Despotic Ducks

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Abstract: This field experiment is designed to test for despotic behavior in Mallards (*Anas platyrhynchos*), and to examine how ducks distribute themselves relative to their resources. Students present Mallards with food patches differing in profitability in order to examine whether ducks distribute themselves ideal freely or ideal despotically. Students also test whether foragers have equal competitive ability, and look for despotic behavior among individuals. Despotic behavior is when certain individuals monopolize resources and prevent others from gaining access to those resources. This exercise is designed to allow students to be involved in every step of the scientific process.

Keywords: despotism, foraging, ideal free distribution, despotic distribution, ducks.

Introduction

Often it is challenging to find field experiments that can be conducted in a reasonable amount of time, and that will provide useful data for analysis. Yet, students enjoy field experiments; and hypothesis-testing experiments enabling students to collect and analyze data provide students with valuable research experience (Darling 2000). This field exercise provides students with an opportunity to conduct a hypothesis-testing experiment, and analyze their results.

Fretwell and Lucas (1970) and Fretwell (1972) proposed the ideal free distribution (IFD) theory to explain how animals should distribute themselves within an environment containing patches of varying suitability. The ideal free distribution theory applies to situations when there is competition over a resource which is patchily distributed (e.g. food or mates) and the following conditions are met: 1) individuals are 'ideal' in assessing patch quality (i.e. they have complete information about the availability of resources), 2) individuals are 'free' to enter or leave any patch of their choice (there is no resource defense), 3) patch quality decreases with increasing competitor density, 4) all individuals select the most profitable patch while compensating for existing competitors in the patch, and 5) all individuals have the same competitive ability.

If these conditions are met, the IFD theory predicts that the number of individuals per patch will be proportional to the fraction of resources in that patch. The theory also predicts that the intake per individual will be equal across all patches.

According to the IFD theory, if there is a group of twenty-four ducks feeding in a pond that has pieces of bread distributed in two patches, and one patch has twice as many equally-sized pieces of bread as the other patch, you would expect that there would be eight ducks in the poor patch, and sixteen ducks in the rich patch. Furthermore, the IFD predicts that the food intake (number of pieces of bread consumed per duck) will be equal in both the rich and poor patches.

A number of studies have tested the ideal free distribution theory in a variety of species, and have found that animals tend to distribute themselves as predicted (Milinski 1979; Harper 1982; Power 1984; Godin and Keenleyside 1984; Gillis and Kramer 1987; Darling 1989; Baum and Kraft 1998). However, often individuals do not get equal shares of the resources. Often, dominant individuals obtain more than their fair share of the resources (Milinski 1979; Harper 1982; Desrochers 1989; Baum and Kraft 1998; Cresswell 2001). These dominant individuals may act as despots chasing subordinates away from the resources (Milinski 1979; Harper 1982; Desrochers

1989; Baum and Kraft 1998; Cresswell 2001). If some individuals behave despotically, then individuals are no longer 'free' to enter or leave any patch of their choice.

In contrast to the ideal free theory, the ideal despotic distribution assumes that individuals vary in their ability to obtain resources (Fretwell 1972). The best competitors are expected to occupy the most profitable patches and prevent others from gaining access to those resources. Thus, the ideal despotic distribution predicts variation in food intake between individuals (Fretwell 1972).

This field exercise is designed to examine how ducks distribute themselves relative to their resources (ideal freely, or despotically). In this exercise, students will present ducks with bread distributed into two patches (a rich patch and a poor patch, Figure 1). Students will test the prediction that competitors will distribute themselves such that the number of individuals per patch is proportional to the fraction of resources in that patch. Students will also test to see if the assumption of equal competitive abilities among ducks is met, and if despotism occurs in ducks.

Figure. 1. A test for despotic behavior using Mallard ducks.Ducks are fed equal sized pieces of bread in two patches of different profitability.One patch is a "poor" patch, while the other is a "rich" patch with twice the profitability as the poor patch.

Methods

use when conducting this experiment with ducks. Buy several loaves of bread. Cut each bread slice into pieces (use quarters if you don't have many ducks in your area, use eighths if you have a lot of ducks).

Experimental Design and Procedures

In my class, after I have introduced the students to the ideal free distribution theory and the ideal despotic distribution, I engage the students in a discussion about experimental design. Rather than give students the methods, I prefer to encourage the class to think about the issues involved with designing an experiment, and allow them to design their own field experiment. I have outlined questions and issues that the class should discuss below.

