Insects a prime driver in plant evolution and diversity, study finds

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A caterpillar of the evening primrose moth (*Schinia florida*) devouring a flower bud of common evening primrose (*Oenothera biennis*). These moths exclusively feed on the flowers and fruits of evening primrose and in response to natural selection imposed by this and other specialist moths, evening primrose populations evolve to flower later and to produce high levels of toxic chemicals called ellagitannins in their fruits. This evolution effectively reduces damage of the plant�s reproductive organs and progeny. Credit: Marc Johnson

Take a good look around on your next nature hike. Not only are you experiencing the wonders of the outdoors – you're probably also witnessing evolution in action.

New research from the University of Toronto Mississauga (UTM) on the effect of insects on plant populations has shown that evolution can happen more quickly than was previously assumed, even over a single generation. The study is to be published in the Oct. 5 issue of *Science*.

"Scientists have long hypothesized that the interaction between plants and insects has led to much of the diversity we see among plants, including crops, but until now we had limited direct experimental evidence," says Marc Johnson, Assistant Professor in the UTM Department of Biology. "This research fills a fundamental gap in our understanding of how natural selection by insects causes evolutionary changes in plants as they adapt, and demonstrates how rapidly these changes can happen in nature."

Johnson and his collaborators from Cornell University, University of Montana and University of Turku in Finland, planted evening primrose, a typically self-fertilizing plant with genetically identical offspring, in two sets of plots. Each plot initially contained 60 plants of 18 different genotypes (plants that contain different sets of mutations).

The larvae of the seed feeding moth *Mompha brevivitella* devouring the seeds of common evening primrose (*Oenothera biennis*). The larvae of this moth exclusively feed on the fruits of evening primrose and in response to natural selection imposed by this and other moth species, evening primrose populations evolve to flower later and to produce high levels of toxic chemicals called ellagitannins in their fruits. This evolution effectively reduces damage to the plant's seeds. Credit: Marc Johnson

To test whether insects drive the evolution of plant defenses, one set of plots was kept free of insects with a regular biweekly application of insecticide over the entire study period. The other set of plots received natural levels of insects.

The plots were left to grow without other interference for five years. Each year, Johnson and his collaborators counted the number and types of plants colonizing the plots. They also analyzed the changing frequencies of the different evening primrose genotypes and the traits associated with these genotypes.

Johnson says that evolution, which is simply a change in genotype frequency over time, was observed in all plots after only a single generation. Plant populations began to diverge significantly in response to insect attack in as few as three to four generations. For instance, plants that were not treated with insecticide had increases in the frequencies of genotypes associated with higher levels of toxic chemicals in the fruits, which made them unpalatable to seed predator moths. Plants that flowered later, and thus avoided insect predators, also increased in frequency.

Johnson says the findings also show that evolution might be an important mechanism that causes changes in whole ecosystems. "As these plant populations evolve, their traits change and influence their interactions with insects and other plant species, which in turn may evolve adaptations to cope with those changes," says Johnson. "The abundance and competitiveness of the plant populations is changing. Evolution can change the ecology and the function of organisms and entire ecosystems."

Video: Anurag Agawal provides hard evidence of evolution. Credit: National Science Foundation

Additional ecological changes occurred in the plots when insects were removed. Competitor plants, such as dandelion, colonized both sets of plots but were more abundant in plots without insects. This in turn reduced the number of evening primrose plants. The dandelion used more resources and also potentially prevented light from reaching the evening primrose seeds, impacting seed germination. According to Johnson, these ecological changes were the result of the suppression of a moth caterpillar that preferred to feed on dandelion.

"What this research shows is that changes in these plant populations were not the result of genetic drift, but directly due to natural selection by insects on plants," says Johnson. "It also demonstrates how rapidly evolutionary change can occur – not over millennia, but over years, and all around us."

More information: Insect Herbivores Drive Real-Time Ecological and Evolutionary Change in Plant Populations," by A.A. Agrawal et al., *Science*, 2012.

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