The Associations of Nutritive Seed Value on Bird Feeding Preference: A Multiple-offer, Observational Bird Feeding Experiment

Harjap D. (Harjapdhillon3@hotmail.com)

Abstract

In the winter, birds are resource limited and demand more energy for migration and the endurance of harsh winter conditions. Through the use of bird feeders, humans can help to supplement a bird's increased requirements. This experiment intends to examine which seeds wild, wintering, west-coast bird species prefer and the association between nutritional value of a seed and its respective consumption. I offered sunflower, millet, hemp seed and peanuts simultaneously using identical bird feeders hung on the same tree in western Canada. Bird seed consumption at the end of experimental trials revealed that 2.5 g (SD= ±0.50 g) of sunflower seeds, 1.88 g (SD= ±0.40 g) of millet, 1.56 g (SD= ±0.30 g) of hemp seeds and 0.74 g (SD= ±0.25 g) of peanuts were consumed on average. Seed intake was related to bird seed preference and I found statistical differences in the amount of seeds consumed (Friedman Test, X^2= 15, n= 5, p= 0.0018). Seed consumption comparisons revealed that peanuts were the least preferred seed ($p < 0.05$), millet and hemp seed were equally preferred ($p > 0.05$) and sunflowers were preferred compared to peanuts and hemp seed ($p < 0.05$) but equally to millet ($p > 0.05$). Pearson's correlation test associating seed preference to total energy (r= 0.11), protein (r= 0.078), lipid (r= 0.26) and carbohydrate (r= -0.22) content were not found to be significant ($p > 0.05$). To assess correlations, connections were made to migratory behavior, differences in biochemical processes required to digest nutrients, seasonal shift and presence of harmful secondary compounds. Overall, I found sunflower seeds as being the seed of preference due to the seeds having the highest mean of consumption and a balanced nutritional composition; which can be used to attract and aid the most birds in the winter.

Introduction

As winter approaches, birds become increasingly resource-limited due to decreases in their natural food supply. Consequently, birds experience a higher energy demand during this critical time. This dietary requirement can be met through supplemental food resources provided by human-wildlife interaction. Bird feeders can provide nutrients to malnourished birds (Buczacki, 2007) and have been related with an array of positive effects. For example, birds provided with additional food were generally found to have increased antioxidant levels, reduced stress levels, were better suited to handle disease and displayed more rapid feather growth (Wilcoxen et al., 2015). However, this perturbation can also have undesired effects including an increase in infectious disease and reduced breeding success at the population level (Plummer et al., 2013). Despite this, negative effects can be reduced by engaging in safe bird-feeding practices such as ensuring the bird feeder is clean and rid of pathogens and feces (Wilcoxen et al., 2015).

Many factors contribute to the variability in bird feeding behavior. The role of bird and seed morphology has previously been linked to feeding preference. Particularly, the size of a bird's bill and bill-depth was positively correlated to the size of bird seed selected (Díaz, 1994). In addition, previous literature has found seed chemical composition and nutrition to factor in bird feeding preferences (Ríos et al., 2012). The presence of anti-nutritional compounds, such as phenols, can negatively affect a bird's energy balance, and have been reported to negatively affect intake rate and diet selection (Ríos et al., 2012). Whereas, a seed's energy, lipid (Carrillo et al., 2007), protein (Valera et al., 2005) and carbohydrate (Kelrick et al., 1986) content has been positively related to feeding behavior. Majority of previous experiments have been conducted in controlled lab environments and utilized captured bird species (Díaz, 1994; Ríos et al., 2012; Valera et al., 2005). In contrast, this experiment looks at seed nutritional content and the effect it has on feeding preference patterns through natural observation.

In this study, I examine the effect of different seed varieties and their respective nutritive value on the consumption of seeds in wild, wintering, west-coast bird species. The associations of four nutritional variables including total energy, protein, lipid and carbohydrate content in sunflower, millet, hemp seed and peanuts are examined. I propose that sunflower seeds will be strongly associated with feeding preference because they contain the highest energy content; primarily provided from high levels of lipids and carbohydrates relative to the other seeds. That is, I propose that birds will prefer sunflower seeds to fulfill energy demands rather than millet, hemp seed and peanuts. Understanding preference and selection patterns can be used to optimize supplementation which has implications on seasonal bird seed choice and the ability for humans to attract the more birds to feeders. Overall, the aim of this study is to aid the most number of birds during the winter; an essential and demanding time.

