Chapter 7

A Field Study of the Ant Trail Phenomenon

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Reprinted from: Moody, D. 1993. A field study of the ant trail phenomenon. Pages 99-104, *in* Tested studies for laboratory teaching, Volume 5 (C.A. Goldman, P.L.Hauta, M.A. O'Donnell, S.E. Andrews, and R. van der Heiden, Editors). Proceedings of the 5th Workshop/Conference of the Association for Biology Laboratory Education (ABLE), 115 pages.

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Introduction

Ant foraging and food gathering provides an excellent opportunity for students to directly observe a form of animal communication. The activity described here is a field investigation which can generally be done in a laboratory period and conducted just outside the science building doors. The only major requirement is an ant colony or "ant hill."

The focal point of this activity is the ability of foraging insects to "lay down" chemical trails. Ants, the most widely studied of the foraging insects, use pheromone trails to lead colony members to food sources and new nest locations (Horn, 1976).

Pheromones are defined by Jacobson (1972) as "those substances secreted by an animal to influence the behavior of other animals of the same species." They are generally synthesized within specialized exocrine glands and secreted directly. Ants secrete the trail pheromone from an exocrine gland located in the posterior abdomen and the trail is established as the pheromone flows down the sting (Wilson, 1963).

Other ants encountering the trail receive the chemical message through chemoreceptors located in their antennae. Pheromones evaporate easily, thus ensuring an upward movement from the trail to the receiving ant's antennae. One worker, upon finding food, leaves a fairly uniform trail, but the volatile nature of the pheromone causes the trail to dissipate within a short time (Figure 7.1). Two minutes after a worker has marked a trail, the pheromone has evaporated to a point that is below detection level. A worker can travel about 40 cm in 2 minutes, so if a fresh trail is to be encountered, another foraging worker must cross the trail or be directed to it by tactile communication. The second worker adds his pheromone contribution, making the trail more prominent, while subsequent workers reinforce the trail.

The trail does fade rapidly, but this is advantageous because old trails which lead to exhausted food supplies do not linger to confuse workers. An additional advantage is inherent in the reward for finding food. Only if food is found does the worker emit a pheromone trail and only on the way back to the nest. Thus, if the find is sufficient to allow several workers to bring food back to the nest, a high pheromone concentration is maintained and even more workers are attracted. When the food supply dwindles, the trail begins to fade, fewer workers are attracted, and gradually the trail diffuses and evaporates (Wilson, 1963).

If the trail leads to a fairly permanent food source, "chemical signposts" set by a territorial pheromone, are deposited at points along the trail, establishing a greater degree of permanency and warning ants from other colonies of territorial boundaries (Holldobler and Lumsden, 1980).

