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Food Fights and Avian Interactions: Investigating Dominance Hierarchies at Bird Feeders

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Birds play major roles in many significant ecosystem functions and provide rich opportunities for sharpening the observation skills of undergraduate students exploring ecology, behavior, and general biology. In this investigation, students collect data on displacements at bird feeders, using natural field sites, live web cams, or both, to model dominance hierarchies using the Clutton-Brock Index (CBI) modified to apply to interspecific interactions. Students then analyze data to explore a variety of questions about bird behavior and interspecific interactions that may include student-generated hypotheses. Examples of questions included in this exercise are whether dominance hierarchies are transient or consistent across sites, how species composition may vary among locations, and comparisons of behaviors that may derive from either bird or site-specific characteristics.

Keywords: interspecific competition, interspecific interactions, ecology, animal behavior, birds, dominance hierarchy, Clutton-Brock index

Link To Supplemental Materials: https://doi.org/10.37590/able.v42.sup17

Introduction

This open-ended investigation involves students in observing, recording data, and analytically answering questions about interspecific interactions using birds visiting feeders. Birds are important indicators of environmental health and ecological integrity, yet recent research indicates that populations of even very common species are experiencing significant declines (Rosenberg et al. 2019). Observing local birds to understand ecological interactions is not only valuable to build field and identification skills, but can engage students with nature and natural history at a personal level.

In the field (or remotely via web-cams) students will record data on bird species identity, duration of visits to feeders, and displacements that occur by other bird species. Interspecific interactions that students observe at feeders will be used to build a quantitative model of dominance hierarchies using the Clutton-Brock Index (CBI; Clutton-Brock et al. 1979). As a class, they will start by posing two questions about the nature of feeder dominance hierarchies: 1) Are dominance hierarchies highly developed and predictable, or are they transient and unpredictable? 2) What characteristics of a species may be important in predicting the species position in the mixed-species feeder dominance hierarchy? Data collected by students in the field and/or using live web-cams can also be used to test additional student-generated questions about dominance hierarchies in relation to bird species and site characteristics. The outcomes can be considered in the context of changing bird population dynamics interacting with human-altered landscapes that influence bird resources (including the provisioning of food via feeders). Thus students are challenged to consider how behavioral patterns at the organismal level translate into community-level ecological patterns (e.g. species composition, changing distributions).

Whether students become scientists or not, they will be introduced to the significant impact that

Citizen Science programs have had in accumulating data on very large temporal and spatial scales. Hopefully, they will be inspired that anyone can contribute to important information that is used to address relevant scientific questions and significant environmental problems.

Student Outline

Objectives

- Learn about natural history by observing wild birds and their behavioral interactions
- Improve identification and observation skills
- Describe interspecific competition, interspecific interactions and understand how altered habitats and/or human-changed habitats can influence those interactions
- Quantitatively model a dominance hierarchy
- Pose questions and hypotheses regarding the effect of species, location, and other factors on the dominance hierarchies and interspecific social behavior of wild birds at feeders, and to use statistical methods to evaluate those hypotheses
- Appreciate some of the significant contributions of Citizen Science to our understanding of wildlife populations

Introduction

In this investigation, you will observe wild birds, either in-person or remotely, at a local site where humans have influenced resource availability by provisioning bird feeders. Your observations will enable you to characterize, and mathematically model, some of the behavioral interactions that occur during interspecific competition. You will be testing hypotheses about what bird (or site) attributes might influence the formation of avian dominance hierarchies. Wild birds often form flocks to exploit certain types of resources. For example, large flocks of European Starlings (*Sturnus vulgaris*) can often be observed gathering seeds and invertebrates from agricultural fields left fallow in the autumn, and Ring-billed Gulls (*Larus delawarensis*) often congregate near garbage dumps or public beaches where they opportunistically capitalize on human-generated food resources. The occurrence of feeding flocks may be strongly seasonal, but flocks may also occur opportunistically in response to fluctuating resource types, or in response to the changing social dynamics that play out when birds are breeding vs. not breeding. Even more intriguing perhaps, are cases when different species of birds come together under certain conditions to exploit similar food resources (Chilton and Sealy 1987). For example, “mixed species flocks” in tropical rainforests occur when multiple species of birds with different foraging strategies may “cooperate” in the search for, and exploitation of, patchy food resources (e.g. Powell 1985, Sridhar et al. 2009, Martinez et al. 2018). Although “naturally” occurring mixed species flocks may have their greatest level of development in the tropics (e.g. flocks of various species of ant birds that follow army ant swarms e.g. Wiley 1971, Roberts et al. 2000, O’Donnell 2017), there are similarly intriguing scenarios in human-dominated landscapes such as suburban North America where multiple species of birds regularly visit bird feeders.

Provision of supplemental food via bird feeders is an enormously popular enterprise in the United States, where an estimated 43% of households regularly feed birds (Martinson and Flashpoler 2003, Robb et al. 2008). In addition, recent reports of declining bird populations, even relatively common species such as those that frequent feeders, have fueled even more interest in understanding the dynamics of bird populations on a global scale (Rosenberg et al. 2019) and will undoubtedly spark renewed interest in interactions occurring at human-created food resources such as feeders (Wasserman 1996, Newtoff and Small 2013, Haigh 2018, Wydner 2019). In fact, the very dataset on which the widely-cited Rosenberg et al. (2019) study is based was largely amassed over several decades by amateur “birdwatchers” – people who have contributed consistently high-quality records of bird sightings that were aggregated and analyzed by a research team at the Cornell Lab of Ornithology (https://www.birds.cornell.edu/home/). “Birdwatchers” are abundant, serious about contributing to knowledge of natural history (Wells et al. 1998), and have been highly innovative about developing mechanisms to share accurate data (e.g. ebird: https://ebird.org/home); they are an amazing example of what citizen science can accomplish on a global scale!

The study of interspecies interactions is of great importance in the field of community ecology, as competitive interactions as well as beneficial interactions, can strongly influence the abundance and distribution of birds that visit feeders (Wilson 1994). Interspecific interactions most likely undergo dramatic changes for migratory birds, who likely interact with different species on the breeding vs. wintering grounds, as well as at potentially multiple stopover sites during a very energetically-stressful journey. With increasing stress on bird populations from a variety of sources (Rosenberg et al. 2019), the competitive "balance" in avian social interactions may indeed be shifting. Bird species that are socially dominant under certain conditions may find themselves socially subordinate where the habitat has been altered or where populations of competitors have increased, or vice versa. This changing backdrop against which species are interacting with one another can provide important information about how large scale environmental changes may affect particular populations in ways that are more subtle than outright mortality, but biologically significant nonetheless (e.g. Robb et al. 2008).

Animal behaviorists have long sought to quantify the aggressive interactions that often occur in animal groups. When winners and losers are easily identified, such interactions are usually referred to as dominance-subordinate interactions, and based on who wins against whom, all or most individuals can be ranked in a **dominance hierarchy** (first described by Schjelderup-Ebbe 1922 in the domestic chicken, *Gallus gallus*, and therefore sometimes referred to as a "pecking order"). To derive a dominance hierarchy from observations of the interactions between individuals, the numbers of supplants between pairs are arranged in a matrix (e.g. Figure 10.5 Martin and Bateson, 2007; Table 1 in Bang et al. 2010), or even as a phylogeny of rank relationships (e.g. Miller et al. 2017). If all individuals in a group can be arranged in strict order of dominance (C dominates A, A dominates D, D dominates E and E dominates B), then the dominance hierarchy is said to be linear. In reality, few dominance hierarchies are perfectly linear. Sometimes dominance reversals can occur, when a subordinate wins an encounter with a normally dominant individual. Moreover, for a hierarchy to be perfectly linear all dyadic (two-way) relationships must be asymmetric, but in some social groups, two or more individuals may have equal status. Furthermore, in a perfectly linear hierarchy all possible triadic (3-way) relationships must be transitive, which means that if A dominates B, and B dominates C, then A must also dominate C. In its simplest form, the index of dominance status that is assigned to each individual is its rank in the hierarchy. As a result, most dominance indices are measured on an ordinal (ranking) scale, which means that the magnitude of the difference in dominance status between two individuals cannot be quantified. However, dominance can be measured on an interval scale, using a method of paired comparisons (Boyd and Silk 1983). Besides linearity, another property of a dominance hierarchy is its steepness (DeVries et al. 2006). Steepness measures the degree to which individuals differ from each other in winning dominance encounters. Linearity and steepness are complementary measures to characterize a dominance hierarchy. Recent work comparing particular methods of quantifying dominance hierarchies indicates that results can diverge when social behavior is more complex than a simple linear hierarchy; these modeling studies emphasize that choice of a particular index can therefore affect how social interactions are interpreted (Gammel et al. 2003, Martin and Bateson 2007, Bayly et al. 2006, Bang et al. 2010). For this exercise, we are using the CBI: Clutton-Brock index (Clutton-Brock et al. 1979), but it is important to appreciate that a single ranking index is not necessarily the "best" method for all behavioral studies, and that one should explore different techniques when devising one's own research.

