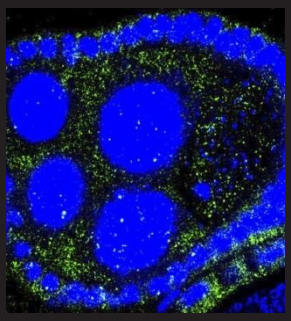
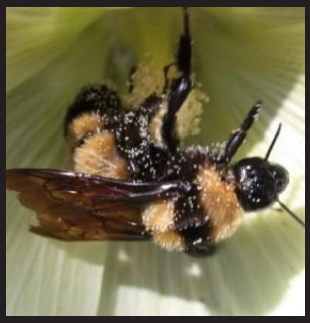
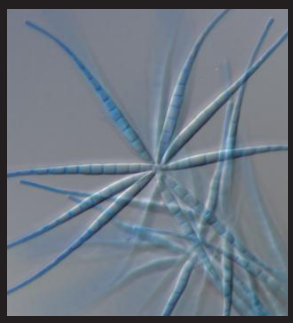




Dimensions of Biodiversity

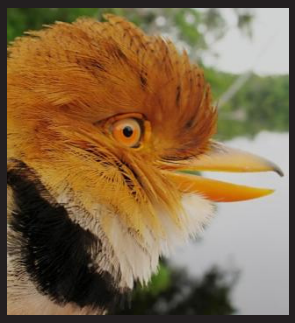







National Science Foundation
2010 – 2012 Projects










The role of taxonomic, functional, genetic, and landscape diversity in food web responses to a changing environment

Anthony R. Ives, Volker C. Radeloff, University of Wisconsin (NSF 1240804); Kerry M. Oliver, University of Georgia (1240892); Jason P. Harmon, North Dakota State University (NSF 1241031)

The project will examine how genetic, taxonomic, ecological, and landscape diversity influence the control of agricultural pests by their natural enemies.

The future of agriculture in the United States will face challenges presented by a changing climate. Our project will investigate the responses of agricultural pests and their natural enemies, as a model system to understand how food webs may respond to changing environments.

Many agricultural pests are kept in check by natural enemies – predators and parasites that suppress pest outbreaks. Promoting the success of these natural enemies is often a cost- effective and environmentally friendly approach to pest control. The changing climate, however, will shift the interactions between pests and their natural enemies in many possibly unforeseen ways. Higher temperatures might increase the population growth rates of pests (bad), or they might increase the predation rate of natural enemies (good). Climatic changes will also likely change the forces of natural selection acting on both pests and predators. The resulting evolution might increase the tolerance of pests to extreme heat events (bad), or it might lead to the greater vulnerability of pests to natural enemies (good). Given these numerous possibilities, anticipating changes to natural pest control in agricultural systems requires an understanding of the interplay between ecological and evolutionary forces in agricultural food webs. Such an understanding may also help to predict how changing environments will affect natural food webs.

Our research addresses how genetic, taxonomic, ecological, and landscape diversity affect the control of agricultural pests by natural enemies. The study will focus on three crops – corn, alfalfa, and soybean – and the group of aphid species that attacks them. Aphids are normally kept in check by roughly 20 common natural enemies. Because these natural enemies move frequently among fields and other habitats, their ability to suppress aphids depends upon the diversity of the landscape. Furthermore, aphids contain bacterial symbionts that give their insect hosts tolerance to high temperatures. These symbionts thus make it possible for aphids to evolve rapidly in response to climate changes. How widespread and important these bacterial mutualists are among aphid species, and more broadly among other herbivorous insects, are unknown. Because they represent a possible "extended genotype" of insects, these symbionts could underlie the potential for rapid evolution to different environmental changes.

Our work will integrate information at the molecular level of the interacting genomes of aphids and their symbionts, at the ecological level of changing abundances of pests and their natural enemies, and at the continental scale at which regional adaptation through evolution will occur. Therefore, we need to employ molecular genetics, ecological sampling, and remote sensing from satellites. The proposed work will not only address the basic and applied scientific challenge of anticipating the consequences of climate change for agricultural pest control. It will also educate the public by enlisting the help of citizen scientists who will sample aphids and natural enemies across the USA, bringing hands-on science into citizen's backyards.

***Above*:** The multicolored Asian ladybeetle, *Harmonia axyridis*, was introduced into North America to control aphid pests. Unfortunately, although it does control some aphid species, it is itself a pest, attacking fruit crops in fall and sometimes nipping humans. [A.R. Ives]

***Above*:** Pea aphids come in two colors controlled by a single gene, similar to eye color in humans. Because different colored lines of pea aphics contain different bacterial symbionts, we can use color as a marker to identify lines with different tolerance to high heat events. [A.R. Ives]

***Above*:** The parasitic wasp *Aphidius ervi* was also introduced to control aphids, in particular pea aphids. It attack-saphids by injecting an egg into them. The egg then hatches and eats the still living aphid from the inside out. This type of parasitic wasp was the inspiration for the movie *Alien* and its sequels. [A.R. Ives]