Field Location

Before conducting this exercise, the instructor needs to locate an appropriate field location. A local park, pond, stream or wetland area may provide a suitable location. Because ducks often aggregate in rural areas as well as in urban and suburban parks, this experiment works well in a variety of settings.

Mallards (*Anas platyrhynchos*) are a common duck species found in many locations, and work well for this experiment. It is not necessary to have a large population of ducks, but you will need approximately eight ducks. If you do not have a location with a duck population nearby, this exercise can be easily adapted to work with other bird species. For example, you could do this exercise in a park using pigeons as your study species, and using a large seed as your food (such as sunflower seeds or peanuts).

Time of Day

Students should discuss when the experiment will be conducted and how long trials will run. One of the assumptions of the IFD model is that the foragers are hungry. Therefore, students will get the best results if they conduct the experiments early in the morning, when the ducks are hungriest. This is especially true of park populations of birds that are fed, and become quickly satiated.

Food

The class should discuss the food type and quantity to be used. Have students prepare the food to be used ahead of time. Pieces of bread are a good food source to

The class should discuss the experimental design. What patch profitability ratio(s) will be tested? For example students could test a 1:1, 2:1, 3:1 or 4:1 ratio. Continuous input experiments work well (food is continually input into the two sides of the

pond at the appropriate ratios). For instance, the class would test a 2:1 ratio by throwing bread continually into the two sides of the pond: throwing in twice as many pieces of bread in the "rich" side as in the "poor" side. Perhaps students may decide that every twenty seconds they will throw ten pieces of bread in the poor patch, and twenty pieces in the rich patch.

What will the control be? The control should be the initial distribution of the ducks prior to throwing in food. When students first arrive at the study site, before conducting any manipulations, students should observe the distribution of the ducks for a set amount of time (perhaps five or ten minutes). During this control period, students should record the number of ducks on each side of the pond at regular intervals.

How many times will students replicate the experiment? Running replicates of the experiment over several days will enable the class to collect sufficient data to run statistical tests. Once a field location is selected, and the students have decided on an experimental design, they can begin collecting data.

What items and equipment will be needed? Students will need bread, stopwatches, tape measures, flagging, paper, and pens for recording data.

Helpful Hints

This experiment works best if the food does not become completely depleted; therefore it is best to choose a sufficient quantity of food for the population of ducks in your study area. It may take a little experimentation to determine the appropriate quantity of food.

Students should count out the appropriate number of pieces of bread and put them in Ziploc bags so that each time they need to add food, it is already counted out.

The pond should be divided in half. Students should measure the midpoint of the pond and mark it with visual markers that they can see (e.g. small pieces of flagging tape near the edges) so that when they are counting which side of the pond ducks are on, they will know where the midpoint is.

Time periods of five to ten minutes in length work well for the experiment. Time periods longer than this may result in ducks becoming satiated.

At each end of the pond two students could be responsible for throwing in the food. Students could work in pairs; one student could have a stop watch and let the other student know when it is time to throw in the food. Another two students (at each end of the pond) should collect data on number of ducks. Additional students can follow 'target' ducks to collect data on the amount of food consumed on each side of the pond.

If one of the desired outcomes is to conduct statistical analysis, then 8 to 12 replicates of the experiment is preferable.

Data Collection and Analyses

The instructor can lead students through a discussion of what data should be collected to test the predictions of the IFD theory and the ideal despotic distribution. Students should periodically (e.g. every twenty or thirty seconds) record the number of ducks in the pond, in both the rich and poor patch, during both the control and feeding periods.

Students should also record the number of food items consumed on each side of the pond for individual ducks. It probably will not be possible for students to record food intake for every duck. Therefore have different students randomly select several 'target ducks' to follow throughout each trial. For each target duck, students will want to follow the duck and record how many bread pieces that duck eats in the poor patch, and how many pieces it eats in the rich patch. Students should also record observations about despotic behavior. Are the target ducks chasing other ducks from the food? Or, are they being chased from the food?

Results and Discussion

This laboratory gives students an opportunity to statistically analyze data. I have conducted this lab in my class after students have been introduced to statistical analyses. The instructor can lead the students through a discussion of what results are expected.