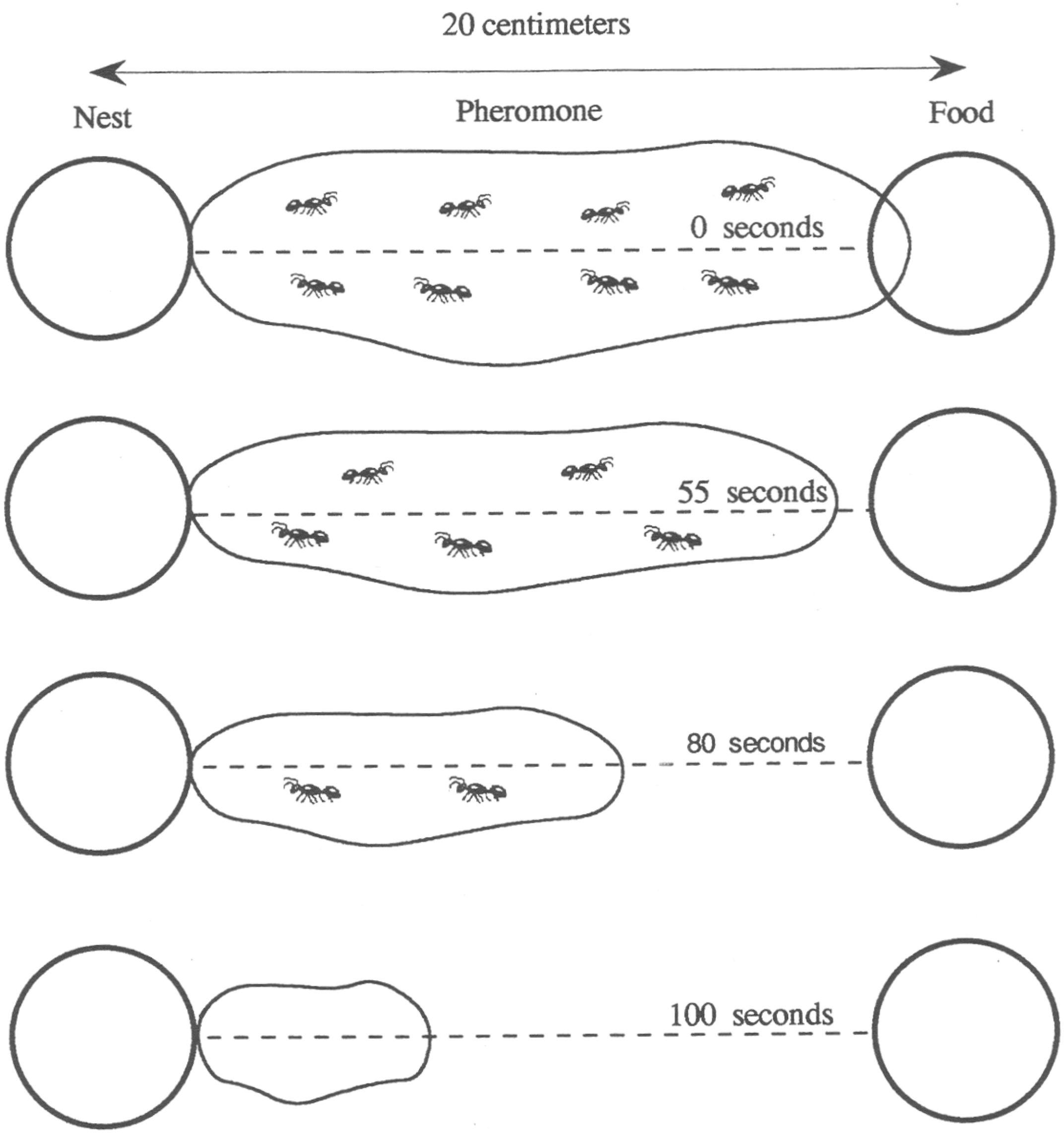

Figure 7.1. Pheromone dissipation for one ant. Adapted from Wilson (1963).

While the trail pheromone appears to be the most advanced and efficient method of establishing routes to food supplies, other behaviors have also been observed. For example, if a worker loses the trail, it travels in small circles until the trail is either found, or another worker intercepts the “lost” ant by antennae touching and guides it back to the trail (Wilson, 1963). Ants may also use kinesthetic and optical cues to keep them on trails which have been disturbed and where the pheromone continuity has been disrupted. And, more primitive than pheromone trails, but useful for small food finds, is the tandem running behavior. This behavior is exhibited when a small quantity of food is found and the foraging worker enlists the aid of one other worker by giving small tastes of food. The recruited worker follows closely behind the lead worker, keeping its antenna in contact with the other's posterior abdomen (Holldobler et al., 1974).

Preliminary Activities for Students

An essential prerequisite for the trail experiment is the background study of the ant and its biology. For example, students may collect ants for anatomic and systematic study. Furthermore, the ecological niche of ants should be investigated. As an insect group, ants are extremely diverse — living in a variety of habitats and feeding as predators, herbivores, and/or scavengers. In addition, study of the social structure of ant colonies provides insight into trail communication and food-getting activities. Other possibilities include library research concerning pheromone function, production, secretion, and detection.

Locating ant colonies and conducting the study described in this article is relatively easy to do outdoors in early fall, late spring, and summer. However, for some schools and localities, outside work may be difficult. Therefore, one might endeavour to establish a colony in the laboratory which, once it stabilizes, will act fairly normally in foraging and laying down pheromone trails.

Workers, eggs, larva, and a queen can be excavated, put into a closed container and brought back to the laboratory. If ants cannot be obtained from the field, workers and a queen may be purchased from some biological supply houses, in particular, Connecticut Valley Biological Supply (P.O. Box. 326, 82 Valley Rd., Southhampton, MA 01073). Good directions for establishing an ant colony in the laboratory will be found in Ettershank (1965) and Markin (1968).

Student Materials

Minimal materials are needed for the trail experiment. Each student will need a sheet of graph paper, and each team of four students will need the following:

Meter stick (1)
Pieces of filter paper or index cards, any size (3)
Microscope slides (3)
Food substance (3 g)
Watch with a second hand (1)

Procedures

1. Locate an ant hill or colony. A good variety of ants have been reported as trail building types, including harvester, sidewalk, wood, and leaf cutter ants. Larger species are much easier to find and follow. However, I have successfully conducted the experiment with two small species of common field ants, Formica subsericea and Lasius americanus, and it is possible that most ground-dwelling species would suffice (Moody, 1981).

2. Place 1 g of food at distances of 20 cm, 40 cm, and 60 cm from the colony site. Distances of 1, 2, and 3 m may also be attempted, if time permits. Once I was able to observe a colony of very small (3 mm) F. subsericea establish a 317 cm trail.

After considerable trial and error, I believe the best system of bait deployment to be a microscope slide placed on filter paper or on an index card. The slide helps to hold the paper in place on windy days and doesn't allow greasy or oily food substances to soak through. If paper alone is used with peanut butter, for example, small ant species will congregate under the paper to consume the oil. As a result, accurate counts of the number of ants involved will be difficult to obtain.

Place the food on the entire surface of the slide to enable a larger feeding area which will accommodate greater numbers of ants. Aromatic food substances appear to attract ants more quickly than drier, more solid foods. Peanut butter and various meat or sandwich spreads are excellent. However, try combinations and/or exotic food types as well as freshly killed insects.