Establishing a quantitative dominance hierarchy for a particular group of animals is more complicated when they are studied in a natural habitat and are involved in repeated, but unequal numbers of interactions, and when winners and losers may exchange positions. The Clutton-Brock index (CBI; Clutton-Brock et al. 1979) is one widely used index of dominance that considers both direct and indirect wins and losses. Direct wins are given by the number of individuals against whom the focal animal wins and the indirect wins are given by the total number of individuals against whom each individual that the focal animal wins against in turn wins). In this exercise, we will be substituting "species" for interactions among "individuals" in using this index, because our objective is to model interspecific dominance interactions.

Questions to be investigated:

Are dominance hierarchies highly developed and predictable, or are they transient and unpredictable?

What characteristics of a species are most important in predicting the species position in the mixed-species feeder dominance hierarchy? (size, behavior, color, habitat, geographic location of feeder?)

Methods and Data Collection

Part A: Preparation: Practicing Data Collection and Introduction to Field Sites

We will be splitting into 3 teams and each team will conduct observations at a local nature center where birds come to feeding stations that are stocked regularly. Alternatively, you may be conducting observations remotely, in which case you will be assigned a live bird feeder cam to watch and record data. If observing

remotely, you will want to time your observations for an appropriate time of day relative to the time zone in which the feeder is located.
Practice bird identification for the 8-12 most common bird species likely to visit your assigned feeder or live web cam. One possible practice option is to us the Cornell Lab of Ornithology live feeder cam: http://cams.allaboutbirds.org/cams/cornell-lab-feederwatch/. If observing in person, it will be important to practice using binoculars before you go to the field site. There are many types of resources for learning to identify birds; most of these are assembled to include a specific geographic area, e.g. "eastern United States". Your instructor will orient you to possible printed field guides, such as the widely-used "Sibley Guide" (Sibley, 2000), on-line resources such as Birds of North America https://birdsna.org/Species-Account/bna/home, and the Merlin App https://merlin.allaboutbirds.org/ . If using the Merlin app, be sure to download the version that is specific to your geographic area and allow the app to read your location; this will allow Merlin to winnow down the 500-600 possible North American bird species to the smaller set that could be in your area at that specific time of year. Note that ornithologists in the U.S. use 4-letter alpha codes to abbreviate the English common names of birds. You can find these codes at the Institute of Bird Populations website: https://www.birdpop.org/pages/birdSpeciesCodes.php or at the USGS Bird Banding Laboratory website: https://www.pwrc.usgs.gov/bbl/manual/speclist.cfm
As a class, use the practice data sheet (Appendix A) to enter information as you are viewing the on-line live webcam. When finished with this exercise, pair up with another student, as assigned by your instructor, and compare observations. Discuss possible reasons for agreements and disagreements and how to improve "quality control" of your data collection.

There may be multiple feeders at each of the field sites and feeders may or may not be numbered. If not, assign imaginary numerical codes from left to right so that all members of your team can communicate regarding the feeders by real or imaginary number (e.g. "*Do you see the Downy Woodpecker on Feeder #4*?"). Each pair of students comprising a team will be assigned a single feeder to observe. On the back of your data sheet, draw a sketch and provide a detailed description of your feeder type and what kind of seeds or other food it contains. Feeders may be flat and tray-like, cylindrical, open or closed, and they may contain specific types of seeds, suet, fruit, peanuts, corn, or a combination. Be as specific as you can.

Some rules for recording:
Record data for only one focal bird at a time. Focal birds are only those birds that land on your assigned feeder. Do not record mammals unless a mammal makes physical contact with the feeder or chases your focal bird off of a feeder. Mammals cannot be recorded as focal birds unless your instructor assigns you to do so.
Record the identity of each focal bird. Add the correct Alpha Codes after your observations have been completed.
If your instructor has assigned you to record data on duration of feeding for each focal bird, use the stopwatch to record the duration of time (in secs) that the focal bird spends on the feeder. This is defined as physical contact with the feeder, regardless of whether food is being consumed or not, and regardless of whether the focal bird leaves on its own accord or because it is displaced (see below). Record from the time the bird lands on the feeder, physically, to the time it departs, physically. The maximum time for recording duration is 5 minutes. If an individual bird remains on the same feeder more than 5 minutes, record the maximum amount (300 seconds) on the data sheet, and then switch to recording for a different focal bird.
Displacements, and identity of displacer. Any focal bird you are observing that is displaced by another bird (or mammal) is recorded. A displacement is when the focal is **caused** to depart from the feeder upon the arrival of another bird, which may or may not be the same species. If your focal physically leaves your assigned feeder within one second of the arrival of another bird on the **same** feeder (even if it is still in view, or lands on a different feeder, etc.), it is counted as displaced. Upon a displacement, you would also be ending a duration measurement and recording the number of seconds your focal bird was at the feeder before it was displaced. Sometimes it will be apparent that a bird has shifted its position on the feeder as the result of the arrival of another bird. For example, a bird might move to the opposite side of a cylindrical feeder or move to the opposite side of a feeding tray when another bird lands on the same feeder. This will not count as a displacement, but if your instructor indicates, you should record such behavioral interactions in the notes column.
Correctly identifying the bird that has just displaced your focal bird is a critical piece of information, so take the time to use resources to accurately identify the displacer **before** starting a new observation on a new focal bird at your assigned feeder.

If you are working in the field, one student in your pair will be the observer using binoculars to keep track of all visits to the feeder, and that person will quietly dictate information to the second student in the pair, who will record written information on the field data sheet (Appendix A). Switch roles halfway through the observation period. If you are working remotely, you may be working on your own, or you and a partner may observe simultaneously and consult with one another to compare events and bird identifications. When your observation time is ended, re-code all species names by filling in the column for the standardized 4-letter "Alpha Codes" assigned to each bird species. Enter your data into a compiled spreadsheet file, as assigned by your instructor; this will include data from the entire class for each separate feeder at all locations (feeder sites) included in your study.

Part B: Data Analysis

Your instructor will provide information regarding which analyses are to be completed by which student teams. Your instructor may also assign each team to generate a new, testable hypothesis about behavior of birds with respect to feeder resources and/or dominance hierarchies, in which case you will analyze the data to answer this new question as well.

Species Composition at Each Study Site

Use the data in your spreadsheet file to construct bar graphs or pie charts illustrating the proportional representation of each bird species observed at each location. For example, if there are 42 bird observations, including both focals and displacers, at Site A and 18 of them were Black-capped Chickadees (*Poecile atricapillus;* BCCH), the proportional representation of BCCH at Site A is 0.43 or 43%. Note that proportional representation of species in this case is based on the number of observations and may not be equivalent to the actual relative abundance of the different bird species because, (unless the birds are banded or otherwise recognizable as individuals) some individuals may be counted in multiple observations. For example, the same individual Blue Jay (BLJA; *Cyanocitta* cristata) might return to the feeder repeatedly during your observation period, as a focal, as a displacer, or both. Yet, you are unlikely to be able to know this Blue Jay from other Blue Jays. Therefore, the graphs you construct will illustrate the proportional representation of species relative to observations of species (not the number of individuals of each species). Construct a similar graph for each site, being consistent in the assignment of colors or symbols for each bird species so that the graphs can be compared among student teams easily. Examples of sample pie charts are included in the supplementary materials described in Appendix B.

