeding time and frequency with respect to weather throughout October and November. Previously studied weather factors affecting feeding include temperature and wind speed, though these have not been assessed in urban settings (Carr & Lima, 2010; Carr & Lima, 2014). Birds have shown an ability to discern brightness, but environmental illuminance has not previously been measured in relation to feeding behaviours (Pritz et al., 1970). This study measured the impact of temperature, wind speed, and brightness on bird feeding. I hypothesized that if feeding patterns of garden birds in Vancouver, Canada are related to weather, then birds will feed more frequently and will spend more time feeding in colder, less windy, and brighter weather.

Methods and Materials

I hung a Stokes Select Blossom 24 oz Bird Feeder from the southeast corner of a 2.5m-tall garage roof (Fig. 1). This nectar feeder was filled with an artificial nectar composed of a 1:4 volumetric ratio of white sugar to tap water and was replaced as needed (about every two weeks). To prepare the nectar, I combined the sugar and water in a sterilized cooking pot and heated until combined. I then allowed the sugar-water mixture to cool before filling the feeder.

I hung a Bird Feeder Lantern on the eastern side of a 2.5m-tall garage roof, 3m away from the nectar feeder (Fig. 1). I filled the lantern feeder with Armstrong Feather Treat Ultra Blend Bird Seed and replenished it as needed (about every three days).

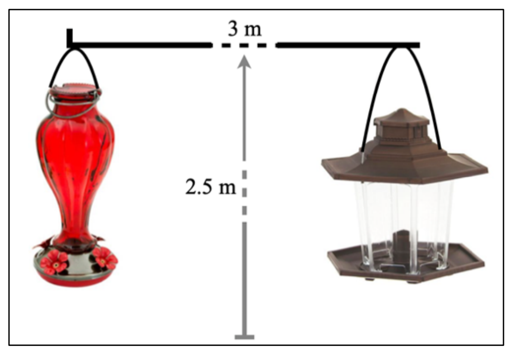

Fig. 1. Experimental setup. Stokes Select Blossom 24 oz Bird Feeder (left) (n=1) and Bird Feeder Lantern (right) (n=1) hanging on the corner and side of a garage, respectively. Horizontal line represents garage roof. Vertical line represents hanging height above ground. Feeder photos reproduced without permission from Canadian Tire (n.d.).

I measured feeding patterns for 15 minutes, once in the morning (09:00-11:00) and once in the afternoon (15:00-17:00) on 11 separate days throughout October and November of 2020 on the westside of Vancouver, Canada (Wheeler, 1980). Before each observation period, I ensured that both the nectar and seed feeders were more than half-full. I then swept away any seeds that had fallen on the ground under the feeder. I waited inside for 10 minutes to ensure my presence at the feeders did not impact feeding behaviours. During the observation period, I recorded the number of feeding events and the total feeding time over the 15-minute period at the nectar feeder and seed feeder using the DuckDuckGo online stopwatch. I used a Panasonic DCM-FZ200 camera to capture the birds at the feeders for subsequent species identification. After the observation period, I immediately measured the illuminance at each feeder using the Lux Light Meter Pro iPhone application. I took 10 brightness measurements at the feeders and recorded the average reading. I then visited the Environment Canada website to view the most recent weather report for Vancouver and recorded local temperature and wind speed (Environment Canada, 2020).

I performed one-tailed paired t-tests to determine if there were significant differences between the morning and afternoon data, and the seed feeder and nectar feeder data. The null hypotheses for morning vs. afternoon and seed vs. nectar feeders were both that the two groups being analyzed were the same. I analyzed the data by creating graphs with a weather factor (temperature [ºC], wind [km/h], or illuminance [lux]) on the x-axis and a feeding pattern (total feeding time (s) or number of feeding events) on the y-axis. I fit a linear regression to the data of each graph and obtained the slope and y-intercept values of the trendline, as well as the R^2 value of the model. I then visually assessed the plots and determined if a polynomial model better represented the data.

Results

A paired t-test revealed that the average feeding time within the 15-minute observation periods was significantly different between the seed (124.1 ± 155.5s) and nectar feeders (21.6 ±

24.2s) ($p=0.002$). Thus, the null hypothesis was rejected. The seed and nectar feeder data were therefore not combined for analysis.