The size of card or filter paper is not critical. Its only purpose in the experiment is to provide a light background to enable easy counting of ants as they feed. The edges of the papers should not be an obstacle to the ants reaching the food source. On sidewalks and other flat surfaces the edges can be taped down. In uneven areas and in grass, small stakes (e.g., toothpicks) can aid in getting the paper as near to the surface as possible. Furthermore, don't hesitate to tear the paper along its edges to make it “fit” the terrain.

3. Draw a map of the study area showing the locations of the food sources and the colony.

4. Position yourself so that you do not obstruct the ants' movements, but near enough to the colony and food locations to enable continuous and accurate observations.

5. Make and record observations immediately upon establishing the sites. The time required to complete the investigation will depend upon many variables such as weather, ant species, and other factors. In my experience, within 15 minutes firm trails begin to be established and after 1 hour a steady stream of moving ants can usually be observed. However, on other occasions I have waited for as long as 3 hours before definite trails were established.

6. The data collection should also include: (a) the time of the initial discovery of each food location by the first worker to that location, (b) the time it takes to recruit subsequent workers to the food source, and (c) the time of exhaustion of the food supply from each food location.

7. Graph the recruitment of ants to each food location. Plot the arrival of the first feeding ant and then the time interval of the arrival for each group of 10 foragers at each location. The time of exhaustion of each food source can be noted on the same graph (Figure 7.2). In Figure 7.2 note the geometric increase in numbers of foragers with time. For example, at the 20 cm site, approximately 30 minutes elapsed before the tenth ant arrived and within approximately 45 minutes 30 ants had been recruited.

8. On the map of the colony site and food locations, draw in the ant trails that were established during the experiment.

9. Summarize and explain the results of the experiment.

This is about all that can be accomplished in a normal lab session, but other variables, such as food quantity and quality, could be studied in subsequent sessions or as special projects.

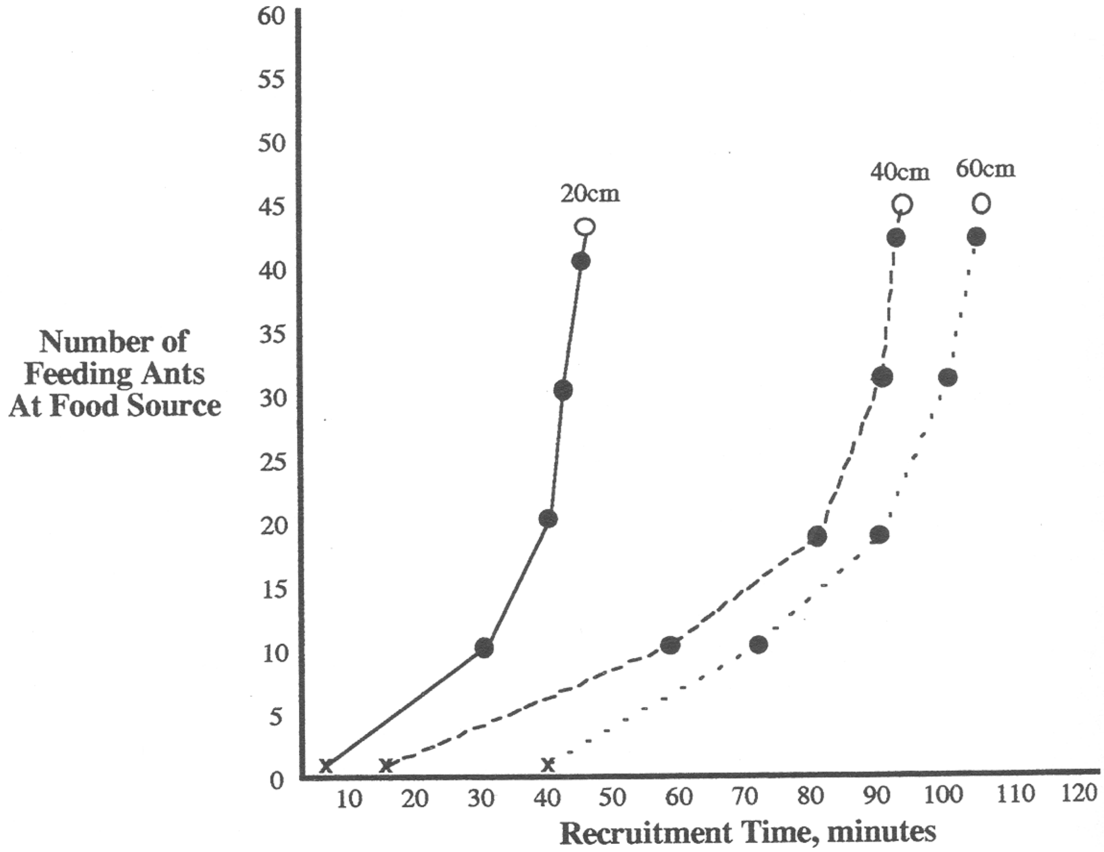

Figure 7.2. Hypothetical graph of recruitment time for groups of 10 foragers for each food source.

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