Researcher shows evolution of milkweed defense system

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A monarch butterfly caterpillar gets ready to devour a milkweed leaf. Before feeding, the caterpillar disarms the plant's natural defense system by cutting the milkweed's veins that deliver a toxic and sticky latex. Credit: Anurag Agrawal

(PhysOrg.com) -- The adage that your enemies know your weaknesses best is especially true in the case of plants and predators that have co-evolved: As the predators evolve new strategies for attack, plants counter with their own unique defenses.

Milkweed is the latest example of this response, according to Cornell research suggesting that plant may be shifting away from elaborate defenses against specialized caterpillars toward a more energy-efficient approach. Genetic analysis reveals an evolutionary trend for milkweed

plants away from resisting predators to putting more effort into repairing themselves faster than caterpillars -- particularly the monarch butterfly caterpillar -- can eat them.

"An important question with co-evolution is where does it end?" said Anurag Agrawal, Cornell associate professor of ecology and evolutionary biology and lead author of a paper in the current issue of the *Proceedings of the National Academy of Sciences*. "One answer is when it becomes too costly. Some plants seem to have shifted away from resisting herbivory [plant eating] and have taken that same energy and used it to repair themselves."

The paper is important because it sheds light on key theories of co-evolution, claiming that pressure by foraging insects makes plants diversify as they evolve new defensive strategies and that such diversification follows trends in one direction or another, said Agrawal.

Milkweed species have evolved elaborate resistance strategies to fight off caterpillars that eat their leaves. These include hairs on their leaves, heart poisons called cardenolides in their tissues and milky-white toxic latex that pours from the plants' tubes. A caterpillar's bite into a milkweed leaf leads to a flood of latex that is "like getting a gallon of sticky paint thrown into your face," said Agrawal.

Some caterpillars, in turn, have adapted by shaving the leaf, cutting a leaf's veins in a circle and then eating in the middle where the latex doesn't flow. Also, the monarch caterpillar has become immune to the cardenolides.

Using DNA sequence data to look at relationships between 38 species of milkweed, Agrawal and colleague Mark Fishbein, a Portland State University biologist, found evolutionary declines in milkweed's three most important resistance traits (hairs, cardenolides and latex) and an

escalation in the plant's ability to regrow.

Agrawal was surprised, he said, to find that the plant became more tolerant rather than more diverse in its defenses. The reason, he speculated, could be because as its predators have become so specialized, the plant was better off choosing a new defensive tactic "to tolerate the herbivory damage instead of resisting it." It is unknown whether such strategies have also evolved in animals trying to evade parasites.

The findings address questions about plant evolution, biodiversity and keystone species and may give plant scientists clues about profitable pest control strategies.

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