OPTIMAL FORAGING BEHAVIOR: GROUP VS. SOLITARY FORAGING UNDER DIFFERENT FOOD DISTRIBUTION PATTERNS

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INTRODUCTION

The demands of food acquisition exert strong selective forces on the anatomy, physiology, and behavior of birds. Natural selection for efficient foraging affects "decisions" about prey choice, patch choice for foraging, patch exploitation strategy, and foraging group size (solitary versus flock foraging) (Krebs 1978). It has been widely demonstrated that food abundance and distribution (along with predation) are the primary determinants of foraging behavior (e.g., Caraco et al. 1980, Pulliam and Caraco 1984).

This exercise is intended to provide experimental data to test hypotheses about optimal foraging behavior (flock or solitary) in environments with different food distribution. Specifically, the exercise tests the hypotheses that widely dispersed food favors solitary (or pair) foraging and that clumped food distribution favors foraging in flocks (Cody 1971, 1974; Krebs et al. 1972.).

LEARNING OBJECTIVES

Students will:

- Participate in testing null and alternative hypotheses
- Demonstrate how solitary or group foraging efficiency is affected by different patterns of food distribution
- Understand optimal foraging theory better by collecting data on their own foraging behavior

MATERIALS

4 different colors of sticky notes
Stop watch
Calculator (access to a statistical analyses system may be desirable)
Lecture room

PROCEDURE

Previous studies suggest that when food is approximately evenly dispersed in an environment, solitary foraging yields a higher energy return per unit time (or less time to acquire a set amount of energy) (Verbeek 1973). Alternatively, when food is clumped, flock foraging is more efficient (Zahavi 1971, Krebs et al. 1972). To let students experience these non-intuitive concepts, this exercise lets students be "foragers" searching for "prey." The foraging environment is the classroom, prey are colored note papers attached to the underside of desks or chairs, and the birds are students. Four basic trials are conducted in this exercise to test the following hypotheses.

Hypothesis 1. There is no difference in time required to locate and capture prey necessary to meet energy requirements between solitary and flock foragers when food is evenly (approximately) distributed in space.

Alternative Hypothesis 1a. Solitary foragers require less time to locate and capture prey than flock foragers when food is evenly (approximately) distributed in space.

Hypothesis 2. There is no difference in time to acquire prey needed to meet energy requirements between group and solitary foragers when food is patchily distributed (clumped) in space.

Alternative Hypothesis 2a. Group foragers require less time than solitary foragers to acquire prey to meet needed energy demand when food is patchily distributed (clumped) in space.

Classrooms of almost any size can be used for this exercise, but very small ones (ca. 20 desks) introduce larger chance variation in the results. I have used the experiment successfully in banked or flat classrooms with from 60 to >100 desks (or chairs). Separate trials (with replicates if desired) with solitary and with flock foragers are conducted to test each hypothesis resulting in 4 different trials.

For Trial 1 (solitary foragers; food evenly dispersed), 12 sticky notes (all of a single color, e.g., blue) are placed in a widely dispersed (pseudo-uniform) pattern on the underside of desktops or chairs. Nine student volunteers are gathered outside the foraging patch (e.g., at the front of the class). Other students act as timekeepers. On a set signal the student foragers begin searching for food (sticky notes) in the foraging patch (set of desks). Students are told that once they find and "capture" a food item (i.e., met their daily energy need) they should leave the foraging patch. Total elapsed time from beginning of search until a prey item is captured is recorded for each student forager (alternatively total time elapsed until the last of the 9 foragers captures a food item can be recorded).

For Trial 2 (group foraging, food evenly dispersed), 12 sticky notes (of a different color, e.g., yellow) are again distributed in a widely dispersed pattern in the classroom. Again 9 student volunteers are gathered outside the foraging patch. To simulate flock foraging, students should be grouped into 3 flocks of 3 individuals. Flock integrity is maintained by requiring students to hold hands through the foraging bout. To mimic within flock dominance hierarchies and possible interference during prey capture, student flocks should have a dominance hierarchy assigned (e.g., by student height). Subordinate individuals must pass any prey item they capture to the next highest ranking individual in the flock until all (if any) higher ranking individuals have been fed. Once all members of a flock have obtained 1 prey item the flock should leave the patch. Time from onset of foraging until each individual within flocks captures a prey item should be recorded. Again, to simplify, record only total elapsed time from initiation of foraging until the last individual locates a prey item.

To test hypotheses regarding solitary and flock foraging efficiency when food is clumped also requires 2 different trials. For Trial 3 (solitary foraging; food clumped) 12 sticky notes (all of a single color, e.g., green) are placed in a clumped distribution throughout the classroom foraging environment. Distribute the sticky notes in 4 clusters with 3 prey items in each cluster (under a single desk or adjoining desks). Nine foragers again search individually for prey and total elapsed time is recorded for each.

For Trial 4 (flock foraging, food clumped), again distribute sticky notes (e.g., pink) in a clumped distribution as in trial 3. Nine student foragers should be arranged in flocks and forage under the rules described for trial 2.

To prevent "information transfer" (*sensu* Zahavi 1971), all sticky notes should be hidden prior to students entry into the classroom. Additionally, having different students act as foragers in each trial reduces errors associated with learning patch characteristics, search image development, etc. When notes for the 4 trials are all distributed before class time, care must be taken to prevent mistakes in prey choice (wrong color of sticky notes). I tell students that prey other than their assigned (preferred) items are unpalatable or toxic and if they inadvertently capture them (remove them from under the desk) they must be replaced immediately.

After the trials are completed, means and variances of foraging times for the different trials can be calculated. If desired the data can be analyzed statistically to test the stated hypotheses. Alternatively, total elapsed time until the last forager in each trial found a prey item can be examined to assess the hypotheses and used to discuss the concept of foraging efficiency and optimality. Discussion of what happened during the foraging trials usually results in observations of "information transfer," learning of prey locations, etc. being raised. In repeated trials at the University of Missouri it has been rare that the data have not supported the theoretically expected results (the alternative hypotheses). In any case, discussion of what went wrong can be insightful. Occasionally the last forager to capture a prey item takes an inordinately long time to find their prey. This can be discussed in terms of patch depletion and strategies for knowing when to leave a patch in search of another, higher quality patch. [Note: the reason for the number of prey items (12) exceeding the number of foragers (9) is too minimize prey depletion effects]

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