A Field Project Investigating the Influence of Urban Noise on Eastern Gray Squirrel Behavior

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Abstract: Many science departments encourage students to gain experience conducting research. However, finding ecological research projects that allow students to test a hypothesis in the field, over the relatively short time span of a semester, can be challenging. This article describes an inquiry-based research activity examining the influence that urban noise has on the behavior of gray squirrels. One of the consequences of urbanization is increased noise from automobiles and other human activities. This research project allows students to pose hypotheses regarding how squirrel behavior changes in response to human noise and then test those hypotheses. This activity is well suited for students in ecology, animal behavior, or vertebrate biology classes. It allows students flexibility in the hypothesis they test and the methods they use, while giving students a framework that lets them successfully complete a field research project. Students gain experience developing hypotheses, designing a field experiment, writing a research proposal, collecting field data, conducting data analysis, and presenting the results of their project.

Keywords: Ecology, urban ecology, animal behavior, squirrels, behavioral ecology, foraging behavior, student research, research projects, teaching methods, undergraduate research, flight initiation distance, flight distance, escape distance, alert distance, noise pollution, urban noise, vertebrate biology

Introduction

There has been an increasing desire among many science departments to encourage students to gain experience conducting scientific research. When conducting laboratory experiments, it is relatively easy to control variables. However, field projects can be extremely time-consuming, and it can require tremendous amounts of time and effort to conduct experiments on animals in the field. This article describes an inquiry-based research activity examining the influence that urban noise has on the behavior of gray squirrels. Students gain experience developing hypotheses, designing an experiment, writing a research proposal, conducting data analysis, and presenting the results of their project

One of us, the first author, is an instructor for a course that uses this activity at our institution. The other two authors are students that have conducted this research project and have assisted in revising the activity.

Introduction to Eastern Gray Squirrels

Eastern gray squirrels (*Sciurus carolinensis*) are common in North America and range throughout much of the central and eastern part of the United States and the southern regions of Canada (Koprowski, 1994; Whitaker 1996). These squirrels are generally grayish or brownish in color, although there is a black (melanistic) morph that is found in certain regions, particularly in Canada. They are medium-sized tree-dwelling squirrels and build large nests (dreys) of twigs and leaves high up in trees. When the leaves of deciduous trees drop in the fall, it is easy to spot the conspicuous dreys. In addition to dwelling in dreys, gray squirrels frequently have a den in a hollowed-out tree trunk (Koprowski, 1994; Whitaker 1996). The dreys are frequently used in warmer months while cavity dens are often used in winter (Koprowski, 1994). Eastern gray squirrels are not territorial, and squirrels have overlapping home ranges. Their home ranges vary from 0.5 hectares to over 20 hectares (Koprowski, 1994).

Gray squirrels are diurnal (are most active at dawn and dusk). Their peak activity occurs about two hours after sunrise, and two-five hours before sunset (Koprowski, 1994). They have a broad diet that includes seeds, nuts, flowers, fruit, tree bark, buds, and mushrooms as well as occasional eggs and nestlings of small birds (Koprowski, 1994; Whitaker, 1996). Females consume more food than males and food consumption peaks in summer or fall, while declining in the winter (Knee, 1983). During periods when food resources are abundant, squirrels collect and store food. They are scatter hoarders and may have thousands of stored caches. Eastern gray squirrels do not hibernate, but during the cold winter months they will venture out of their nests on warm days and dig up some of their stored caches (Whittaker, 1996).

Introduction to Influence of Urban Noise on Squirrel Behavior

Urbanization has resulted in an increase in noise from automobiles, businesses, and human interactions. Common urban noise includes not only automobiles but also mowers and other yard equipment, recreational vehicles, construction work, sirens, alarms, barking dogs, and music. Noise can influence wildlife in many different ways. Often noise can cause wildlife to move away from an area, to increase their time spent being vigilant (examining their surroundings for potential threats), and decrease the time spent foraging (Dertien & Larson, 2021; Engelhardt & Weladji, 2011; Cooper et al., 2008). Dertien and Larson (2021) found that small mammals tend to avoid areas within 50-100m of trails or people. Squirrels that were exposed to predator calls showed increased vigilance and decreased foraging (Jayne et al., 2015).

Flight initiation distance is a common behavioral measurement examining how close a person or object can get to an animal before the animal flees. Flight initiation distance is also referred to as flight distance, escape distance, or alert distance. Engelhardt and Weladji (2011) and Cooper et al.