Methods

Bird Feeder Construction

I constructed bird feeding apparatuses using a circular tray (diameter= 19.5 cm, circumference= 61.25 cm, depth= 2.5 cm). The tray was marked with four points 13.8 cm away, in order to inscribe a square inside the circular area, which were then drilled to form small holes. To each hole, twisted manila rope (25 cm) was threaded and knotted at one end to secure to the tray. The free rope from each of the holes was brought together above the center of mass of the tray to ensure balance. The rope ends were taped together and in doing so, resulted in the formation of an easily accessible and hang-able bird feeder (*Figure 1.*). This process was repeated for each of the four circular trays to construct identical bird feeders.

Figure 1. Bird feeder (diameter= 19.5 cm, circumference= 61.25 cm, depth= 2.5 cm) containing sunflower seeds.

Seed Samples

Bird seeds used in this experiment include sunflower, millet, hemp seed and peanuts; common seeds found in bird feed blends. Hulled organic seeds of each type were purchased and 30 g were added and spread evenly on the surface of a respective bird feeder. To control for seed morphology, only hulled seeds were used in this experiment. This accounted for shell casing hardness and ease of accessibility, which are extraneous factors that impact feeding behavior. Additionally, the difference in seed metrics such as size and weight were reduced by physical manipulation. Peanuts, which are relatively larger than other seed variants, were crushed using a rubber mallet to promote physical uniformity between all seeds. Seed nutritional data was extracted and compiled from U.S Department of Agriculture (USDA) Food and Nutrition Database (*Table 1*).

	Energy (kcal)	Protein (g)	Lipids (g)	Carbohydrates (g)
Hulled Sunflower Seed	600	20	50	20
Hulled Millet	356	20	1.11	73
Hulled Hemp Seed	550	33.33	50	3.33
Hulled Peanuts	500	18	73	53

Table 1. The energy, protein, lipid and carbohydrate content of hulled sunflower seeds, millet, hemp seeds and peanuts. Data collected from U.S Department of Agriculture (USDA) Food and Nutrition Database. Quantitative measures are based on 100 g portions of each seed.

Data was collected in South Surrey, British Columbia, Canada at Redwood Park; a dense, forested park geographically located on the boundary of urban and agricultural land. Bird feeders were hung on a tree at an equal height and approximately 1 m away from each other during each experimental trial (*Figure 2.*). Placement of bird feeders on the tree was marked with a small rope to keep the site and position constant. The position of feeders was rotated for each trial to reduce variation in data. All seeds were presented at once, constituting a multiple-offer experimental design. Five experimental trials were conducted for one hour each and observations on the behavior and identity of species were noted from a distance. Bird species were identified using illustrations by Larry McQueen for Project FeederWatch at the Cornell Lab of Ornithology. After each trial, the remaining seeds were collected and weighed to calculate the mass of each bird seed consumed.

Figure 2. The experimental set-up in South Surrey, British Columbia, Canada at Redwood Park.

Statistical Analysis

For each of the five experimental trials, treatments (type of seed) were regarded as dependent data values since bird seeds were presented simultaneously. Therefore, a Friedman test was conducted in R-studio and was used to analyze if birds have a seed preference (i.e. differences in the amount of grams consumed per trial). Data for each trial was treated independently and paired. Correspondingly, pairwise comparisons of bird seed intake were made using Wilcoxon signed-ranks tests in R-studio, in order to determine which seeds were significantly preferred. Mean consumption intake was also computed and was used for correlational analysis in Excel. To examine correlation between seed preference and seed nutritive variables (energy content, protein, lipids and carbohydrates), Pearson correlation coefficients were calculated. The correlation matrix was tabulated and individual relationships were graphed on a scatterplot with a linear trend line to ease positive and negative correlation visualization. The reported Pearson correlation r values were used to conclude whether associations exist between nutritive seed value and bird feeding preference. All statistical analysis tests were considered significant if $p < 0.05$.

