Rapid adaptation of bean beetles to a novel host

Introduction:

If individuals of a species are adapted to a particular environment, any change in the environment may lead to reduced fitness. As a result, a rapid evolutionary response to environmental changes can be advantageous. Environmental changes that might lead to an evolutionary response include changes in the local environment, changes in the global environment (e.g., global climate change), or changes in the natural range of environments that a species inhabits due to range expansion.

In phytophagous (phyto=plant, phagous=eating) insects, different species or different populations of the same species are often specific to a particular host plant species (i.e., are specialists). Therefore, a change in the availability of a particular host plant or the introduction of a new host plant may lead to a shift in the host plant used, which in turn could lead to strong natural selection for adaptation to the new host plant. Adaptation after host shift in herbivorous insects has been documented in a wide range of species (Via 1990). In some species, the evolutionary response of insects to a new host can be very rapid. For example, soapberry bugs (*Jadera haematoloma*) historically used balloon vine (*Cardiospermum corindurn*) and the soapberry tree (*Sapindus saponaria*) as their host (Carroll et al. 1997). However, in the 1950s, the goldenrain tree (*Koelreuteria elegans*) was introduced into Florida. By 1990, soapberry bugs that had switched to using goldenrain trees as a host had evolved shorter beaks. In addition, when soapberry bugs from both balloon vine and goldenrain tree were reared on goldenrain tree, those that had switched to using goldenrain trees were larger and developed more rapidly on goldenrain (Carroll et al. 1997). Similarly, in the checkerspot butterfly *Euphydryas editha*, females evolved a preference for a novel host and rejected their native host in just seven years (Singer et al. 1993).

Bean beetles (cowpea seed beetles), *Callosobruchus maculatus*, are agricultural pest insects of Africa and Asia. Females lay their eggs on the surface of beans of several species in the family Fabaceae. Although bean beetles are generalists, females prefer to lay eggs on their natal host (Messina 2004). Eggs are deposited (=oviposition) singly. Several days after oviposition, a beetle larva (maggot) burrows into the bean and cannot move from the bean on which an egg was deposited. As a result, the quality of the food resources available in a bean will influence the developing individual's growth, survival, and future reproduction (Mitchell 1975, Wasserman and Futuyma 1981). At 30°C, pupation and emergence of an adult beetle occurs 25-30 days after an egg is deposited, completing one generation of the life cycle. Adults are mature 24 - 36 hours after emergence and they do not need to feed. Adults may live for 1-2 weeks during which time mating and oviposition occurs. Because the ability to use the resources of the host bean efficiently is important in determining larval growth, survival, and future reproduction, we would expect populations to adapt rapidly to the host plant species that are available.

Materials and Methods

In class, you will be provided with live cultures of bean beetles containing adults that have been raised on mung beans (*Phaseolus aureus*), for a large number of generations and other bean beetle cultures that were originally from mung beans but were switched to adzuki beans, (*Phaseolus angularis*), or black-eye peas (*Vigna unguiculata*) about 18 generations ago.

Supplies of each bean type also will be available. Female beetles are easily identified in the live cultures because they have two dark stripes on the posterior of the abdomen, whereas the posterior abdomen of males is uniformly light in color (Figure 1).

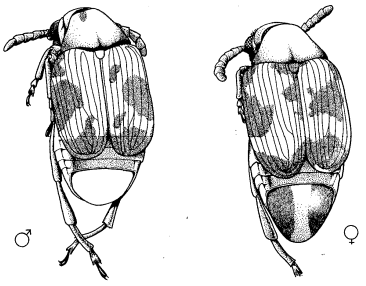

Figure 1. Dorsal view of male and female *Callosobruchus maculatus* . The sex specific coloration of the posterior abdominal plate (pygidium) is shown (Figure from Brown and Downhower, 1988).

Prior to the laboratory class, each student should design an experiment or set of experiments to address whether rapid adaptation to a novel host has occurred in the bean beetle cultures that were recently switched to a new host bean. Each individual will discuss his or her experimental design with others in a small group, and each group will present a consensus design to the class. Based on the experimental designs presented by the groups, we will discuss common experimental approaches for the entire class.

After you have read the background information and before the laboratory class meeting:

- Describe at least one experimental design for evaluating whether adaptation to a novel host species has occurred.
- Predict the outcomes for the experiment.
- List the dependent variables you would measure to determine if your predictions were true.
- Identify and list the variables you would manipulate in each experiment.
- Identify and list the variables you would keep constant in each experiment.
- Describe what comparisons between treatments you would need to make to test your predictions.

Come to class prepared to present your experimental designs. Each individual will share his or her experimental design with their group and then the group will present their consensus experimental design to rest of the class. Together, we will develop a class-consensus experimental design.

Literature Cited:

Brown, L. and J.F. Downhower. 1988. *Analyses in Behavioral Ecology: A Manual for Lab and Field*. Sinauer Associates Publishers, Sunderland, MA.

Carroll, S. P., H. Dingle, and S. P. Klassen. 1997. Genetic differentiation of fitness-associated traits among rapidly evolving populations of the soapberry bug. Evolution **51**:1182-1188.

Messina, F. J. 2004a. How labile are the egg-laying preferences of seed beetles? Ecological Entomology 29:318-326.

Mitchell, R. 1975. The evolution of oviposition tactics in the bean weevil, *Callosobruchus maculatus* F. Ecology **56**:696-702.

Singer, M. C., C. D. Thomas, and C. Parmesan. 1993. Rapid human-induced evolution of insect host associations. Nature **366**:681-683.

Via, S. 1990. Ecological genetics and host adaptation in herbivorous insects - the experimental study of evolution in natural and agricultural systems. Annual Review of Entomology **35**:421-446.

Wasserman, S.S. and D.J. Futuyma. 1981. Evolution of host plant utilization in laboratory populations of the southern cowpea weevil, *Callosobruchus maculatus* Fabrivius (Coleoptera: Bruchidae). Evolution **35**:605-617.