Seed Feeder

Species observed at the seed feeder, in order of frequency of observation, include the red-breasted nuthatch (*Sitta canadensis*), dark-eyed junco (*Junco hyemalis*), song sparrow (*Melospiza melodia*), black-capped chickadee (*Poecile atricapillus*), American bushtit (*Psaltriparus minimus*), and Steller's jay (*Cyanocitta stelleri*). The northwestern crow (*Corvus brachyrhynchos caurinus*), American robin (*Turdus migratorius*), and northern flicker (*Colaptes auratus*) were observed feeding on the ground beneath the feeder, but not at the feeder itself. Birds were observed feeding on the ground in 17/22 observation periods. Birds of the same species were often observed feeding in groups.

One-tailed paired t-tests revealed insignificant differences between morning (AM) and afternoon (PM) mean total seed feeding time (142.8 ± 128.1s [AM], 105.4 ± 183.3s [PM]; $p=0.27$) and mean number of seed feeding events (5.8 ± 9.0 [AM], 2.4 ± 3.9 [PM]; $p=0.10$). Thus, the null hypotheses failed to be rejected. Morning and afternoon seed feeder data were plotted together, and a linear regression was established (Table 1).

Table 1. Seed feeder linear regression models for plots of temperature (ºC), wind (km/h), or illuminance (lux) against number of feeding events or total feed time (s) within a 15-minute observation period ($n=22$), and R^2 values for each model. Data collected in Vancouver, Canada.

	Temperature (ºC)	Wind (km/h)	Illuminance (lux)
Number of seed feeding events	$y = -0.196x + 5.7288$ $R^2 = 0.0089$	$y = -0.2446x + 8.7154$ $R^2 = 0.1182$	$y = 0.0032x + 1.1749$ $R^2 = 0.055$
Total seed feeding time (s)	$y = 4.2475x + 88.596$ $R^2 = 0.0085$	$y = -6.0022x + 237.58$ $R^2 = 0.1452$	$y = 0.0339x + 92.754$ $R^2 = 0.013$

The seed-feeding linear regressions that best fit their data (largest R^2 values) modelled the relationship between wind speed and total feed time (m=-6.0; R^2=0.15) or number of feeding events (m=-0.2; R^2=0.12) (Fig. 2).

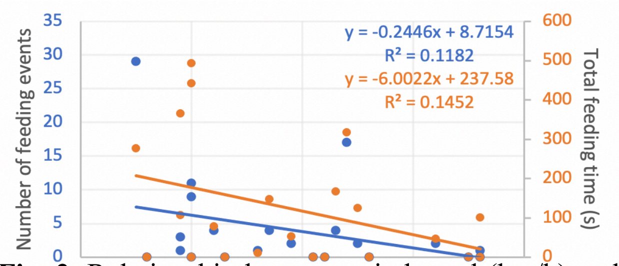

Fig. 2. Relationship between windspeed (km/h) and number of feeding events at the seed feeder, and windspeed (km/h) and total feeding time (s) at the seed feeder. Blue and orange data represent the number of feeding events and the total feeding time (s), respectively, in a 15-minute observation period (n=22). Trendlines are linear regression models. Data collected in Vancouver, Canada.

Nectar Feeder

The only bird species identified at the nectar feeder was Anna's hummingbird (*Calypte anna*). Hummingbirds were not observed landing on the nectar feeder, leading to visibly shorter feeding times compared to seed feeders, who were seen landing on their feeder. One-tailed paired t-tests revealed insignificant differences between morning (AM) and afternoon (PM) mean total nectar feeding time (23.5 ± 24.2s [AM], 19.7 ± 25.1s [PM]; p=0.38) and mean number of nectar feeding events (3.0 ± 3.2 [AM], 2.7 ± 3.3 [PM]; p=0.43). Thus, the null hypotheses failed to be rejected. Morning and afternoon nectar feeder data were plotted together, and a linear regression was established (Table 2).

Table 2. Nectar feeder linear regression models for plots of temperature (ºC), wind (km/h), or illuminance (lux) against number of feeding events or total feed time (s) within a 15-minute observation period (n=22), and R^2 values for each model. Data collected in Vancouver, Canada.