Graphing the data will let students visualize whether the ducks distribute themselves according to the predictions of the IFD theory. Students can graph the results to observe if:

1) Ducks are distributed equally on both sides of the pond during the control period as expected.

2) The number of individuals per patch is proportional to the fraction of resources in that patch during the feeding period.

To address these two predictions, students can plot the mean number of ducks on each side of the pond for the control and the feeding periods respectively (see Figures 2 and 3).

Figure. 2. The mean number of ducks recorded in each patch of the pond (the left and right patches) during the control period of the experiment. Because no food is added to either side of the pond during the control period, it is expected that there should be approximately equal numbers of ducks on both sides of the pond

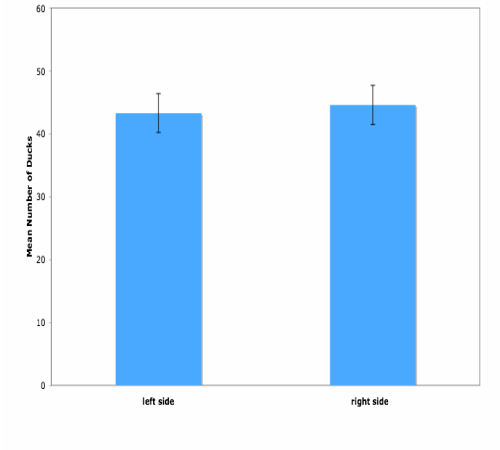
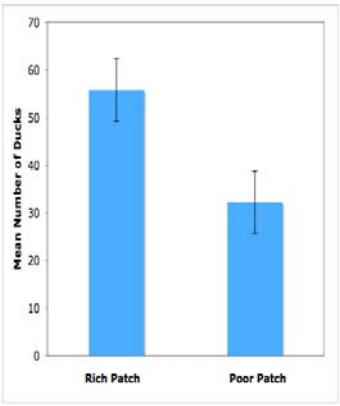


Figure. 3. The mean number of ducks recordedin each patch of the pond (the rich and poor patch) during the feeding period of the experiment. The rich patch contained twice as much bread as the poor patch. If the ducks behaved ideal freely, the expectation is that there would be twice as many ducks in the rich patch as in the poor patch.

number by performing a chi-square test.

3) The food intake per individual is equal across patches. To test this expectation, students can calculate the mean (mean ± SE)



Students can also graph the food intake per duck to examine if all of the "target" ducks have approximately equal competitive abilities or whether some ducks consume more food than others.

Students can statistically analyze the data to determine whether:

1) There were equal numbers of ducks on both sides of the pond during the control period as expected. To test this expectation, students can calculate the mean (mean ± SE) number of ducks on each side of the pond during the control period and compare the means statistically by performing appropriate statistical tests (e.g. t-tests or Mann-Whitney U tests).

2) The number of individuals per patch is proportional to the fraction of resources in that patch. To test this expectation, students can calculate the mean (mean ± SE) number of ducks on each side of the pond during the experimental period. The mean number of ducks can be compared to the expected

number of food items consumed on each side of the pond during the feeding period. The means can be compared statistically by performing appropriate statistical tests (e.g. t-tests or Mann-Whitney U tests).

4) The average food intake is equal among all ducks. To test this expectation, students can calculate the mean (mean± SE) total number of food items consumed (on both sides of the pond) during feeding periods by a given duck. The means for different ducks can be compared statistically by performing appropriate statistical tests (e.g. ANOVA or Kruskal-Wallis test to compare means).

Questions students can address include: Did the ducks distribute themselves according to the predictions of the IFD theory? If the ducks did not distribute themselves according to the IFD theory, why not? Were the assumptions of the IFD theory met? Were all ducks equal in their competitive ability, or were some ducks superior competitors? Were some ducks despotic, taking more than their fair share of the resources and keeping others away from the resources?

Students can present their results in written laboratory reports (in scientific format) and/or orally present their results. For lower division courses, students could write a shorter report by answering a series of questions provided by the instructor.

In conclusion, this field exercise provides students with an opportunity to be involved with designing and conducting an experiment, and analyzing and summarizing their results. Often it is challenging for instructors to find field laboratory experiments that involve testing a hypothesis. This exercise provides a hypothesis-testing field experiment that is fun to do and gives interesting results.

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