(2008) found a difference in how squirrels react to humans in environments with different levels of human disturbance. They found flight initiation distance in squirrels significantly increased with decreasing human disturbance. Thus, in areas where squirrels are frequently exposed to humans (areas of increased human disturbance), squirrels let humans approach more closely, perhaps due to squirrels learning to adjust their antipredator behavior with experience to humans (Engelhardt & Weladji, 2011; Cooper et al., 2008).

This study allows students to examine how noise affects the behavior of squirrels. Students can pose hypotheses regarding how the presence of noise will influence squirrel behavior, design experiments to test their hypotheses, analyze their results and draw conclusions about the influence of noise on squirrel behavior.

General Methods

General Format of Research Projects

Rather than providing students with a hypothesis to test and methods to follow, I (the first author and course instructor) prefer to have students pick their own hypothesis and develop their own methods, as it provides students with valuable experience developing a hypothesis and designing their own experiment. Also, this makes the project truly "theirs" and they become more invested in their projects. I have found that student research projects work best when students collaborate in groups of three or four because it enables students to divide up the work so that they can collect sufficient data to allow them to conduct statistical analysis and draw meaningful conclusions. Because these projects are field projects, for safety reasons, I like to have a minimum group size of two so that students always go out to the field with a partner. I generally let students form their own groups based upon which students are interested in pursuing similar hypotheses. If there are students that haven't found partners, I try to help them find a group to work with. It is also preferable to avoid large groups; I have observed that groups of more than four students tend to have considerable problems fairly dividing the work among group members. Having students work in groups, means that the instructor has a more reasonable number of projects to oversee.

First, students are provided with background information on squirrel foraging behavior and the influence of urbanization on wildlife. Next, groups conduct a literature search and write a two-to-three-page summary of squirrel behavior and the influence of urban noise disturbances on squirrel behavior. Students are required to cite a minimum of five sources, three of which must be scientific journal research articles. After going over their summaries with each group, I ask groups to come up with a hypothesis that they could test regarding the influence of noise on squirrel behavior. If students have a difficult time developing a hypothesis to test, we discuss how they think that noise might influence squirrels, and I help guide them toward possible hypotheses that they could test. Examples of possible hypotheses that students could test (ones that my classes have examined) include:

• Squirrels presented with loud noise (e.g., music from a speaker, or the sound of a siren being played from a speaker) will demonstrate a greater flight initiation distance than when they are not exposed to loud noise.

• The type of noise that squirrels are exposed to will influence their flight initiation distance (students could use their cell phone to play different sounds at a set volume such as a siren, car alarm, motorcycle, barking dog, leaf blower, mower, or loud music).

• Increasing the level of noise (none, low, medium, high) results in squirrels showing greater flight initiation distance.

• Squirrels exposed to higher levels of human disturbance (e.g., in regions closer to trails or areas in parks that are more frequently visited) will be less likely to respond to human noise (will have a lower flight initiation distance) than squirrels exposed to lower levels of human traffic.

Once students have developed a hypothesis that they plan to test, and their hypothesis has been approved by me, each group designs an experiment to test their hypothesis. Next, groups submit a scientific research proposal which should include an introduction with supporting background literature, and a detailed methods section including a discussion of proposed statistical analysis (Darling, 2020 includes a handout on writing a research proposal). I also ask students to include a list of required items, and a detailed calendar outlining what the group will do each week (preparation/set-up, data collection, data analysis, and preparation for presentation of their results). I have found that requiring a formal, graded, research proposal helps students structure their ideas and prevents students from jumping ahead and making major mistakes in their experimental design.

After reading their proposals, I meet with each group to discuss their projects and make suggestions regarding their hypothesis and experimental design. I then ask groups to revise their proposals based upon that discussion. After groups rewrite their proposals, I then meet with groups again. Students do not begin data collection until their proposals have been reviewed and approved. Generally, it takes several revisions before students have refined their experimental design. Their revised proposal is graded, and their final proposal grade is an average of the grades on their proposals.

Before students begin their projects, I ensure that they have background knowledge on how to conduct their projects, understand that they must work with a partner when they are out in the field, have worked out the details of their experimental design and know what data they will record, I also make certain that they have an idea of how they will analyze their data, understand what results will support their hypothesis, and what results will cause them to reject their hypothesis. I then ask each group to provide me with a data collection sheet detailing what data they will record and how often data will be collected. If necessary, I also ensure that groups have submitted Institutional Animal Care and Use Committee (IACUC) proposals required by the university and that their IACUC proposals have been approved.