	Temperature (ºC)	Wind (km/h)	Illuminance (lux)
Number of nectar feeding events	y = -0.311x + 5.4621 R^2 = 0.1093	y = -0.0973x + 4.7037 R^2 = 0.0912	y = 0.0002x + 2.5363 R^2 = 0.0032
Total nectar feeding time (s)	y = -3.0003x + 46.679 R^2 = 0.1765	y = -0.8044x + 36.823 R^2 = 0.1081	y = 0.0024x + 17.355 R^2 = 0.0094

The regression models that best fit their data (largest R^2 values) show an inverse relationship between temperature and total feed time (m=-3.0; R^2=0.18), and temperature and number of feeding events (m=-0.3; R^2=0.11) at the nectar feeder (Fig. 3A). A visual assessment of these plots revealed that these data are better fit with a parabolic model for temperature and total feeding time ($y = 1.4658x^2 - 28.85x + 144.32$; $R^2 = 0.5225$), and temperature and number of feeding events ($y = 0.1048x^2 - 2.1585x + 12.44$; $R^2 = 0.2112$) (Fig. 3B). Polynomial models were not applied to any other relationships.

A) B)

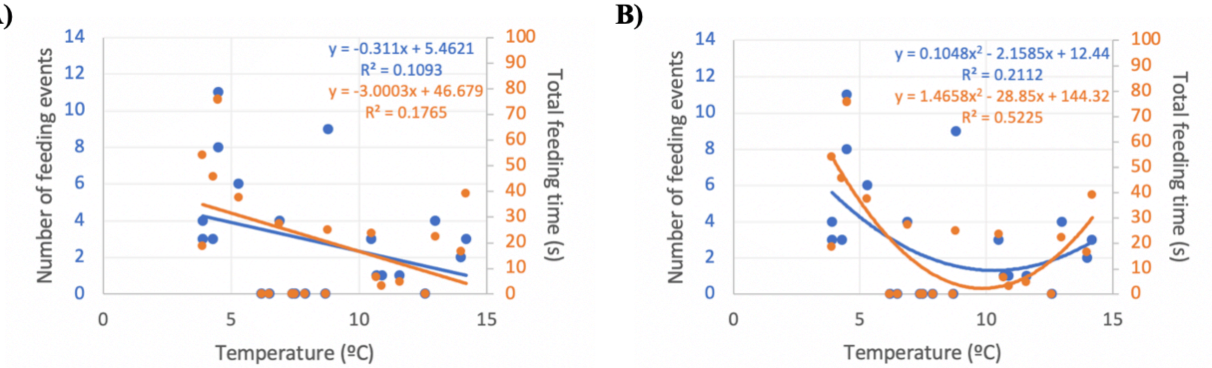

Fig. 3. Relationship between temperature (ºC) and number of feeding events at the nectar feeder, and temperature (ºC) and total feeding time (s) at the nectar feeder. Blue and orange data represent the number of feeding events and the total feeding time (s), respectively, in a 15-minute observation period (n=22). A) Trendlines are linear regression models. B) Trendlines are 2nd order polynomial regression models. Data collected in Vancouver, Canada.

Discussion

This study assessed total garden bird feeding time and frequency of seed- and nectar-feeders with respect to illuminance, temperature, and wind speed in Vancouver, Canada. No strong relationship was discovered between bird feeding patterns and illuminance at the seed feeder or nectar feeder. The linear models fit the scattered data poorly, as explained by R^2 values of 0.06 or lower, so no conclusions can be drawn from the positive slopes of the regressions. Bird feeding is likely more heavily influenced by the wavelength of light than the brightness. Olofsson et al. (2010) suggest that bird feeding is more prevalent at sunrise than later in the day due to the shorter-wavelength nature of the atmosphere. Birds are able to visually distinguish different wavelengths but may have a weaker ability to assess brightness, explaining the inconsistent patterns of feeding with respect to illuminance (Lawrence & Noonan, 2018).