Results

The black-capped chickadee *Poecile atricapillus* and the house sparrow *Passer domesticus* composed 90% of interactions at the bird feeders, while the red-throated thrush *Turdus ruficollis* and the Steller's jay *Cyanocitta stelleri* accounted the remaining. Birds approached the bird feeders and carried a seed to a distance, then re-approached after consumption. Initially, re-approaches were random however, as duration progressed, I observed a higher frequency of re-approaches to the bird feeder containing sunflower seeds. This behavior was noted especially for smaller birds including the black-capped chickadee *Poecile atricapillus* and the house sparrow *Passer domesticus* whereas, larger birds including red-throated thrush *Turdus ruficollis* and the Steller's jay *Cyanocitta stelleri* spent more time around bird feeders before departure.

The total amount of a specific seed consumed per each trial (*Figure 3.*) was used to calculate the mean seed consumption throughout the experiment. The recorded average intake of sunflower seeds was

2.5 g (SD= ±0.50 g), millet 1.88 g (SD= ±0.40 g), hemp seeds 1.56 g (SD= 0.30 g) and peanuts 0.74 g (SD= 0.25 g). Seed intake during experimental trials significantly differed from each other (Friedman Test, X^2=15, n=5, p= 0.0018). Wilcoxon signed-rank tests for pairwise comparisons revealed peanuts were significantly less preferred than all other seeds ($p > 0.05$). Sunflower seed consumption was significantly greater than hemp seed (p= 0.03) but not millet (p= 0.25) and no differences were found between millet and hemp seeds (p= 0.29).