Suggestions and Helpful Hints for Projects

While students should develop their own hypothesis and experimental design, they may need some assistance. Below I outline some helpful suggestions to consider when discussing experimental design with each group.

- Students should design an experiment to examine the influence of noise on squirrel behavior. There are many ways that they could do this. Exactly how they do this will depend on what hypothesis they choose to address.

- Students should conduct their projects in field sites that squirrels frequent. This could be locations on campus or nearby local or state parks. One of the advantages of using squirrels as a study animal is that they are prevalent; they frequent urban and suburban areas. Exactly which locations students use may depend upon the hypothesis they test. To have success encountering squirrels, students should be certain to pick areas where squirrels are common.

- When conducting experiments, students can attract squirrels using plates of food (e.g., sunflower seeds or peanuts). However, they should be certain to keep the type and quantity of food constant for all their trials.

- "Seeding" the area with nuts or seeds prior to conducting experiments is essential. Without seeding the area, students waste a tremendous amount of time in the field waiting for animals to come. However, if they go out and seed the area, each day for 4-6 days before they begin their experiments, they will have a much easier time attracting squirrels to the area.

- It is preferable to conduct trials during mornings and/or late afternoons when squirrels are most active.

- Students should try to control for everything except the variable that they are testing. For example, if they are testing the hypothesis that noise (e.g., music from a speaker) will result in squirrels showing a greater flight initiation distance, then during each trial, squirrels should always be given the same quantity and type of food and the only thing that should be changed is the presence or absence of music from a speaker. If students are not comparing the influence of squirrel exposure to human traffic, then they should try to control for exposure to human traffic by choosing sites that have similar levels of human traffic. Students can use their cell phones to manipulate noise. For example, they could choose a particular song to play and then manipulate the volume on their cell phone. Alternatively, they could test a hypothesis about how squirrels respond to different types of sounds by using their cell phones to play different sounds (car alarm, siren, music) at a set volume.

- Students can measure flight initiation distance by waiting for a squirrel to begin foraging at the food plate and then starting to slowly walk toward the squirrel. The flight initiation distance is recorded as the distance from the student to the squirrel when the squirrel begins to flee as approached. Students can drop markers (e.g., small colored markers) at the beginning and ending locations and then use a measuring tape to measure the flight initiation distance. This distance represents how close the researcher was able to get to the squirrel.

- Students should conduct sufficient replicates, from a variety of locations, and over many different days to allow for statistical analysis. Generally, it is useful to have a minimum of 20 replicates for each treatment.

- This exercise allows students to statistically analyze data. I conduct this project in an upper- division course and students have previously been exposed to some statistics in introductory biology. However, I provide students with a brief overview of statistical analyses, and I meet with each group to discuss appropriate data analysis.

Results and Discussion

Graphing the data will help students visualize their results. The data analysis will depend upon what hypothesis was tested. For example, students can graph the results to determine if the average flight initiation distance (FID) increases with the presence of noise. Then, they can conduct appropriate statistical analyses. For example, students could compare the mean flight initiation distance between treatments by using t-tests or ANOVA (depending upon the number of means that they are comparing).

Examples of student results from this exercise are shown in Figures 1 and 2. In general, my students have found that as noise increases, FID significantly increases (Figure 1). Students in my class have also found that FID varies among locations that have different levels of foot traffic. Overall, FID was highest in parks that had the lowest foot traffic (Figure 2). Mt. Tom (a more remote location in Massachusetts) had the highest overall average FID whereas, busy Ray Ash Park (MA) had the lowest FID. This is consistent with the results from Engelhardt & Weladji (2011) that found squirrels would flee faster, creating a higher flight distance in areas that were around many humans or are in areas of decreased foot traffic.

As in any science experiment, students do not always find what they predict, and this is a great opportunity to discuss with students all the reasons why they may find results that differ from their predictions. After analyzing their data, I have students present their results in an oral presentation to the class, in a poster presentation at our collegewide poster symposium, and as a full written report.