Is the bird species composition (based on observations) similar across all sites? You may test this statistically with a Chi-squared test of independence (Siegel 1956) that will determine if species observation composition is independent of feeder site. One appropriate on-line resource for calculating the Chi-squared test statistic is available here: http://www.quantpsy.org/chisq/chisq.htm If you use this resource note that: 1) your different locations can be represented by the "condition" rows, and your bird species can be represented by the column "group" labels. Enter the raw data for the *number* of birds in each cell, not the proportion (as was used in the construction of observation composition graphs). These raw numbers are your observed values for the number of each bird species at each feeder location. 2) If the number of columns and/or rows is large, then it is likely that the "expected" values (based on the null model for a Chi-squared test) will be very small for some or several of the cells. In this case, it is appropriate to use the more conservative Yate's corrected value for X^2 which will be included in your output at this website.

If the P value associated with your Yate's corrected X^2 is greater than or equal to 0.05, then you will accept the null hypothesis and conclude that species observation composition is independent of site (location). However, if your X^2 value is large as a result of your observations deviating from those expected on the basis of the null model (that species observation composition is independent of location), then the P value associated with your X^2 may be smaller than 0.05. In this case, you will reject the null hypothesis and conclude that species observation composition is *not* independent of location, with 95% confidence of drawing the correct conclusion. A sample screenshot from a set of data analyzed at Quantpsy.org is shown in Appendix C.

Dominance Hierarchy Analysis Using the Clutton-Brock Index (CBI)

We will be calculating the CBI based on interactions between members of a species, rather than interactions between known individuals of each species (as described in the original paper by Clutton-Brock et al. 1979), in part because we do not know if an observation of a BCCH by one team might have been the very same bird observed by another team at another feeder, or by the same team at a later time. In addition, in this exercise we are primarily interested in interspecific interactions (the interactions between each species with each other species).

CBI = (B + b+ 1)/(L + l + 1)

where B = number of species whom the subject species dominates,
b = number of species whom those dominated by the subject species in turn dominate,
L = number of species who dominate the subject species, and
l = number of species who dominate those dominating the subject species.

Table 1. Sample computation of the Clutton-Brock Index (CBI) for 6 species of birds interacting at a bird feeder.

	"Wins" – Species that Displaces Focal Bird							
"Loss" – Species Displaced	BLJA	BCCH	HOSP	NOCA	TUTI	WBNU	L	l
BLJA	-	0	0	0	0	0	0	0
BCCH	10	-	8	5	3	4	5	12
HOSP	12	1	-	7	0	0	3	6
NOCA	4	0	0	-	0	0	1	0
TUTI	6	0	5	10	-	1	4	8
WBNU	8	0	5	9	3	-	4	8
B	5	1	3	4	2	2		
b	12	3	5	8	3	3		
CBI	**18.0**	**0.28**	**0.90**	**6.50**	**0.46**	**0.46**		

For this investigation, occurrences of an individual displacing another individual of the same species will be "cancelled out"; these are indicated by dashes in Table 1. Alpha codes are as follows: BLJA Blue Jay (*Cyanocitta cristata*), BCCH Black-capped Chickadee (*Poecile atricapillus*), HOSP House Sparrow (*Passer domesticus*), NOCA Northern Cardinal (*Cardinalis cardinalis*) , TUTI Tufted Titmouse (*Baeolophus bicolor*), WBNU White-breasted Nuthatch (*Sitta carolinensis*).

Using Table 1 as a sample matrix of displacement data collected at a bird feeder, the relative CBI is calculated for each species as follows, where the subscripts indicate species associated with each b or l value). Note that when a species displaces other species more than it is displaced, the numerator is larger than the denominator, yielding a higher index.

Blue Jay (BLJA): $\frac{5 + (1_{BCCH} + 3_{HOSP} + 4_{NOCA} + 2_{TUTI} + 2_{WBNU}) + 1}{0 + (0_{All}) + 1} = 18/1 = 18.0$

Black-capped Chickadee (BCCH): $\frac{1 + (3_{HOSP}) + 1}{5 + (0_{BLJA} + 3_{HOSP} + 1_{NOCA} + 4_{TUTI} + 4_{WBNU}) + 1} = 5/18 = 0.28$

House Sparrow (HOSP): $\frac{3 + (1_{BCCH} + 2_{TUTI} + 2_{WBNU}) + 1}{3 + (0_{BLJA} + 5_{BCCH} + 1_{NOCA}) + 1} = 9/10 = 0.90$

Northern Cardinal (NOCA): $\frac{4 + (1_{BCCH} + 3_{HOSP} + 2_{TUTI} + 2_{WBNU}) + 1}{1 + (0_{BLJA}) + 1}$ = 13/2 = 6.50

Tufted Titmouse (TUTI): $\frac{2 + (1_{BCCH} + 2_{WBNU}) + 1}{4 + (0_{BLJA} + 3_{HOSP} + 1_{NOCA} + 4_{WBNU}) + 1}$ = 6/13 = 0.46

White-breasted Nuthatch (WBNU): $\frac{2 + (1_{BCCH} + 2_{TUTI}) + 1}{4 + (0_{BLJA} + 3_{HOSP} + 1_{NOCA} + 4_{TUTI}) + 1}$ =6/13 = 0.46

Analysis: Is the dominance hierarchy consistent across locations or transient?

When you have determined the Clutton-Brock Index (CBI) for each species, construct a graph showing the relative dominance hierarchy rankings of each species at each site where feeder behavior was recorded. You may be able to answer this question by visually comparing the results on each graph. In addition, your instructor may ask you to use a non-parametric statistical test called the Friedman Two-Way ANOVA (Siegel 1956) to statistically answer this question. In the Friedman test, your groups are related by virtue of having observed several bird species at each feeder, and so the groups are related by feeder location. The different conditions will correspond to your different bird species. Hence, we are determining whether the dominance index (or rank) of a species tends to consistently be higher or low, even across different feeder locations (groups). In the Friedman test, "scores" for focal bird observations at each feeder will be ranked by group (feeder location) from highest to lowest CBI. If Blue Jays were always at the top of the dominance hierarchy (as in the sample Table 1), regardless of the feeder location, then the highest ranks would usually be associated with Blue Jays, and so on. If the dominance hierarchies (and hence the rank values in the Friedman test) are consistent, then the null hypothesis will be accepted – that average rank for a species does not depend on the feeder location. This result would provide evidence that dominance hierarchies are consistent at different feeder locations. On the other hand, if Blue Jays are dominant at some locations and House Sparrows or White-breasted Nuthatches are dominant at others – if the rank order of species depends on the feeder site being observed - then the null hypothesis for the Friedman test will be rejected and you will conclude that CBI depends on the feeder location (or some other factor strongly correlated with feeder location).

Analysis of the Effect of Species on Mean Duration at a Feeder

One type of behavior that might be influenced by dominance hierarchies at bird feeders is the duration of time that an individual bird spends feeding. One might expect that strong dominance interactions might limit the time that subordinate species feed, or may elucidate other aspects of how behavior is enhancing or limiting food intake for some species relative to others. One way to approach this question is to compare the mean duration (in seconds) for time at the feeder across all bird species. This can be done with a one-way ANOVA (Sokal and Rohlf 1969), or if sample sizes are small, a Kruskal-Wallis analysis of variance is more appropriate (Siegel 1956). Your instructor will let you know if your sample sizes are sufficiently small for some species that it might be desirable to "lump" groups of similar species (e.g. all nuthatches or all woodpeckers) to create fewer groups to compare. Since it is likely that the strongest effects are produced by the behavior of the most common species at your feeder site, lumping durations for rare observations is not likely to significantly alter your statistical outcome. Construct a bar graph illustrating the mean values of feeding duration (secs) for each bird species, showing standard error of the mean for each bar to indicate the variance around the mean. Do some species exhibit much higher standard errors than others? If so, what does this indicate?