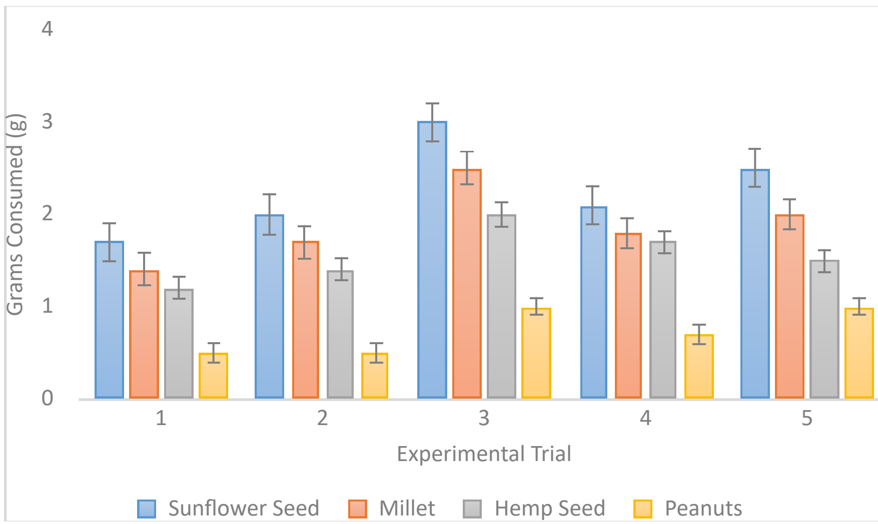
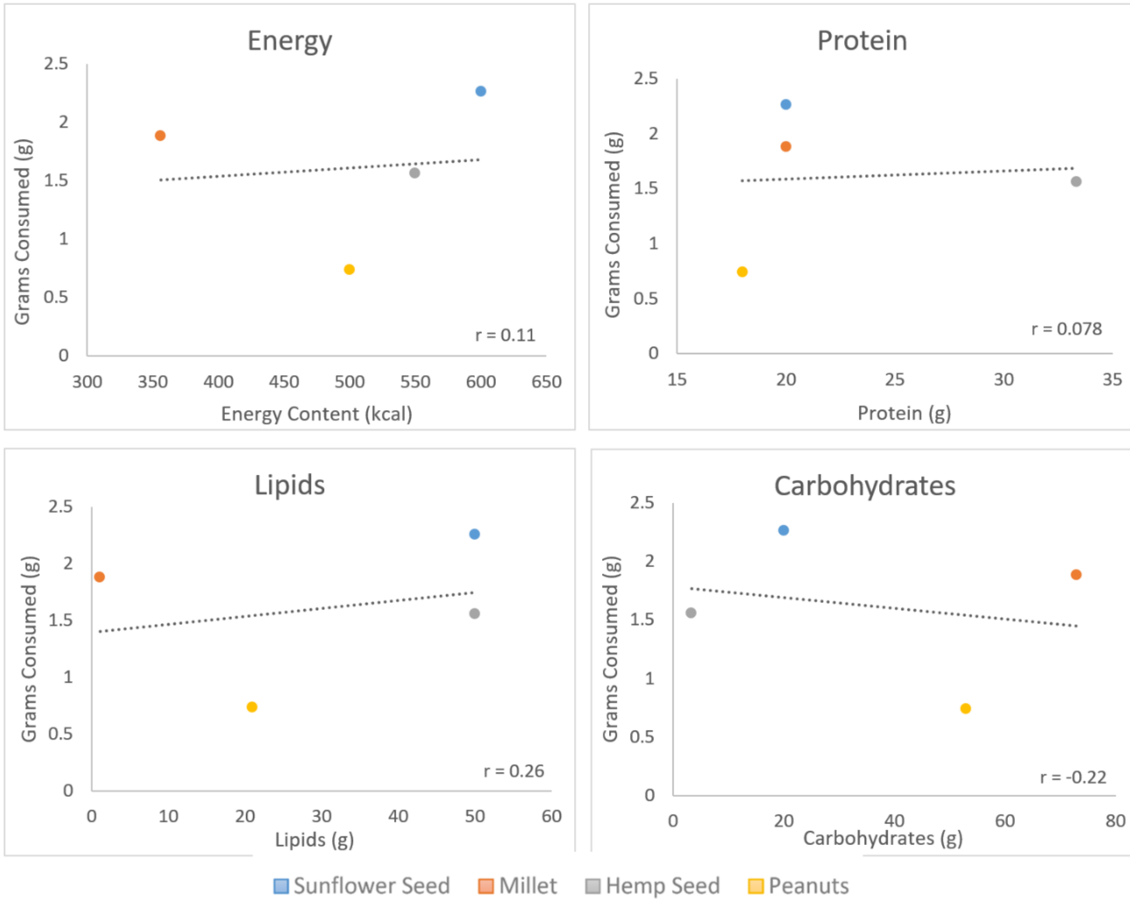


Figure 3. The grams consumed of each seed (sunflower seeds, millet, hemp seed and peanuts) per experimental trial (n=5). Error bars represent the standard error for sunflower seeds (SE=0.22 g), millet (SE=0.18 g), hemp seeds (SE=0.14 g) and peanuts (SE=0.11 g).

Correlation between seed nutritional variables and seed consumption (*Figure 4.*) conveyed a weak-positive relationship between consumption and energy content (Pearson's correlation coefficient, r= 0.11, n= 5) and consumption and lipids (Pearson's correlation coefficient, r= 0.26, n= 5). Whereas, protein showed a relatively weaker positive association (Pearson's correlation coefficient, r= 0.078, n= 5) and carbohydrates displayed a weak-negative relationship (Pearson's correlation coefficient, r= -0.22, n= 5) with bird seed preference. All associations were not found to be significant ($p > 0.05$).



Discussion

Results from the multiple-offer experiment conducted during the transition into winter, reveal that birds have a significant selective preference for predominantly sunflower seeds when compared to hemp seeds and peanuts; although, consumption differences with millet were not significant. Additionally, peanuts were a disfavored seed choice in the presence of all other seeds. Peanuts have a similar nutritional composition to sunflower seeds however, literature reports that they also contain secondary compounds which can restrict biochemical reactions required for digestion (Molokwu et al., 2011). This presence may have deterred birds from consuming peanuts in high concentrations when alternative seeds with similar energy, protein, lipid and carbohydrate content were available. Overall, my initial prediction aligned with bird feeding trials as the mean intake of sunflower seeds was the greatest although, correlations to nutritional values were found to be insignificant and weak. Statistical significance is dependent on sample size thus, I suggest increased sampling in future studies. Construction of a bird feeder with potential to withstand weather conditions such as rain would enable the ability to run more trials and for longer time periods. Though correlation coefficients were weak, the correlational values calculated have practical consequences in wintering birds and are not dependent on sample size. Coefficients may be related to which wild bird species were present to use the feeders, in order to supplement dietary requirements.