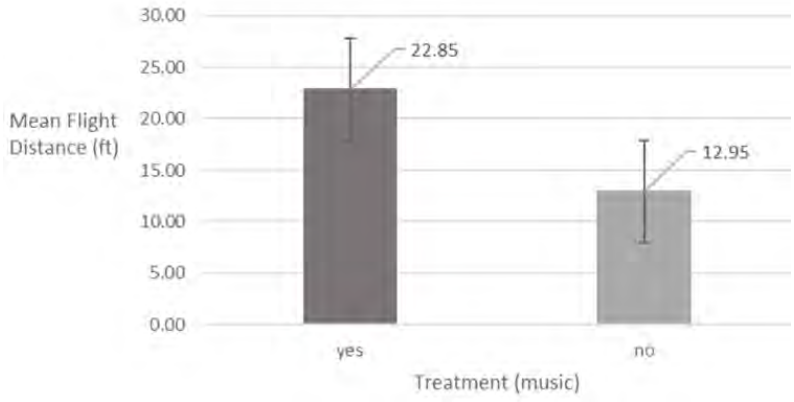

Figure 1: An example of one group's results for the mean flight initiation distance (FID) for squirrels exposed to loud noise (music playing from a speaker) compared to squirrels not exposed to loud noise. Treatment "yes" is the experiment group that had music playing while treatment "no" was the control group that had no music playing. There was a significant increase in FID with exposure to loud noise.
(t-test: t= 10.9, df=118, p= 6.91x E-20)

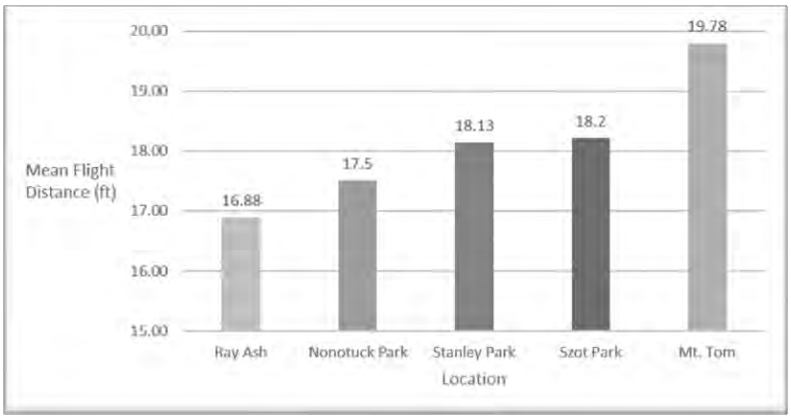

Figure 2: An example of one group's results for the mean flight initiation distance (FID) for five different locations. The five locations are different parks ranked from high (Ray Ash, MA) to low (Mt. Tom, MA) foot traffic. FID was significantly higher in regions that had lower foot traffic (Mt. Tom) than for regions (Ray Ash) that with high foot traffic (ANOVA p=0.033).

Conclusion

It can be very challenging to find ecology and animal behavior field research projects that can be easily and inexpensively conducted. This exercise provides an opportunity for students to gain experience developing hypotheses, designing a field experiment, collecting field data, writing a research proposal, conducting data analysis, and presenting the results of their project. This exercise provides students with flexibility regarding what hypothesis they test, and what methods they use, while providing a framework that helps them successfully complete a behavior project.

References

Cooper, C.A., Neff, A.J., Poon, D.P., & G.R. Smith. (2008). Behavioral responses of eastern gray squirrels in suburban habitats differing in human activity levels. Northeastern Naturalist, 15(4): 619-625.

Darling, R.A. (2020). The influence of habitat complexity on crayfish foraging behavior. Bioscene: Journal of College Biology Teaching, 46(2):3-7.

Dertien, J. S., Larson, C. & S.E. Reed. (2021). Recreation effects on wildlife: a review of potential quantitative thresholds. Nature Conservation, 44:51-68.

Engelhardt, S.C., & R.B Weladji. (2011). Effects of levels of human exposure on flight initiation distance and distance to refuge in foraging eastern grey squirrels (Sciurus carolinensis). Canadian Journal of Zoology, 89(9):823-830.

Jayne, K., Lea, S. E. & L. A. Leaver. (2015). Behavioural responses of Eastern grey squirrels, Sciurus carolinensis, to cues of risk while foraging. Behavioural Processes, 116:53-61.

Knee, C. (1983). Squirrel energetics. Mammal Review, 13:113-122.

Koprowski, J.I. (1994). Sciurus carolinensis. Mammalian Species. American Society of Mammologists, 480:1-9.

Whitaker, J. O. 1996. National Audubon Society Field Guide to North American Mammals. Alfred Knopf, New York.