Chapter 18

An Investigation of the Behavior of the Pea Aphid, *Acyrthosiphon pisum*

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Introduction

Aphids are versatile and fascinating laboratory organisms. They are easy to obtain, easy to rear, and are at once familiar to and yet poorly understood by students. The pea aphid, *Acyrthosiphon pisum*, is a large, pale-green aphid that lives on many plants of the pea family, including the long bean, *Vicia faba*. Like most aphids, the pea aphid displays cyclical parthenogenesis. In summer, all are female, producing live young by parthenogenesis from diploid, unfertilized eggs. The newly born nymph already has embryos developing inside her. She develops to adulthood in 2 weeks and gives birth almost immediately. This combination of the telescoping of generations and a very short life cycle leads to very rapid population increases under favorable conditions.

Summer females may be winged (alate) or wingless (apterous). Production of winged females — also by parthenogenesis — may be triggered by overcrowding or by deterioration of the host plant. Winged females can disperse to start a new clone on another host plant. In fall, changing photoperiod triggers the production of sexual males and females. After mating, the sexual female lays a few large, overwintering eggs. Each egg hatches into a female nymph who serves as a fundatrix, the first individual of a new clone.

Several aspects of the aphid life cycle may be used to illustrate or investigate interesting biological concepts. For example:

1. The rapid increase in population size on a new host from a single individual can be used to demonstrate the advantages of asexual reproduction.
2. Consideration of aphid life histories may lead to a discussion of the nature of individuality. Each aphid in a clone feeds, lives, and reproduces independently. However, members of the clone do not represent genetically distinct individuals and the whole clone in some sense represents a super-individual. These ideas are discussed in papers by Addicott (1979) and Janzen (1977).
3. Variations in plant quality, population density, and photoperiod can be used to investigate the environmental factors triggering the production of winged and sexual forms. Dixon (1973, 1977, 1985), who has written extensively on aphid biology and ecology, provides useful background information for students designing investigative experiments. Mousseau and Dingle (1991) discuss the factors triggering the production of winged forms.

The laboratory exercise described in this chapter investigates the escape behavior of the pea aphid. This investigation addresses the ultimate causation of behavior (its ecological function and adaptive significance) rather than proximate causation (the environmental or internal cues triggering the behavior).

To investigate the ultimate causation of behavior, it is necessary to assess what behavior is optimal (i.e., maximizing the animal's evolutionary fitness) under particular environmental conditions. This assessment requires a consideration of the costs and benefits associated with specific behaviors. The costs of a behavior may include the energetic costs of performing the behavior, the increased risk of predation that may result from performing the behavior, and the lost opportunity to perform other behaviors. A behavior benefits an animal by increasing its survival or reproductive success.

When an aphid is attacked by a predator, for example, a ladybug larva, she releases alarm pheromone from her cornicles. This pheromone signals predation risk to nearby aphids, who may be assumed to be genetically identical to the aphid releasing the pheromone. When an aphid is exposed to alarm pheromone, she has several behavioral choices:

1. Continue to feed, displaying no response to the pheromone.
2. Continue to feed but show agitation, kicking with her legs. This may prevent a small predator from carrying out a successful attack.
3. Stop feeding and walk from the feeding site.
4. Stop feeding and drop from the plant.

The costs and benefits of each of these behaviors can be assessed. An aphid which shows no response does not pay energetic costs or sacrifice feeding opportunity. However, she does not reduce her predation risk. An aphid showing agitation pays an energetic cost and may somewhat reduce her predation risk. An aphid walking from her feeding site pays an energetic cost for her actions and does not feed until she finds a new site and reinserts her stylet. She benefits from a reduction in predation risk. An aphid dropping from the host plant must locate and climb another host plant before she can resume feeding. She risks desiccation if she cannot locate a suitable host within a few minutes. However, she is no longer at risk from the original predator. Brodsky and Barlow (1986) and Clegg and Barlow (1982) have described the escape behavior of pea aphids in response to alarm pheromone. Dill et al. (1990) and Roitberg and Myers (1978, 1979) have assessed this behavior using a cost-benefit approach.

In the experiment described below, the costs associated with pea aphid escape behavior are altered by varying the quality of the host plant. Two groups of long bean plants are available. Half the plants have been watered regularly and represent good quality hosts. The other plants have been unwatered for at least 4 days. These plants represent poor quality hosts. Two of the behaviors — walking from the feeding site and dropping from the host plant — represent a loss of feeding opportunity and carry a lower cost to aphids on poor quality host plants. The benefits of reduced predation risk associated with these behaviors remain the same on good or on poor quality hosts. Thus, aphids on poor quality host plants would be expected to walk from the feeding site or drop from the host plant with higher frequency than aphids on good quality host plants. The actual experiment takes students approximately 30 minutes to perform.