Weak correlations may be due to the presence of both smaller non-migratory bird species, including the black-capped chickadee *Poecile atricapillus* and the house sparrow *Passer domesticus* and larger, migratory bird species including the red-throated thrush *Turdus ruficollis* and the Steller's jay *Cyanocitta stelleri.* Smaller birds had a high observed presence at bird feeders compared to larger ones however, the amount of seed consumed by a specific species could not be quantified due to the observational design of this study. Therefore, speculations on seed intake comparisons relate to all species that were present during the duration of the experimental trials.

Seed-eating birds can obtain an immediate and digestible source of energy from polysaccharides (Karasov, 1990) found in starch; the most abundant carbohydrate in seeds (Ferreira et al., 2009). The higher energy requirements of smaller non-migratory birds is likely associated with the consumption of carbohydrates, which can provide an immediate source of energy. Whereas, migratory birds may have favored seeds with a higher lipid content. Birds can store and accumulate energy from lipids which can serve as prime energy required for long-distance migratory flights (Bairlein, 2002). This seasonal shift during winter may be related to a weaker association between protein and seed preference when compared to energy, carbohydrates and lipids.

In addition to migratory behavior, digestion of lipids and carbohydrates differs in birds which may affect seed preference. Lipids require multiple biochemical reactions, namely emulsification, hydrolysis and absorption to increase retention within the digestive tract (Sturkie, 2012). Contrarily, carbohydrates are easily digestible and absorbed through passive hydrolysis by pancreatic and intestinal enzymes which is energetically less costly (Ríos, 2012). Differences in seed profitability and nutritional tradeoffs dependent on the need of a certain bird species could be a factor in a weak correlation to gross energy content, carbohydrates and lipids.

Based on the developed framework, carbohydrates are a beneficial source of energy however, a negative correlation was observed. This could be due to a lack of independence with other nutritional variables and overall seed composition. In 100 g portions, millet contains the highest amount of carbohydrates (73 g) whereas sunflower seeds and hemp seeds both contain the greatest content of lipids (50 g). Moreover, the gross energy content of sunflower seeds (600 kcal), hemp seeds (550 kcal) and peanuts (500 kcal) is substantially greater than millet (356 kcal). Differences in seed profitability and associated tradeoffs could be a factor in why carbohydrates were negatively correlated in this study while previous literature reports a positive effect (Kelrick et al., 1986).

In summation, average sunflower seed consumption was greatest when compared to millet, hemp seeds and peanuts. This can be related to its versatility as a nutritionally balanced seed. Sunflower seeds can account for advantages and disadvantages of lipids and carbohydrates as energy sources as well as absence of toxic secondary compounds. Therefore, I purpose that sunflower seeds can be used to attract and aid the most number of bird species in the winter. However, further research examining nutritional variables and seed consumption in natural habitats should be conducted before results in this experiment are widely accepted. In addition, various sites should also be sampled since different geological locations home different bird species. In addition, the use of video cameras can also be implemented to provide important information to quantify specific bird seed consumption. Although, a multiple-offer study enabled for a direct comparison of bird seed preference, lack of nutritional variable independence led to limitations in correlational results. I recommend a single-offer design in which seeds are manipulated to specific nutrients for future studies. This information can be useful to make robust conclusions that can be applied in the winter to supplement bird nutritional requirements.

Conclusion

Overall, the average amount of sunflower seeds consumed was the greatest when compared to millet, hemp seeds and peanuts which aligned with my initial prediction. Although, relationships to nutritional variables such as energy, protein, lipid and carbohydrate content was not found to be significant, I suggest that sunflower seeds can be used to aid bird species during the winter since these seeds having a balanced nutritional content which can attract and benefit the most birds.