Discussion

Evaluate the questions we set out to explore based upon the data you collected and the analyses completed. Your instructor may ask for written responses to these questions, or may ask you to evaluate the outcome of your analyses in a different format.

Are dominance hierarchies highly developed and predictable, or are they transient and unpredictable? If your evidence indicates that dominance hierarchies are similar across different bird feeder locations, what characteristics of the birds may be driving those patterns? Use the scientific literature to explore additional information about the birds most commonly involved in interspecific interactions at your feeder and generate some new hypotheses. Can you actually test any of these hypotheses with the class data set? How might you do so? If your evidence indicates that dominance hierarchies are quite different from site to site, what are some possible explanations for why that may be so? Did your class observe different sets of species at each study site (use your species observation composition graphs)? How might habitat characteristics at different sites influence the interspecific interactions of birds at feeders, even if the species composition is the same at each site? Does the presence of other types of animals (such as squirrels and other rodents) at bird feeders influence the dominance hierarchies established by the birds? Do you have observations to support this idea?

What characteristics of a species are most important in predicting the species position in the mixed-species feeder dominance hierarchy? Morphological attributes such as body size, beak length or gripping strength could influence a species' position in a dominance hierarchy. Behavioral characteristics such as vocalizations or aggressive displays (wing- or tail-flicking, crest-erecting, etc.) might also influence position in a dominance hierarchy. What morphological and behavioral attributes characterize the bird species that you observed? Do you think these attributes play a role in predicting position in the dominance hierarchy? If so, can you test your hypothesis with the data that you have collected?

Additional questions for discussion:

1. Are the interspecific interactions we observe at bird feeders representative of the types of interspecific interactions that we may be observing in "natural" feeding situations? Why or why not? If not, what may we be learning by observing these interactions, and changes in these types of interactions over time and at different geographic locations, despite the "artificial" nature of the food resource? What are the limitations to observing interactions at bird feeders if we want to understand changing species interactions in the wild? For further ideas, see Chace and Walsh 2006.

2. Rosenberg et al. (2019) have documented the cumulative loss of nearly 3 billion birds in North America. Surprisingly, this loss includes many widespread and common species, including sparrow, finch, and blackbird species that are frequent feeder visitors. How might further loss of these particular groups influence the dynamics of social hierarchies at bird feeders? Would there be positive or negative consequences on other feeder-frequenting species, such as chickadees, nuthatches, and titmice?

3. How often did you observe actual "food fights" (physical combat) at bird feeders, as compared to displacements (when a bird gives way to another bird without physical contact)? How may dominance hierarchies function as a behavioral adaptation to enhance an individual bird's biological fitness? What are the costs and benefits to an individual bird in conforming to an established dominance hierarchy? For further ideas, see Hutto 1988.

4. What are some of the ways that birds may benefit from provision of food by bird feeders? What are some of the possible negative consequences of provisioning bird populations in this way? Are bird feeders likely to benefit some species much more than others? If so, which species might benefit the most, and why? Are bird feeders likely to negatively impact some species more than others? If so, which species might be most vulnerable to negative impacts of bird feeders, and why? For further ideas, see Dunn and Tessaglia 1994, Marzluff et al. 2001, and Chace and Walsh 2006.

Cited References

Bang, A, Deshpande S, Sumana A, Gadagkar R. 2010. Choosing an appropriate index to construct dominance hierarchies in animal societies: a comparison of three indices. Animal Behaviour 79(3): 631-636.

Bayly, KL, Evans CS, Taylor A. 2006. Measuring social structure: A comparison of eight dominance indices. Behavioural Processes 73(1): 1-12.

Birds of North America https://birdsna.org/Species-Account/bna/home

Boyd R and Silk JB. 1983. A method for assigning cardinal dominance ranks. Animal Behaviour 31: 45-58.

Chace, JF, Walsh AM. 2006. Urban effects on native avifauna: a review. Landscape and Urban Planning 74(1): 46-69.

Chilton, G and Sealy SG. 1987. Species roles in mixed-species feeding flocks of seabirds. J. Field Ornithol. 58(4): 456-463.

Clutton-Brock T, Albon SD, Gibson RM, and Guinness FE. 1979. The logical stag: adaptive aspects of fighting in red deer. Animal Behaviour 27: 211-225.

Cornell Laboratory of Ornithology All About Birds https://www.allaboutbirds.org/

DeVries H, Stevens, JMG, Vervaecke H. 2006. Measuring and testing the steepness of dominance hierarchies. Animal Behaviour 71: 585-592.

Dunn, EH, Tessaglia, DL. 1994. Predation of birds at feeders in winter. J. Field Ornithol. 65(1): 8-16.

e-bird: https://ebird.org/home

Gammell MP, DeVries H, Jennings DL, Carlin CM, Hayden TJ. 2003. David's score: a more appropriate dominance ranking method than Clutton-Brock et al.'s index. Animal Behaviour 66: 601-605.

Haigh, A. 2018. When 136 bird species show up at a feeder, which one wins? Living Bird Magazine (Winter 2018). All About Birds; The Cornell Lab of Ornithology. https://www.allaboutbirds.org/when-136-bird-species-show-up-at-a-feeder-which-one-wins/

Hutto RL. 1988. Foraging behavior patterns suggest a possible cost associated with participation in mixed-species bird flocks. Oikos 51: 79-83.

Institute of Bird Populations: https://www.birdpop.org/pages/birdSpeciesCodes.php

Martin P and Bateson P. 2007. Measuring behavior: an introductory guide. Third edition. Cambridge University Press, New York. 176 pages.

Martinez AE, Pollock HS, Kelley JP, Tarwater CE. 2018. Social information cascades influence the formation of mixed-species foraging aggregations of ant-following birds in the Neotropics. Animal Behaviour 135: 25-35.

Martinson TJ and Flashpoler DJ. 2003. Winter bird feeding and localized predation on simulated bark-dwelling arthropods. Wildlife Soc B 31: 510-516.

Marzluff, JM, Bowman R, Donnelly R (eds). 2001. Avian Ecology and Conservation in an Urbanizing World. Boston, MA: Springer US.

Merlin App https://merlin.allaboutbirds.org/

Miller, ET, Bonter DN, Elermire C, Freeman BG, Greig EI, Harmon LJ, Lisle C, Hochachka WM. 2017. Fighting over food unites the birds of North America in a continental dominance hierarchy. Beh. Ecol. 28(6): 1454-1463.

Newtoff KN, Small CJ. 2013. Enhancing statistical skills in ecology: quantifying bird feeding behaviors. Pages 473-474 in Tested Studies for Laboratory Teaching Volume 34. (K McMahon, Editor) Proceedings of the 34th Conference of the Association for Biology Laboratory Education (ABLE), 499 pages. http://ableweb.org/volumes/vol-34/?art=61

O'Donnell S. 2017. Evidence for facilitation among avian army-ant attendants: specialization and species associations across elevations. Biotropica 49(5): 665-674.

Powell GVN. 1985. Sociobiology and adaptive significance of interspecific foraging flocks in the Neotropics. Ornithol. Monographs No. 36, Neotropical Ornithology, pages 713-732.

Preacher KJ. 2001. Calculation for the chi-square test: An interactive calculation tool for chi-square tests of goodness of fit and independence [Computer software]. Available from http://quantpsy.org.

Project Feeder Watch. 2007. About birds and bird feeding. www.birds.cornell.edu/pfw/AboutBirdsandFeeding/abtbirds_index.html

Robb GN, McDonald RA, Chamberlain DE, Bearhop S. 2008. Food for thought: supplementary feeding as a driver of ecological change in avian populations. Front. Ecol. Environ. 6(9): 476-484.

Roberts DL, Cooper RJ, Petit LJ. 2000. Flock characteristics of ant-following birds in premontane moist forest and coffee agroecosystems. Ecol. Appl. 10(5): 1414-1425.

Rosenberg, KV, Dokter AM, Blancher PJ, Sauer JR, Smith AC, Smith PA, Stanton JC, Panjabi A, Helft L, Parr M, Marra PP. 2019. Decline of the North American avifauna. Science 366: 120-124.

