Research project objectives/ Research hypotheses

From the point of view of herbivorous insects, individual trees in a forest can be like islands that are isolated from other trees not by water, but by a sea of trees that they cannot feed on. The proportion of neighboring trees on which an insect can feed is then like distance to the mainland for oceanic islands, because this proportion determines the degree of isolation. Similar to isolated islands, more isolated trees are colonized by fewer insect species. More isolated trees have also been shown to suffer less insect leaf damage. In addition, isolation of individual trees may drive local adaptation in the insects. These may be adaptations to the particular genetic background of the tree (similar to the abiotic environment on an oceanic island), as well as to different levels of competition or natural enemy pressure (biotic environment). The traits of a tree to which insects adapt may include, for example, concentrations of defensive chemicals, the timing of budburst in spring, and leaf size. Isolation can affect local adaptation on individual trees in two ways: reduced exchange of genes between insect populations may permit local adaptations to persist, and less competition among insects or natural enemy pressure on more isolated trees alters the environment that exerts selection pressure on insects. While both adaptation to individual trees and large effects of isolation of trees on the insect community have been recorded, local adaptation has not been linked to the degree of isolation of trees in a forest, except in our own study on click beetles. In that study, we found that on more isolated trees, beetle species with larvae that feed on the tree itself tended to become larger, while predators were smaller. This could be because the tree-feeders had less competition and the predators less prey on more isolated trees.

Methods

In a forest, we will select 30 oak trees that vary in the extent of isolation, from oaks surrounded by other oaks, oaks surrounded by other broad-leaved species, to oaks that are surrounded by pine trees. We will compare the insect communities on these trees, and test for local adaptation using correlative and experimental studies. We will use molecular genetic tools and chemical analyses to estimate the role of genetic similarity and leaf chemistry in determining insect community similarity and adaptation to individual trees.

1) **Insect community structure**: We will place traps in the canopy of the focal trees and cut small branches from the canopy to compare the insect faunas among trees.

2) **Phenotypic responses to isolation**: We will measure traits (e.g. body size) of abundant moth and leaf miner species from the 30 oak trees. We will first determine how within-species averages of traits differ among trees that differ in isolation. To test if more host-plant specific and less dispersive insect species show more local adaptation, we will compare the within-species effects of tree isolation on insect phenotype. Furthermore, we will test if on more isolated trees, there is a better fit between particular tree and insect traits, such as fit between timing of budburst in oaks and timing of egg hatching in the winter moth.

3) **Transplant experiments on insects**: We will transplant particular leaf miner and moth species among the focal trees, and then measure performance traits (e.g. survival and growth rate). If an insect population is adapted to an individual tree, then individuals should do better on the tree of origin than on other trees. If local adaptation is more pronounced on more isolated trees, this difference in performance should be larger in populations from more isolated trees.

4) **Transplant experiments with cloned oaks**: Shoots taken from the focal trees will be used for cloning during the first year. The cloned oaks will be planted directly in the vicinity of the focal trees. The next year, we will take leaf samples of these clones to compare their leaf morphology and leaf chemistry with the tree of origin. This will provide insight into which part of the differences between focal trees are due to genetic differences, and which part is due to differences in their environments.

Expected impact of the research project on the development of science, civilization, and society

If insect populations become adapted to isolated trees in a forest, then small-scale tree diversity generates diversity within insect populations. Therefore, a reduction in tree diversity can cause a reduction in diversity within insect species, adding to the extinction cascade. Our questions may be extended to other systems, because many organisms live on or in hosts that are part of diverse assemblages, such as feather lice on birds and gut parasites in mammals. Our experimental studies will be the first in this area of research.