Acknowledgements

I would like to thank Dr. Leander for accepting my research proposal and providing insight and a focal point for my experimental research. In addition, I would like to thank UBC for the opportunity of taking BIOL 342.

Literature Cited

Bairlein, F. (2002). How to get fat: nutritional mechanisms of seasonal fat accumulation in migratory songbirds. *Naturwissenschaften*, *89*(1), 1-10.

Buczacki, S. (2007). *Garden natural history*. Collins.

Carrillo, C. M., Moreno, E., Valera, F., & Barbosa, A. (2007). Seed selection by the trumpeter finch, Bucanetes githagineus. What currency does this arid-land species value?, *Annales Zoologici Fennici* 44(5), 377-386.

Deshpande, S. S. (2002). *Handbook of food toxicology*. CRC Press.

Díaz, M. (1994). Variability in seed size selection by granivorous passerines: effects of bird size, bird size variability, and ecological plasticity. *Oecologia*, *99*(1-2), 1-6.

Ferreira, C. D. S., Piedade, M. T. F., Tiné, M. A. S., Rossatto, D. R., Parolin, P., & Buckeridge, M. S. (2009). The role of carbohydrates in seed germination and seedling establishment of Himatanthus sucuuba, an Amazonian tree with populations adapted to flooded and non-flooded conditions. *Annals of Botany*, *104*(6), 1111-1119.

Karasov, W. H. (1990). Digestion in birds: chemical and physiological determinants and ecological implications. *Studies in avian biology*, *13*(39), l-4.

Kelrick, M. I., MacMahon, J. A., Parmenter, R. R., & Sisson, D. V. (1986). Native seed preferences of shrub-steppe rodents, birds and ants: the relationships of seed attributes and seed use. *Oecologia*, *68*(3), 327-337.

Molokwu, M. N., Nilsson, J. Å., & Olsson, O. (2011). Diet selection in birds: trade-off between energetic content and digestibility of seeds. *Behavioral Ecology*, *22*(3), 639-647.

Plummer, K. E., Bearhop, S., Leech, D. I., Chamberlain, D. E., & Blount, J. D. (2013). Winter food provisioning reduces future breeding performance in a wild bird. *Scientific reports*, *3*(1), 1-6.

Project FeederWatch. (n.d.). Retrieved November 21, 2020, from https://feederwatch.org/

Ríos, J. M., Mangione, A., & Marone, L. (2012). Effects of nutritional and anti-nutritional properties of seeds on the feeding ecology of seed-eating birds of the Monte Desert, Argentina. *The Condor*, *114*(1), 44-55.

Sturkie, P. D. (Ed.). (2012). *Avian physiology*. Springer Science & Business Media.

U.S. Department of Agriculture, Agricultural Research Service. FoodData Central. (2019). Retrieved November 21, 2020, from fdc.nal.usda.gov.

Wilcoxen, T. E., Horn, D. J., Hogan, B. M., Hubble, C. N., Huber, S. J., Flamm, J., ... & Wrobel, E. R. (2015). Effects of bird-feeding activities on the health of wild birds. *Conservation Physiology*, *3*(1)

Valera, F., Wagner, R. H., Romero-Pujante, M., Gutiérrez, J. E., & Rey, P. J. (2005). Dietary specialization on high protein seeds by adult and nestling serins. *The Condor*, *107*(1), 29-40.

Appendix

Trial #	Sunflower Seed	Millet	Hemp Seed	Peanuts
1	1.7 g	1.4 g	1.2 g	0.5 g
2	2 g	1.7 g	1.4 g	0.5 g
3	3 g	2.5 g	2 g	1 g
4	2.1 g	1.8 g	1.7 g	0.7 g
5	2.5 g	2 g	1.5 g	1 g

*Appendix 1.*The grams consumed of sunflower seeds, millet, hemp seed and peanuts during each experimental trial.

	Mean grams consumed
Mean grams consumed	1
Energy	0.115677
Protein	0.078353
Lipids	0.259356
Carbohydrates	-0.22207

Appendix 2. Correlation matrix between nutritional seed variables including energy, protein lipid and carbohydrate consumption. Values represent Pearson's correlation coefficient r-values.