Schjelderup-Ebbe T. 1922. Beitrage zur sozialpsychologie des Haushuhns. Zeitschrift fur Psychologie 88: 225-252.

Sibley DA. 2000. The Sibley Guide to Birds. National Audubon Society. Alfred A. Knopf, Inc. New York. 545 pages.

Siegel S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., Inc. New York. 312 pages.

Sokal RR and Rohlf FJ. 1969. Biometry: the principles and practice of statistics in biological research. WH Freeman and Company, San Francisco. 776 pages.

Sridhar H, Beauchamp G, Shanker K. 2009. Why do birds participate in mixed-species foraging flocks? A large-scale synthesis. Animal Behaviour 78: 337-347.

The Cornell Lab of Ornithology: https://www.birds.cornell.edu/home/

USGS Bird Banding Laboratory website: https://www.pwrc.usgs.gov/bbl/manual/speclist.cfm

Wasserman F. 1996. Avian niche partitioning. Pages 289-298 in Tested Studies for Laboratory Teaching Volume 18 (Glase JC, Editor). Proceedings of the 18th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 322 pages. http://www.ableweb.org/biologylabs/wp-content/uploads/volumes/vol-18/16-wasserman.pdf

Wells JV, Rosenberg KV, Dunn EH, Tessaglia DL, Dhondt AA. 1998. Feeder counts as indicators of spatial and temporal variation in winter abundance of resident birds. J. Field Ornithol. 69(4): 577-586.

Wiley RH. 1971. Cooperative roles in mixed flocks of antwrens (Formicariidae). The Auk 88(4): 881-892.

Wilson, H. 1994. The distribution of wintering birds in central Maine: the interactive effects of landscape and bird feeders. J. Field Ornith. 65(4): 512-519.

Wydner, K. 2019. Use of Project Feeder Watch to engage undergraduates in bird studies and behavior. *In:* McMahon K (ed.) Tested Studies for Laboratory Teaching: Proceedings of the 41st Workshop/Conference of the Association for Biology Laboratory Education (ABLE) 40: (55)

Materials

computers connected to the internet for each group of students (ideally one computer per 2 students); Excel spreadsheet software on each computer; additional statistical/graphics software as desired by instructor (e.g. SPSS)

one projection computer set-up; instructor computer with excel and connected to internet

if conducted in the field - transportation to nearby nature center (or more than one if comparing sites) that has a bird feeder viewing window; field-collected data can also be compared with on-line feeder live cams (see Instructor Notes); if the lab is conducted remotely, the instructor will assign feeder cams (preferably at different locations) to different groups of students

hand-held calculators - 1 per pair of students

for the field: binoculars - one pair per student is ideal, but one per pair of students is sufficient

for the field: clipboard - one per student or pair of students

copies of field data sheets (several per pair of students)

stopwatches - one per student or pair of students

if conducting statistical analysis – students will need access to, and instructions for, appropriate software (e.g. IBM SPSS) and/or instruction handouts with worked examples from statistical resources such as Siegel (1956)

Notes for the Instructor

Field Sites: Students benefit on many levels from observing and recording the behavior of birds in the field. We have found that many nature centers have viewing windows at bird feeding stations, solving many of the logistical issues associated with field work (expert assistance, protection from inclement weather, proximity to restrooms, etc.). In Holland, we have used the Outdoor Discovery Center, DeGraaf Nature Center, and Hemlock Crossing County Park, all within a 20-minute drive from our campus.

Alternatives to field sites and remote resources: We perform a practice run of the field data collection (as indicated in student instructions; the practice exercise used by ViABLE participants 2021 is included in Appendix D) and all sample data generated by participants in ViABLE 2021 were collected using the Cornell Lab of Ornithology's live feeder cam:

https://www.allaboutbirds.org/cams/cornell-lab-feederwatch/

Other sites that offer opportunities for live observations at feeders include:

https://explore.org/livecams Explore.org

Houston Audubon Society: https://houstonaudubon.org/birding/cameras/elmns.html

Sportsman's Paradise: http://sportsmansparadiseonline.com/live-bird-feeder-cams/

Wild Birds Unlimited: http://wbu.com/live-cam/

If using hummingbird feeders, duration will need to be defined differently than stated in this protocol, since hummingbirds may be at the feeder longer than they are actually in physical contact with it.

Recording alternatives: If students are not familiar with bird identification and have trouble keeping up with recording behavior while simultaneously identifying birds, you may wish to consider using recording devices and/or video camcorders for students to record observations and do the identifications later, at leisure.

Mammals such as Eastern Gray Squirrel (*Sciurus carolinensis*), Eastern Fox Squirrel (*Sciurus niger*), Eastern Chipmunk (*Tamias striatus*) and Red Squirrel (*Tamiasciurus hudsonicus*) are also frequent visitors to bird feeders in our local area, and they may sometimes displace birds. Decide ahead of time if you want your students to include mammals in the displacement part of the data collection, and if so, whether mammals are to be included or not in calculating the Clutton-Brock Index. We have chosen to record displacement of birds by mammals to encourage students to be aware of this, but we leave mammals out of the CBI calculations entirely.

Additional variables that can be recorded include feeder characteristics (seed type provided, proximity to edge of woods, human trails, etc.), location characteristics (degree of urbanization, proportion of landcover that is greenspace, forested, protected, etc.), and/or characteristics of the birds themselves (body mass, natural diet, beak size, color, wing shape, foraging strategy, migratory vs. non-migratory, vulnerability to predators, etc.). Site and location characteristics may be easily obtained from maps provided by your local nature center or using resources such as Google Earth. There is ample literature on the many characteristics for bird species; a great place to start is Cornell Lab of Ornithology's All About Birds: https://www.allaboutbirds.org/ Researching these characteristics will add to the variety and value of variables that can be included in student-generated questions. For even more comprehensive information about birds, encourage your library to hold an institutional subscription to Cornell Lab of Ornithology's Birds of North America resource: https://birdsna.org/Species-Account/bna/home

In teaching the CBI calculation, we do the entire calculation by hand as a demonstration for the whole class for at least one species, and then assign each student, or pair of students, to calculate the CBI for each remaining species in the dominance matrix during class time, so that results can be checked before assigning students to begin the statistical tests. Appendix B includes an explanation for sample data generated by ViABLE 2021 participants. The data and data analysis for the sample data are included as Supplementary Files.

We have included a sample Chi-squared analysis for the comparison of species composition for 3 feeder sites in Appendix C. Ideas for additional spin-off questions that can be tested statistically with the class data set were discussed at the ViABLE 2021 remote conference. For example, instructors could ask their students to compute an index of association for different bird species (e.g. Martin and Bateson 2007, p. 129), or students could analyze differences in number of feeding visits per feeder, effects of environmental variables such as proximity to trails on the species composition, etc. For ViABLE 2021, we chose the question: Is the dominance hierarchy consistent for observations collected during two different daytime periods? The results of those analyses are found in the Supplementary Files and described in Appendix B.

Cited References

Bang, A, Deshpande S, Sumana A, Gadagkar R. 2010. Choosing an appropriate index to construct dominance hierarchies in animal societies: a comparison of three indices. Animal Behaviour 79(3): 631-636.

Bayly, KL, Evans CS, Taylor A. 2006. Measuring social structure: A comparison of eight dominance indices. Behavioural Processes 73(1): 1-12.

Birds of North America https://birdsna.org/Species-Account/bna/home

Boyd R and Silk JB. 1983. A method for assigning cardinal dominance ranks. Animal Behaviour 31: 45-58.

Chace, JF, Walsh AM. 2006. Urban effects on native avifauna: a review. Landscape and Urban Planning 74(1): 46-69.

Chilton, G and Sealy SG. 1987. Species roles in mixed-species feeding flocks of seabirds. J. Field Ornithol. 58(4): 456-463.

Clutton-Brock T, Albon SD, Gibson RM, and Guinness FE. 1979. The logical stag: adaptive aspects of fighting in red deer. Animal Behaviour 27: 211-225.

deVries H, Stevens, JMG, Vervaecke H. 2006. Measuring and testing the steepness of dominance hierarchies. Animal Behaviour 71: 585-592.