The linear regression models developed suggest that as temperature decreases, the total feeding time (R^2=0.18) and the number of feeding events (R^2=0.11) increases for the nectar-feeding Anna's hummingbird (*Calypte anna*). These linear models, however, were bested in their ability to describe the data by 2nd order polynomial models (R^2=0.52; R^2=0.21), which had minima around 10ºC. The polynomial models' trends are explained by the increased demand for energy required by birds such as hummingbirds in cold weather to meet metabolic demands (Skryten, 2020). This is also consistent with the finding that Anna's hummingbird becomes increasingly reliant on supplemental feeding by humans in the cold (Jones, 2018). The increase in feeding above 10ºC may be explained by Carr and Lima's (2014) proposed tradeoff between the thermal benefits of feeding at higher temperatures and increased predation at higher temperatures. Below 10ºC, predation effects may dominate, while the thermal benefits may outweigh predation risks above 10ºC, explaining the increase in nectar feeding. No relationship between seed-feeding and temperature was discovered. Applying a polynomial model to the data was unjustifiable due to their scattered nature, and the linear regression models both had R^2 values of 0.01, suggesting that the models were very poor fits for their data and thus should not be used to draw conclusions about the temperature and seed-feeding relationship.

A relationship was discovered between wind speed and both total feed time and number of feeding events for the seed and nectar feeders. Negative slopes of -6.0 (R^2=0.15) and -0.8 s/km/h (R^2=0.11) for the wind speed and total feed time relationship for seed- and nectar-feeders, respectively, tentatively suggests that feeding time decreases in windier conditions. Feeding frequency follows the same trend, with negative slopes for the seed (m=-0.2; R^2=0.12) and nectar (m=-0.1; R^2=0.09) feeder models of the relationship between wind speed and number of feeding events within a 15-minute observation period. These trends are explained by birds' evolved predator-prey interactions. Smaller birds, such as garden feeders, are likely to interpret objects blowing in the wind as threatening, thus increasing hiding behaviours and reducing feeding (Carr & Lima, 2010). This effect was amplified in this study because it was conducted during autumn in an urban area with many trees shedding their leaves.

The variation in bird feeding patterns irrespective of weather conditions can be partially explained by the observation of seed feeders appearing in groups, causing sporadic bursts of activity at the feeder. By chance, I may have observed many or few groups of birds within the 15-minute observation period, resulting in inflated or deflated readings relative to the average over a longer period of time. Future studies should observe feeding over a longer period, reducing the impact of random group movement.

This study underestimated garden seed feeding because birds fed on the ground in 17/22 observation periods, including four occasions when no activity was measured at the feeder. Only birds present at the feeder were recorded. Feeding events on the ground were not counted or timed, so did not contribute to the seed-feeding data. Future studies should consider ground seed-feeding in their measurements.

While this study does not support the hypothesis of increased feeding in brighter conditions, it provides some evidence of decreased garden bird feeding in windier weather. The hypothesis of increased feeding at lower temperature was only partially supported, as feeding was found to increase above 10ºC. Future analyses on garden birds should occur in less windy weather, below 7ºC or above 12ºC for maximal observations.

Conclusion

This study assessed total garden bird feeding time and frequency of seed- and nectar-feeders with respect to illuminance, temperature, and wind speed in Vancouver, Canada. Brightness showed no relationship to seed- or nectar-feeding time or frequency, wind showed tentative inverse linear relationships, and temperature showed a parabolic relationship with minimum feeding occurring at about 10ºC for nectar-feeders only. The results therefore only partially support the original prediction that birds would feed more frequently and for longer in colder, less windy, and brighter weather.

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Literature Cited

Campbell, R. W. (1997). *The birds of British Columbia* (Vol. 1). UBC Press.

Canadian Tire. (n.d.). Wild Bird. Retrieved October 20, 2020, from https://www.canadiantire.ca/en/household-pets/pet-care/wild-bird.html

Carr, J. M., & Lima, S. L. (2010). High wind speeds decrease the responsiveness of birds to potentially threatening moving stimuli. *Animal Behaviour, 80*(2), 215-220. doi:10.1016/j.anbehav.2010.04.021

Carr, J. M., & Lima, S. L. (2014). Wintering birds avoid warm sunshine: Predation and the costs of foraging in sunlight. *Oecologia, 174*(3), 713-721. doi:10.1007/s00442-013-2804-7

Environment Canada. (2020, November 20). Vancouver, BC. Retrieved November 20, 2020, from https://weather.gc.ca/city/pages/bc-74_metric_e.html

Jones, D. N. (2018). *The birds at my table: Why we feed wild birds and why it matters*. Ithaca, NY: Comstock Publishing.

