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Bugs with Benefits

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Peter and Jacques: Bugs with Benefits
Insects outnumber humans by more than a billion to one. They buzz, creep and crawl into nearly every facet of human life. Kansas State University researchers have given these curious creatures the benefit of the doubt and found they can help people in many ways.

Entomology professor James Nechols, who has studied biological control of pests for more than 30 years, said it’s hard to name just a few of the most beneficial insects because there are so many.

Beneficial insects, or “beneficials” as he calls them, fall into five categories: pollinators that help fertilize plants; predatory and parasitic insects that kill other insect pests; weed-eating insects; scavengers and decomposers that feed on dead animals or plants and help break down nutrients to support plant growth; and those that are part of the food chain — in other words, a lot of creepy crawlies.

“There are thousands, if not millions, of insect species that are part of the food chain, and that alone is a benefit to humans,” Nechols said.

Whether people like them, ignore them or squish them, insects are unavoidable. Better understanding of beneficials through research can help us increase the odds of harnessing them to help battle pests, pollinate crops and even comprehend genetics to lead to better medicines.
Eating the enemy

Nechols and his K-State entomology colleagues, Brian McCornack, John Ruberson and J.P. Michaud, plus many others, are examining biological control of plant pests, or controlling insect pests with other insects — beneficial insects, that is.

Insect and weed pests destroy millions of acres of crops each year, putting a huge dent into a farmer’s bottom line and ultimately raising food and feed production costs. To combat the problem, pesticides have been developed to kill the pests. But pesticides entail both financial and environmental costs.

“Nature has its own predators and parasites that can take care of a significant number of the pest insects plus other pests, such as weeds,” Nechols said. “Farmers wouldn’t have to spend as much money on pest control if they could take advantage of what is available for free. But often pest controls — especially pesticides — kill beneficial insects that provide biological control as well as pollinators.”

The total estimated global potential loss from all biological pests in crops, including insects and weeds, varied from about 50 percent in wheat to more than 80 percent in cotton production, according to a 2006 research paper, “Crop losses to pests,” in the Journal of Agricultural Science. The responses were estimated as losses of 26 to 29 percent for soybean, wheat and cotton, and 31, 37 and 40 percent for corn, rice and potatoes, respectively.

Using non-pesticide options like biological controls as an alternative has many benefits.

“It reduces the likelihood that pests will develop a tolerance to pesticides, which results in ineffective chemical control,” Nechols said. “It is safer for the environment, and it is sometimes the only feasible economical way to control pests — especially invasive species that occupy thousands or millions of acres of land.”

In his own work, Nechols has studied the use of beneficials to combat the invasive Russian wheat aphid and has evaluated using biological control for squash bugs, an important pest in pumpkins and squash. Because not all pests are found in farm fields, some of Nechols’ research has focused on the best ways to control spider mites and thrips using predators in greenhouses.

“There are no biological controls in a greenhouse, so we looked at the best timing and most efficient distribution methods for releasing predators that can be purchased by producers,” Nechols said. “Knowing the right number of predators to order also is important because it’s possible to get too many or too few, which either wastes money or results in poor control.”

K-State Research and Extension entomology specialist Jeff Whitworth works with farmers every day to find the best ways to minimize damage to crops from insect pests. Extension specialists like Whitworth are a conduit, taking the knowledge gained through research and connecting it with real-life, everyday situations for Kansans.

“Aphids can be the bane of farmers and gardeners,” said Whitworth, who added that aphids are also called “plant lice.” Where you find aphids, you’ll also find other insects that feed on them, making these species beneficial insects. The insect that inspired a nickname for the VW bug, the lady bug — also called a lady beetle — is a beneficial insect that preys on aphids, many of which are harmful to vegetable and other crops, such as corn and soybeans.

“Whenever we have a lot of aphids in a field, we always see more lady beetles,” Whitworth said.

A recent aphid threat in grain sorghum is the sugarcane aphid, which was first detected in Kansas just three years ago. Kansas is the top sorghum-growing state in the country. McCornack, Michaud and a team of researchers are investigating controlling sugarcane aphids with lady beetles.

Another dainty-sounding insect whose name belies its predatory ways is the common lacewing, whose larvae, and sometimes adults, also feed on aphids.
Lacewings can eat a significant number — more than 100 — of aphids a week plus several other pest insects species,” Whitworth said.

With a quick stab of its mouthparts, another insect called the assassin bug can kill aphids and much larger insects. Although they are an asset to farmers and gardeners, assassin bugs also can deliver a painful bite to humans. Wasps, ground beetles and minute pirate bugs — also called flower bugs — are examples of other beneficials. But despite their large numbers, beneficials’ efforts often go unnoticed.

“Biological control is often unseen in the field and therefore underestimated,” Nechols said. “Most of the benefits we get from beneficial insects are undervalued because people aren’t aware of how many there are or how much of a factor they can be in controlling other pests.”

Nechols pursues two goals in his research. The first is to more efficiently and economically control field pests by protecting and taking advantage of free, natural biological control. The second is to promote and protect pollinators essential to the food supply. He and other scientists use methods known as integrated pest management to make farmers and ranchers aware of beneficials and help protect agricultural crops without harming natural biological controls and pollinators.

“Some people say there’s no good insect but a dead insect, but up to 97 percent of insects are beneficial to the environment in one or more ways,” Nechols said.

**The bee’s knees**

Entomology doctoral student Shelly Wiggam, working with McCornack and Greg Zolnerowich, professor of entomology, is researching the effects of various rangeland management practices on essential habitat and floral resources of native pollinators. She surveys native bee and butterfly communities on privately owned cattle ranches in the southern Great Plains.