Dunn, EH, Tessaglia, DL. 1994. Predation of birds at feeders in winter. J. Field Ornithol. 65(1): 8-16.

e-bird: https://ebird.org/home

Gammell MP, DeVries H, Jennings DL, Carlin CM, Hayden TJ. 2003. David's score: a more appropriate dominance ranking method than Clutton-Brock et al.'s index. Animal Behaviour 66: 601-605.

Haigh, A. 2018. When 136 bird species show up at a feeder, which one wins? Living Bird Magazine (Winter 2018). All About Birds; The Cornell Lab of Ornithology. https://www.allaboutbirds.org/when-136-bird-species-show-up-at-a-feeder-which-one-wins/

Hutto RL. 1988. Foraging behavior patterns suggest a possible cost associated with participation in mixed-species bird flocks. Oikos 51: 79-83.

Institute of Bird Populations: https://www.birdpop.org/pages/birdSpeciesCodes.php

Martin P and Bateson P. 2007. Measuring behavior: an introductory guide. Third edition. Cambridge University Press, New York. 176 pages.

Martinez AE, Pollock HS, Kelley JP, Tarwater CE. 2018. Social information cascades influence the formation of mixed-species foraging aggregations of ant-following birds in the Neotropics. Animal Behaviour 135: 25-35.

Martinson TJ and Flashpoler DJ. 2003. Winter bird feeding and localized predation on simulated bark-dwelling arthropods. Wildlife Soc B 31: 510-516.

Marzluff, JM, Bowman R, Donnelly R (eds). 2001. Avian Ecology and Conservation in an Urbanizing World. Boston, MA: Springer US.

Merlin App https://merlin.allaboutbirds.org/

Miller, ET, Bonter DN, Elermire C, Freeman BG, Greig EI, Harmon LJ, Lisle C, Hochachka WM. 2017. Fighting over food unites the birds of North America in a continental dominance hierarchy. Beh. Ecol. 28(6): 1454-1463.

Newtoff KN, Small CJ. 2013. Enhancing statistical skills in ecology: quantifying bird feeding behaviors. Pages 473-474 in Tested Studies for Laboratory Teaching Volume 34. (K McMahon, Editor) Proceedings of the 34th Conference of the Association for Biology Laboratory Education (ABLE), 499 pages. http://ableweb.org/volumes/vol-34/?art=61

O'Donnell S. 2017. Evidence for facilitation among avian army-ant attendants: specialization and species associations across elevations. Biotropica 49(5): 665-674.

Powell GVN. 1985. Sociobiology and adaptive significance of interspecific foraging flocks in the Neotropics. Ornithol. Monographs No. 36, Neotropical Ornithology, pages 713-732.

Preacher KJ. 2001. Calculation for the chi-square test: An interactive calculation tool for chi-square tests of goodness of fit and independence [Computer software]. Available from http://quantpsy.org.

Project Feeder Watch. 2007. About birds and bird feeding. www.birds.cornell.edu/pfw/AboutBirdsandFeeding/abtbirds_index.html

Robb GN, McDonald RA, Chamberlain DE, Bearhop S. 2008. Food for thought: supplementary feeding as a driver of ecological change in avian populations. Front. Ecol. Environ. 6(9): 476-484.

Roberts DL, Cooper RJ, Petit LJ. 2000. Flock characteristics of ant-following birds in premontane moist forest and coffee agroecosystems. Ecol. Appl. 10(5): 1414-1425.

Rosenberg, KV, Dokter AM, Blancher PJ, Sauer JR, Smith AC, Smith PA, Stanton JC, Panjabi A, Helft L, Parr M, Marra PP. 2019. Decline of the North American avifauna. Science 366: 120-124.

Schjelderup-Ebbe T. 1922. Beitrage zur sozialpsychologie des Haushuhns. Zeitschrift fur Psychologie 88: 225-252.

Sibley DA. 2000. The Sibley Guide to Birds. National Audubon Society. Alfred A. Knopf, Inc. New York. 545 pages.

Siegel S. 1956. Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Co., Inc. New York. 312 pages.

Sokal RR and Rohlf FJ. 1969. Biometry: the principles and practice of statistics in biological research. WH Freeman and Company, San Francisco. 776 pages.

Sridhar H, Beauchamp G, Shanker K. 2009. Why do birds participate in mixed-species foraging flocks? A large-scale synthesis. Animal Behaviour 78: 337-347.

The Cornell Lab of Ornithology: https://www.birds.cornell.edu/home/

USGS Bird Banding Laboratory website: https://www.pwrc.usgs.gov/bbl/manual/speclist.cfm

Wasserman F. 1996. Avian niche partitioning. Pages 289-298 in Tested Studies for Laboratory Teaching Volume 18 (Glase JC, Editor). Proceedings of the 18th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 322 pages. http://www.ableweb.org/biologylabs/wp-content/uploads/volumes/vol-18/16-wasserman.pdf

Wells JV, Rosenberg KV, Dunn EH, Tessaglia DL, Dhondt AA. 1998. Feeder counts as indicators of spatial and temporal variation in winter abundance of resident birds. J. Field Ornithol. 69(4): 577-586.

Wiley RH. 1971. Cooperative roles in mixed flocks of antwrens (Formicariidae). The Auk 88(4): 881-892.

Wilson, H. 1994. The distribution of wintering birds in central Maine: the interactive effects of landscape and bird feeders. J. Field Ornith. 65(4): 512-519.

Wydner, K. 2019. Use of Project Feeder Watch to engage undergraduates in bird studies and behavior. *In:* McMahon K (ed.) Tested Studies for Laboratory Teaching: Proceedings of the 41st Workshop/Conference of the Association for Biology Laboratory Education (ABLE) 40: (55)

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About the Authors

Kathy Winnett-Murray received a B.S. in Biological Sciences from the University of California, Irvine, an M.S. in Biology from California State University Northridge, and a Ph.D. in Zoology from the University of Florida. She is currently a Professor Emeritus of Biology at Hope College where she taught animal behavior, ecology, natural history, introductory biology, and vertebrate zoology until 2021. Her research interests include the behavioral ecology of birds and other animals, and the ecology of invasive species. She also enjoys participating in a wide variety of science outreach and ecological education programs that connect students of all ages with the natural world.

Lori Hertel served as the Director of Biology Laboratories at Hope College from 1986 until her retirement in 2021. She received a B.S. in Biology from The University of Michigan and an M.S. in Biology from Western Michigan University. She helped develop and teach introductory biology courses for both majors and non-majors. Lori is deeply involved in pre-college science education and has organized many outreach programs at Hope College. In 2003, she was awarded Hope College's Sigma Xi Outreach Award.

Appendix A

Sample Student Data Sheet with Entries

Observer:___*Song Sparrow*_____**Date:**___*25 May 2020*___**Location:**__*Bird Cove, San Diego, CA*__

Weather Information:_*75F, no wind, no ppt, 50% clouds*_**Feeder:**_ *cylindrical hanging, sunflower seed*

Focal Species	Arrival Time	DepartTime	Duration at Feeder (secs)	Displaced? Y or N	Species of Displacer	Notes
BCCH	*14:35*	*14:36*	*51*	*N*		
BCCH	*14:37*	*14:39*	*74*	*Y*	*BCCH*	
TUTI	*14:40*	*14:40*	*12*	*Y*	*HOFI*	*2 HOFI arrived together*
BLJA	*15:00*	*15:00*	*5*	*N*		
HOSP	*15:04*	*15:04*	*2*	*Y*	*HOSP*	*male displaced female*
HOSP	*15:10*	*15:10*	*3*	*N*		
BLJA	*15:11*	*15:12*	*20*	*N*		
HOSP	*15:15*	*15:16*	*43*	*N*		
BLJA	*15:18*	*15:18*	*4*	*N*		
BLJA	*15:20*	*15:20*	*19*	*N*		
HOSP	*15:21*	*15:22*	*21*	*Y*	*BLJA*	
HOSP	*15:24*	*15:24*	*16*	*N*		
BLJA	*15:25*	*15:26*	*46*	*N*		
HOSP	*15:27*	*15:32*	*300*	*N*		*exceeded 5 minutes*
HOSP	*15:32*	*15:32*	*31*	*N*		*first HOSP still feeding*
HOSP	*15:35*	*15:35*	*3*	*N*		
BCCH	*15:59*	*16:00*	*2*	*N*		*end of observations*

Alpha codes: BCCH – Black-capped Chickadee; TUTI – Tufted Titmouse; HOSP – House Sparrow;

BLJA – Blue Jay; HOFI – House Finch

Sample Student Data Sheet - Blank

Observer:_________________________Date:__________________________Location:_____________________________

Weather Information:_________________________________Feeder:__________________________________

Focal Species	Arrival Time	DepartTime	Duration at Feeder (secs)	Displaced? Y or N	Species of Displacer	Notes

Alpha codes:

Appendix B

Explanation of Sample Data in Supplementary Materials

Four Excel files are included in the Supplementary Materials; these include empirical data collected by ViABLE 2021 participants in the Lab Discussion for this activity, and the analyses completed using those data.

