Monarchs and milkweed: Probing the plant, pollinator partnership

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As dwindling populations of monarch butterflies prepared for their annual migration, two undergraduate students in the William & Mary Plant Ecology Lab spent their summer trying to more deeply understand the plants upon which they rely.

Melissa Hey '15 and Reilly Henson '15 both received research money from the Garden Clubs of America to examine interactions between milkweed plants and the pollinators and caterpillars that depend on them for breeding and food.

Monarch butterfly populations have declined at an alarming rate. Citing a 90-percent drop over 20 years, conservationists with the Center for Biological Diversity and others recently petitioned the U.S. Fish & Wildlife Service in late August to extend Endangered Species Act protection to the flittering monarchs.

The butterflies' Mexican wintering grounds have been increasingly logged, and American farmers in the Midwest are planting more genetically modified crops. The crops resist weed killers, allowing farmers to spray herbicides more liberally. Milkweed, the only plant on which monarchs lay their eggs, is often found at the edge of farm fields. But it can't resist the weed killers. Climate change, pesticides and sprawl are also conspiring against the monarchs, according to a release from the center.

Hey and Henson said their research isn't going to solve that crisis, but

they hope it will help by deepening the understanding of evolutionary relationships developed between milkweed and butterflies, beetles, wasps and other insects.

Even sans monarchs, milkweed is a worthy enough subject of research, as it's evolved an entire armory of defenses to ward off herbivores.

To that end, Hey spent the bulk of her summer in the greenhouse, while Henson sweated it out in the field.

'I get very protective of them'

Hey, who is majoring in biology, raised milkweed plants from seed, transplanting them in varying degrees of density in tubs in Millington Hall's greenhouse. She ordered monarch caterpillars, which arrived in late July, to place on the plants. In the wild, monarch butterflies lay eggs only on milkweed – and only one egg per plant – making the plant pivotal to their survival.

"I've been with these plants since they were seeds," she said. "I get very protective of them. So on a day when it's 95 degrees in Williamsburg, I'm up in the greenhouse all afternoon because I'm worried about whether the plants are getting enough water. I really can't have them scorched."

Hey is examining whether milkweed in dense patches reacts differently than sparse plantings to being eaten. Milkweed has three defenses to herbivory: It emits latex (the sappy white "milk" for which it is named), it grows protective hair-like structures on its stems and leaves, and it produces steroids, called cardenolides, toxic to most herbivores, but not to monarch caterpillars.

"Plants are a lot more responsive than what you may have originally

thought," Hey said. "Milkweed is a really awesome plant to study because it has so many defensive traits. Many plants don't have any of these traits. A lot of plants will exhibit one or another. But the fact that milkweed has three different ways to defend itself to herbivory is really interesting and sort of lends a lot of personality to the plants."

Hey will test plant tissue samples in the lab this fall to measure the levels of cardenolides produced under the varying densities. Much of the Garden Club of America money, plus funds from the Charles Center Honors Fellowship, went toward equipment to conduct the high-performance liquid chromatography analysis. She suspects crowded plants will produce less of the toxin because much of their energy will be used competing for water and nutrients.

"We want to find out as much as we can, especially since the monarchs are in decline," she said. "When you are looking at such a large problem, it's really hard to find the trigger," she said. "We know that the milkweeds are also in decline because of loss of habitat and various other factors … The more pieces of the puzzle we have, the better we're going to be able to put them together."

There may be no better place to conduct such research, as monarch butterflies are said to be named in honor of William of Orange, or King William III, who, along with Queen Mary II, established the College by royal charter.

Hey's research also extended beyond her own lab work, as she and Assistant Biology Professor Harmony Dalgleish of the Plant Ecology Lab donated the fresh monarch chrysalides to Walsingham Academy so elementary students could learn about their life cycle as they emerged and the students released them.

'Like watching a soap opera'

Henson , who is majoring in both biology and environmental science, also studied milkweed density, but took a different tack: She is measuring the diversity of pollinators that visit patches of varying densities.

"I wanted to do work with the relationship between animals and plants that has evolved over hundreds of millions of years, and the milkweed project offered me an opportunity to examine the relationship between insect pollinators and the plant that they've coevolved with," she said.

Although monarch butterflies do pollinate milkweeds as they draw nectar, pollination isn't their primary relationship. Monarchs mostly need milkweed as a host plant for its caterpillars. Milkweed seems to need the voracious monarchs not at all. Other insects do most of the pollination.

"My research, while it doesn't look directly at monarch butterflies, it gives us a lot of insight into the population dynamics of milkweeds that relate to pollinators. And obviously without pollinators we wouldn't have the healthy populations of milkweeds that we do see. Pollination allows a population of milkweed to be a lot more genetically diverse, and that's really important because it allows the populations to adapt, to evolve and possibly even to coevolve even further with the monarchs that are so closely entwined with these plants."

Henson spent her summer literally in the field – a field of milkweed in Yorktown—where she would stand about a meter away from a plant, counting every single insect that visited it, whether or not it was known to be a pollinator.

She also trained a high-definition camera on milkweed flower heads, or umbels, for up to 30 minutes, analyzing the footage later.

"That was a great opportunity, because it really allowed me to look

closely," she said. "Later on I could pause and I could really identify the insects that were hard to identify in the field. I watched hours and hours of footage … You really would sort of get involved, almost like watching a soap opera of these insect characters. And they would interact with each other in interesting ways."

Henson has not yet completed her study, but said she ended the summer with the impression that a few species – namely eastern carpenter bees and soldier beetles – did the lion's share of pollination regardless of milkweed density.

"It's also important to maintain diversity in the insect pollinator realm so that if there were to be a species of pollinator that had a bad year or suddenly started doing poorly, you would still have other insects that would pick up the slack and continue to pollinate.

"That's important to relate to density because if we have populations of milkweed that become less dense and that leads to less pollinator diversity, the risk that one of those pollinators will have a bad year or will stop pollinating as well is a lot higher."

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