One way to track the bees is by placing tiny radio transmitters on bumblebee queens. Wiggam is tracking the queen bees throughout the Flint Hills and Red Hills of Kansas to help ranchers implement land management practices that help these beneficial insects while potentially increasing profits.

“The research I’m conducting throughout Kansas and the Great Plains on private working ranches has never been done before,” Wiggam said. “My research focuses on how
to conserve and restore native pollinators on for-profit cattle ranches in native grassland systems while maintaining landowner profitability and operation functionality.”

Each of the bumblebee transmitters — complete with a tiny battery, circuit board and antenna — that Wiggam places on the queen bees weighs 0.2 grams. Wiggam — who is actually allergic to bee stings — attaches the transmitter and places the bee back on the plant where she caught it to see where it goes next.

Nechols said Wiggam’s work is important for Kansans. Researchers have many unanswered questions about native wild bees’ roles as pollinators — especially considering the rapid global decline of wild native bees and butterflies in recent decades, he said.

Wiggam said that landowners can manage their ranches to benefit pollinators and maintain profitability by using patch-burn grazing, where burning and grazing are less uniform, allowing some areas of a pasture to rest. The practice creates greater habitat structure and plant diversity, which supports increased native pollinator diversity. Wiggam found three times the number of native bee species and two times the number of butterfly species in patch-burn grazing pastures compared to traditionally managed pastures.

“The queens of some of our most threatened bumblebee species in North America prefer patch-burn grazing pastures at much higher rates and are more successful than in traditionally managed pastures,” Wiggam said.

“Queens use each part of a patch-burn grazing pasture for a different purpose to complete different aspects of their life cycle, which all creates a successful nest that supports the production of worker, drones and queen bees all growing season long.”

In addition to mimicking the Great Plains ecosystem before European settlement, patch-burn grazing has also been shown to maintain or increase profitability and herd sustainability through livestock gain and reproductive success.

**Bug of a different color**

Susan Brown, university distinguished professor of biology, is taking one of farmers’ and homemakers’ most hated adversaries away from crops and pantries and into the lab. Her life’s work has centered on developing the red flour beetle, a pest that feeds on flour and dry cereals, as a model organism for developmental biology.

Model organisms like the beetle — the fourth insect to have its genome sequenced thanks to Brown and her collaborators’ work in 2008 — are intensively studied to understand how biological factors work and are an example for other organisms or systems. The flour beetle can help scientists like Brown understand genetics and developmental biology, which is necessary to develop gene-targeting medicines and pest control.

“The biggest benefit of studying the beetle is the power of genetic analysis,” Brown said. “All good model systems have a few things in common. You need something that is small, grows really fast, has a short lifecycle and has a lot of progeny. Then you can do genetics.”

The beetle’s ability to survive in home flour containers and cereal boxes can be exploited in a laboratory to benefit scientific discovery — making what would be a pest in the wild into a beneficial bug. If scientists can understand basic biology of model organisms, then they can apply that information to help people by developing pest management strategies.

“Anytime you can understand the physiology of the organism, you can find targets to fight it, to control it, to manage it,” Brown said. “You want that whether it’s a vector of a disease, a vector of a plant pathogen or just destructive in its own right.”

The beetle can be compared to the fruit fly — the rival model organism also commonly used for genetics research and the first insect to have its genome sequenced.

“The reason we worked on the beetle was because it was still an insect but it looked very, very different than a fruit fly,” Brown said. “We wanted to know how developmental mechanisms work and how the beetle looks and develops so differently than the way a fruit fly develops.”

Brown keeps about 30 different strains of beetles in jars with plenty to eat — pesticide-free flour from a nearby natural grocery store — and uses them as a teaching tool. They have helped researchers see that the beetle has more similarities to humans than the fruit fly, which makes the beetle even more important to understanding human genetics.

K-State’s lab-pampered beetles offered a way for Brown and her colleagues to develop genetic maps and molecular tools to see a beetle’s genes in action. After they had the genome sequence, Brown started
using RNA interference, or RNAi, as a tool to study gene function during the beetle’s growth from egg to adult. These tools have helped scientists with understanding development and controlling diseases and pests using the information in the genome — an organism’s entire genetic system.

“Everything that scientists are doing now is moving more and more toward precision medicine, which requires an understanding of an individual’s genome,” Brown said. Brown used RNAi to look at the development of the beetle’s segmentation into head, thorax and abdomen, which happens in waves. This is opposite of the way that the fruit fly develops — all at once — and more like humans, who gradually develop segments, or vertebrae, also in waves.

“Basically, all the things that you need to understand the insect genome are the same things that you need to understand the human genome,” Brown said. “Our research with the beetle gives a basic understanding of the evolution of developmental mechanisms, embryogenesis and gene networks.”

This research has helped Brown organize a fight against another pest: the Asian citrus psyllid. The tiny tree sap-sucking bug carries bacteria that cause citrus greening disease, which has decimated groves of citrus trees in Florida and is now threatening citrus trees in Texas and California. Brown and her colleagues are in the beginning stages of a study supported by a $6 million grant from the U.S. Department of Agriculture to help fight the problem.

“If we do the basic biology on the insects, that will give us targets that might aid in insect control or keep them from spreading the bacterium from tree to tree,” Brown said. “We are targeting things that will either block the psyllid’s ability to transmit or take up the bacterium. Anything that we look at to kill the bacterium in the insect can also be tried to kill the bacterium in the tree.”

Top: The red flour beetle, a food systems pest in the wild, is tiny and resilient — qualities that make it a great model system for beneficial laboratory genetics research.

Bottom left: Susan Brown, left, and her research assistant, Michelle Coleman, count live verses dead flour beetles.

Bottom right: Brown’s beetles are kept in jars in the lab and feed on organic flour.