Participants followed the pre-presentation instructions included in Appendix D and collected data independently, for 30 minutes each, between June 3 and 16, 2021 between the hours of 0900 and 2000, using the live Cornell FeederWatch cam: https://www.allaboutbirds.org/cams/cornell-lab-feederwatch/

Prior to the virtual Lab Discussion, we decided to pose the question: Is the dominance hierarchy for the bird species visiting this feeder consistent for two different observation time periods; the data were then divided into earlier (0900-1500 hrs) and later (1500-2000 hrs) observation periods.

Feeder Composition Time of day includes 2 sheets. The first sheet, SppComp_ABLE21 shows the breakdown of total observations for the two observation periods by bird species, with accompanying pie charts depicting the distribution of those observations. Observations of various woodpecker species were rare, and so the distribution was also constructed (sheet 2; SppCompWoodLump_ABLE21) with all woodpecker observations lumped together to enable slightly greater resolution of the relative number of observations for the other bird species. The outcome of a sample Chi-squared analysis, directed at testing whether the observed species observations distribution patterns were similar for the two time periods is also included in sheet 2. The on-line Chi-squared calculator http://quantpsy.org/chisq/chisq.htm was used to determine the statistical result, which allowed us to conclude that there was a significant difference in the distribution of species observations during the two time periods. Species other than Common Grackles are proportionally more common later in the day.

The file **Feeder Data_ABLE21_earlier** contains 2 sheets. Sheet 1 (CBI Early Birds) shows the matrix of displacements by bird species, collected by ViABLE participants between 0900 and 1500. A sample CBI (Clutton-Brock Index) calculation is shown for Northern Cardinals (NOCA) and for Hairy Woodpeckers (HAWO). Sheet 2 (CBI Early Results) includes all calculated CBI values for each of the 8 observed bird species.

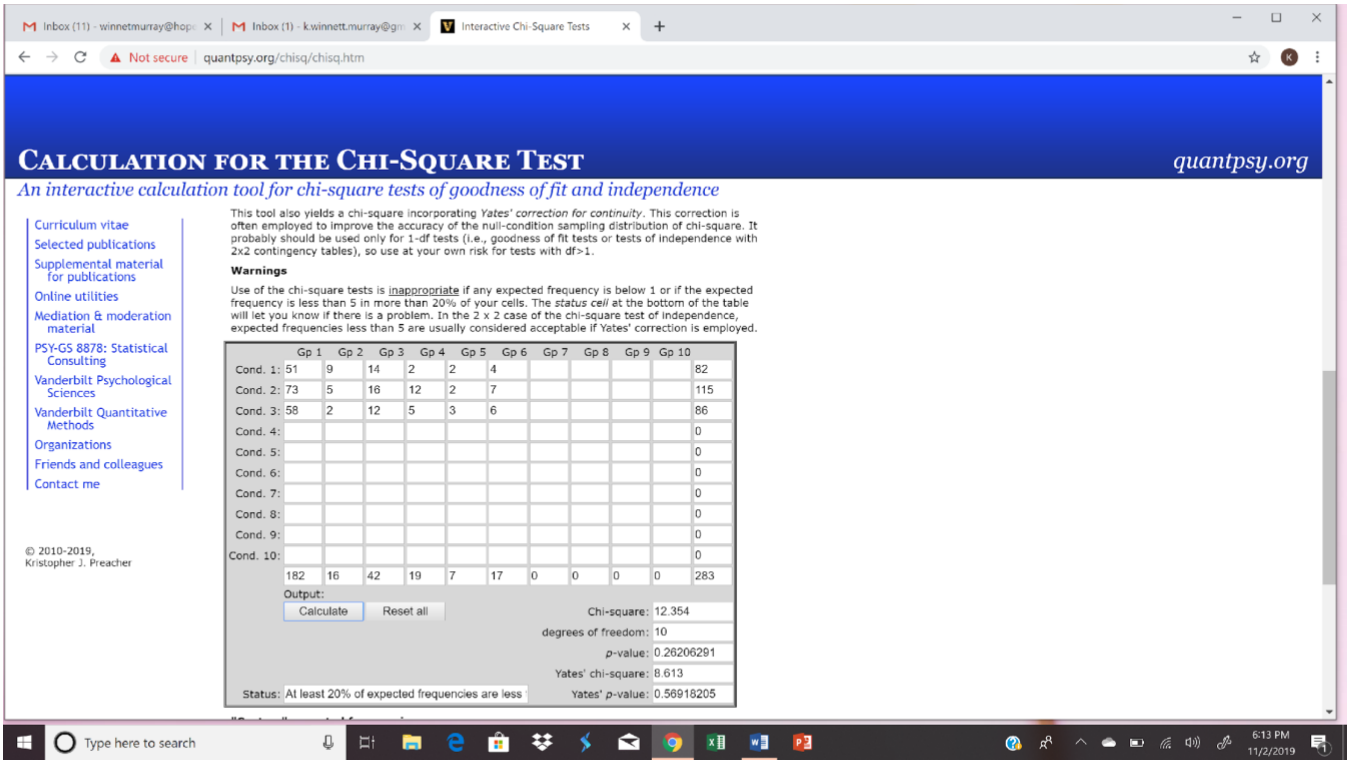
The file **Feeder Data_ABLE21_later** contains 2 sheets. Sheet 1 (CBI Later Birds) shows the matrix of displacements by bird species, collected by ViABLE participants between 1500 and 2000. A sample CBI (Clutton-Brock Index) calculation is shown for Red-winged Blackbirds (RWBL). Sheet 2 (CBI Later Results) includes all calculated CBI values for each of the 10 observed bird species.

The file **CBI correlation early vs late** includes a worked analysis for exploring the question: Are the dominance hierarchies consistent for bird species when they are observed earlier vs. later in the day? We used a Spearman Rank Correlation test (Siegel 1956) because the sample size was small; we included only the 8 bird species that were observed during both time periods. The statistical outcome for this test provides evidence that the CBI index for a given bird species was significantly correlated (consistent) for different times of the day. The Spearman Rank Correlation analysis can also be found in most statistical software programs (e.g. IBM-SPSS).

Appendix C

Sample Chi-squared Analysis

Is Species Composition (based on Observations) Independent of Feeder Location?



	Gp 1	Gp 2	Gp 3	Gp 4	Gp 5	Gp 6	Gp 7	Gp 8	Gp 9	Gp 10	
Cond. 1:	51	9	14	2	2	4					82
Cond. 2:	73	5	16	12	2	7					115
Cond. 3:	58	2	12	5	3	6					86
Cond. 4:											0
Cond. 5:											0
Cond. 6:											0
Cond. 7:											0
Cond. 8:											0
Cond. 9:											0
Cond. 10:											0
	182	16	42	19	7	17	0	0	0	0	283

Figure 1. Screen shot from http://www.quantpsy.org/chisq/chisq.htm Preacher, K. J. (2001, April). Calculation for the chi-square test: An interactive calculation tool for chi-square tests of goodness of fit and independence [Computer software]. Available from http://quantpsy.org. Here, conditions (rows) indicate 3 different feeder locations where data were collected, and Groups (columns) represented 5 bird species (BCCH, TUTI, AMGO, RBNU, WBNU) and a 6th group (column) for all other bird species combined. The result indicates that bird species composition, as indicated by each species observation frequency, was independent of the feeder location. The same calculation can be performed using a TI graphing calculator or by using numerous statistical software programs such as IBM SPSS.