Lawrence, J. P., & Noonan, B. P. (2018). Avian learning favors colorful, not bright, signals. *Plos One, 13*(3), E0194279. doi:10.1371/journal.pone.0194279

Mayntz, M. (2020, October 10). When do hummingbirds migrate? Retrieved November 25, 2020, from https://www.thespruce.com/when-is-hummingbird-migration-386451

Newton, I. (2012). Obligate and facultative migration in birds: Ecological aspects. *Journal of Ornithology, 153*(S1), 171-180. doi:10.1007/s10336-011-0765-3

Olofsson, M., Vallin, A., Jakobsson, S., & Wiklund, C. (2010). Marginal eyespots on butterfly wings deflect bird attacks under low light intensities with UV wavelengths. *Plos One, 5*(5). doi:10.1371/journal.pone.0010798

Pritz, M. B., Mead, W. R., & Northcutt, R. G. (1970). The effects of Wulst ablations on color, brightness and pattern discrimination in pigeons (*Columba livia*). *Journal of Comparative Neurology*, *140*(1), 81-100. doi:10.1002/cne.901400106

Reynolds, S. J., Galbraith, J. A., Smith, J. A., & Jones, D. N. (2017). Garden bird feeding: Insights and prospects from a north-south comparison of this global urban phenomenon. *Frontiers in Ecology and Evolution, 5*. doi:10.3389/fevo.2017.00024

Skryten, K. A. (2020). The effect of artificial light and latitude on foraging activity in resident passerines in northern Europe. *Norwegian University of Life Sciences.*

Watanabe, Y. Y. (2016). Flight mode affects allometry of migration range in birds. *Ecology Letters, 19*(8), 907-914. doi:10.1111/ele.12627

Wheeler, T. G. (1980). Experiments in feeding behavior of the Anna hummingbird. *The Wilson Bulletin, 92*(1), 53-62. http://www.jstor.org/stable/4161293

Appendix

Table A1. Raw data table of total nectar and seed feeding time (s) and number of nectar and seed feeding events in 15-minute observation periods (n=22) throughout October and November of 2020 in Vancouver, Canada. Illuminance at each feeder, and environmental temperature (ºC) and wind speed (km/h) reported.

Date and time of observation	Number of nectar feeding events	Total nectar feeding time (s)	Illuminance at nectar feeder (lux)	Number of seed feeding events	Total seed feeding time (s)	Illuminance at seed feeder (lux)	Temperature (ºC)	Wind speed (km/h)
Oct 26 AM	11	75.9	2879	29	276.5	1759	4.5	5
Oct 26 PM	0	0	2310	0	0	936	6.2	6
Oct 28 AM	1	3.1	1961	17	317.9	842	10.9	24
Oct 28 PM	0	0	1197	2	52.6	700	12.6	19
Oct 30 AM	1	4.6	2180	0	0	1220	11.6	36
Oct 30 PM	3	23.7	1947	2	47	655	10.5	32
Nov 2 AM	1	6.6	3372	1	106.8	1903	10.7	9
Nov 2 PM	4	22.2	1805	9	441.4	857	13	10
Nov 4 AM	3	39.2	2004	4	167.4	1074	14.2	23
Nov 4 PM	2	16.6	467	0	0	457	14	26
Nov 6 AM	0	0	2943	1	100.3	1200	7.4	36
Nov 6 PM	0	0	506	0	0	398	7.9	35
Nov 9 AM	3	45.6	2536	1	10.6	1589	4.3	16
Nov 9 PM	4	54.1	1251	0	0	608	3.9	21
Nov 11 AM	3	18.7	3225	4	77.9	1491	3.9	12
Nov 11 PM	8	75.5	1323	0	0	453	4.5	10
Nov 13 AM	6	37.6	717	4	148	313	5.3	17
Nov 13 PM	0	0	101	0	0	101	7.5	22
Nov 16 AM	4	27.2	2461	3	365	1696	6.9	9
Nov 16 PM	0	0	334	11	492.7	269	6.5	10
Nov 20 AM	0	0	2519	0	0	1151	8.7	13
Nov 20 PM	9	24.9	1046	2	125.7	684	8.8	25