Appendix D

Pre-Lab Discussion Worksheet for ViABLE 2021 Participants

Greetings 2021 ViABLE participants! Please grab something to write with and make a copy of the data sheet below (or just replicate it on a piece of scratch paper at your desk). We're going to practice watching birds at some feeders and then you'll be ready to collect a sample data set at our Lab Discussion workshop on June 18.

1. Please read our ViABLE manuscript: "Food Fights and Avian Interactions: Investigating Dominance Hierarchies at Bird Feeders", but don't get too bogged down in the calculations for the Clutton-Brock Index as we'll be walking through a worked example during our Lab Discussion. You are welcome to send any questions prior to the ViABLE meeting to winnetmurray@hope.edu

2. Observing Displacements. To gain practice recording a displacement, as defined in the lab handout, use this pre-recorded video from the Cornell feeder on May 10, 2021: https://www.youtube.com/watch?v=vp3dUpOdK1M. Use Data Sheet 1 below with the alpha codes of the following species included:

Baltimore Oriole (BAOR) -- bright orange and black

Red-winged Blackbird (RWBL) -- mostly black with red and/or gold in wings (males)

Common Grackle (COGR) – all black; males have glossy iridescent heads

Since this clip is not live, you'll be able to back up as often as you wish to identify the birds or to see interactions again and again. The clip is just under 3 minutes. There are 5 feeders in view plus a 6th feeder which is the flat platform tray. You will record ONLY displacement interactions on the flat platform feeder (no durations are being recorded for this practice). Begin recording data at 0:01 (there's a flurry of activity right at the start so you may want to play this over again). **You will record one check mark in Data Sheet 1 each time an individual bird is displaced by another.** The table reads with displacer bird species as column headings and displaced species as rows. Thus, if a Baltimore Oriole (BAOR) is displaced by a Red-winged Blackbird (RWBL), you place a single check in the box under the RWBL column intersecting with the BAOR row. If a Baltimore Oriole displaces 2 Common Grackles, place 2 check marks in the box under the BAOR column intersecting with the COGR row, because 2 focal birds have been displaced. Etc. Stop recording at 2:45. Check your data sheet against the "answers" on Data Sheet 2, and use the comments at the bottom to rectify any mis-matches.

3. Bird ID: Next, practice identifying birds at a sample Live Feeder Cam. A great place to start is Cornell Laboratory of Ornithology Live Feeder Cam https://www.allaboutbirds.org/cams/cornell-lab-feederwatch/ You can watch any time from dawn through dusk EST. If you are already familiar with feeder frequenters east of the Mississippi River, you can skip this part. If you need help getting started, or a refresher, try the Species ID resources at the bottom of the Cornell Feeder Cam website: https://www.allaboutbirds.org/cams/cornell-lab-feederwatch/

4. **Conduct a sample observation period and submit your data!** The most common visitors to Cornell's Sapsucker Wood's feeder cam (https://www.allaboutbirds.org/cams/cornell-lab-feederwatch/ during the last week of May (& their alpha codes) are:

European Starling (watch for juveniles that have fledged just this year – they are brown instead of black and their beaks are dark instead of yellow) – EUST

Red-winged Blackbirds (be wary that males and females have very different plumage color!): RWBL

Mourning Dove – MODO

Red-bellied Woodpecker - RBWO

Blue Jay - BLJA

Northern Cardinal – NOCA

Common Grackle – COGR – large; all black with black beaks and broad tails; males have glossy heads

I have entered the alpha codes for these 7 species (plus some blanks for additional species you may see) into Data Sheet 3. Please conduct a 30 minute observation any time between now and June 16 and record displacements (no durations) at this feeder just as you did in item 2. above. Add any additional species in the blank columns, keeping the species order the same for both columns and rows. Be sure to record the date and time you were observing! Please email me a screenshot, .pdf, or image of your completed data sheet to winnetmurray@hope.edu NO LATER than **16 June** We will use the compiled data you have collected to conduct some sample analyses for the workshop! See you there!

5. Optional CBI Index Computation: What are the relative CBI values for each of the 3 species observed in practice item 2., above?

COGR: $\frac{1 + (2_{BAOR}) + 1}{1 + (1_{BAOR}) + 1} = 4/3 = 1.33$

RWBL: $\frac{0 + (0) + 1}{1 + (1_{BAOR}) + 1} = 1/3 = 0.33$

BAOR: $\frac{2 + (1_{COGR} + 0_{RWBL}) + 1}{1 + (1_{COGR}) + 1} = 4/3 = 1.33$

6. Optional: Download Merlin (description at https://merlin.allaboutbirds.org/) on your phone. It's free and fun and makes bird identification a breeze compared to what it can be for beginners. Try it out! (Hint: If you are trying to identify a bird at a feeder cam in New York and you are viewing remotely from San Diego, make sure you let the app know the location of the feeder).

Data Sheet 1: Practice with a Pre-Recorded Video

Displacer Species

Displaced Species:	COGR	RWBL	BAOR
COGR			
RWBL			
BAOR			

Data Sheet 2: Answers for Data Sheet 1

Displacer Species

Displaced Species:	COGR	RWBL	BAOR
COGR			xx
RWBL			xxx
BAOR	xx		

Comments:

At the start there are 2 COGR and 1 RWBL on the tray; all 3 are displaced by a BAOR arriving on the tray (3 Xs).

At 1:11, a RWBL arrives on the tray and both birds (the RWBL and BAOR) display by raising wing and tail feathers, then

some quick "air-jabs" and the RWBL leaves (BAOR has displaced RWBL from the tray); (1 X).

An RWBL (probably the same individual) is again displaced by BAOR at 1:18 (1X), and an RWBL lands and feeds on the opposite side of the tray from the BAOR at 1:40. You may notice a BCCH (Black-capped Chickadee) flitting in and out from a cylindrical feeder in the background at 1:47. Remember, we are recording only interactions at the tray.

Likewise, a second RWBL comes in and out of the scene between 1:49 and 1:57, but this bird is never on the tray.

At 2:10, the RWBL that has been on the tray awhile takes a seed and leaves just as a second BAOR arrives at a nearby cylindrical feeder. Whether or not this counts as a displacement is ambiguous but I did not count it because the presumed displacer (BAOR) was never at the tray and it looks like the RWBL was getting ready to leave with a seed anyway.

At 2:15 a RWBL arrives at tray.

At 2:21 a COGR arrives at the tray and the BAOR is displaced as a result of this arrival (1X).

Starting at 2:23 there are several birds moving around the perimeter of your view and its messy, but it appears that some other RWBLs are fluttering around and in the midst of it, both the RWBL and the COGR leave the platform at about the same time a EUST (European Starling) lands on an upright feeder behind the tray and a BAOR comes to the tray again. Since none of these other birds land on the tray, I did not count any as displacements.

At 2:35 a COGR displaces the BAOR on the tray soon after there are other displacements taking place on the *other* feeders.

Data Sheet 3: Remote Observation for ViABLE 2021

Cornell Feeder Cam at Sapsucker Woods

Name: ______________________ Date of Observation: ______________Time:________________

Displacer Species

Displaced	EUST	RWBL	MODO	RBWO	BLJA	NOCA	COGR			
EUST										
RWBL										
MODO										
RBWO										
BLJA										
NOCA										
COGR										

Alpha codes:

EUST: European Starling

RWBL: Red-winged Blackbird

MODO: Mourning Dove

RBWO: Red-bellied Woodpecker

BLJA: Blue Jay

NOCA: Northern Cardinal

COGR: Common Grackle

Please add additional species you observe in the blank columns/rows

Please submit this page electronically to Kathy Winnett-Murray by June 16: winnetmurray@hope.edu Thank you!

Mission, Review Process & Disclaimer

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