Secrets of Butterfly Wings

BY TOMMY NEWTON

WHEN JEFFREY MARCUS LOOKS AT THE WINGS OF A BUTTERFLY, HE'S LOOKING AT MORE THAN JUST THE PATTERNS, SHAPES, OR COLORS. HE'S LOOKING AT ITS GENETIC MAKEUP AND CELL TO CELL COMMUNICATION.

And, as the Western Kentucky University biology faculty member has learned, the color patterns on butterfly wings are important to more than just the butterfly. The genetic pathway involved in determining the size, shape, or location of the wing patterns also plays a role in tumor growth in the human colon.

Dr. Marcus is receiving funding from the National Institutes of Health to continue his research. What he learns over the next few years may provide cancer researchers with additional information on how tumors form in the colon and may provide better options for treatments or medical care.

"What I do is I look at how genes are regulated, how they're turned on and off so that the patterns of gene expression can define different aspects of the color patterns in the wings of a butterfly," said Marcus, who has been at WKU since 2003.

Marcus has been conducting his genetic research for a number of years. He spent six years at Duke University (where he received his doctorate) and one year as a post-doctoral researcher at the State University of New York at Buffalo before coming to WKU.

"I got into this work because the patterns on butterfly wings very clearly play roles in the ecology of these organisms," he said. "Some patterns clearly play a role

Jeffrey Marcus

Photo by LaDonna Harmon

The genetic pathway involved in determining the size, shape, or location of butterfly wing patterns may provide information about how tumors grow in the human colon.

in camouflage. Other patterns are used for warning colorations or for advertising that 'I am a poisonous animal, don't eat me.' Other patterns have a clear role in thermal regulation so the insect doesn't get too hot in the sun and die. A lot of white butterflies are white because they reflect solar radiation. Patterns also are involved in mate selection."

In the wings, a particular set of genes is involved in cell to cell communication, which can create certain color patterns. The cell communication wasn't surprising, Marcus said. "What is a little bit surprising is that this genetic pathway that allows these cells to communicate is actually the same genetic pathway that regulates cell division in the human colon," he said.

a jellyfish and introduced it into butterflies. What we got were butterflies that had eyes that glowed under certain illumination. That experiment was sort of a proof of principle experiment. Now we're modifying these techniques. We can go in and take our green fluorescent gene and interrupt butterfly genes with it."

Third: Marcus and his students are looking at how genes already present in the butterfly work in developing the wing. "We're interested in how these colors have changed over time and if there are groups of butterflies that share certain types of color characteristics. There may be some opportunities to use that information to learn more about the mechanism by which these patterns are produced."

I took a gene that encodes a fluorescent green protein from a jellyfish and introduced it into butterflies. What we got were butterflies that had eyes that glowed under certain illumination.

Mangrove Buckeye Butterfly

Buckeye Butterfly

Luna Moth

Tiger Swallowtail Caterpillar

If that genetic pathway goes haywire in a butterfly, it may change the size, shape or location of pattern, but if the pathway goes haywire in the human colon, you wind up with tumor growth, Marcus said. About eighty percent of inherited colon cancers seem to involve mutations in this one particular path, he added.

For his NIH-funded project, Marcus is looking to make new mutations in the butterfly to alter the set of color patterns. The project has several stages:

First: Marcus and the WKU students working with him will create a genetic map of the butterflies and look at variations in DNA. He's primarily working on the common buckeye butterfly and hybridizing it with a species from Florida called the mangrove buckeye butterfly.

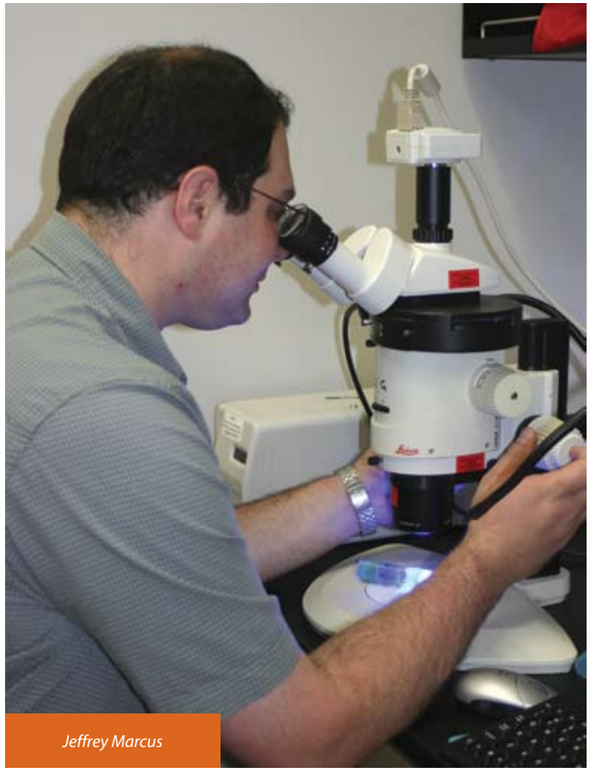
Second: Marcus is continuing his research to develop techniques to introduce new genes into butterflies.

"Right before I came to Western, I was the first person ever to introduce new genes into a butterfly," he said. "I took a gene that encodes a fluorescent green protein from

Fourth: The research isn't limited to butterflies. Marcus also conducts genetic studies on moths and fruit flies. Some of the fruit fly research parallels the butterfly work, "but fruit flies have a charisma problem," he said.

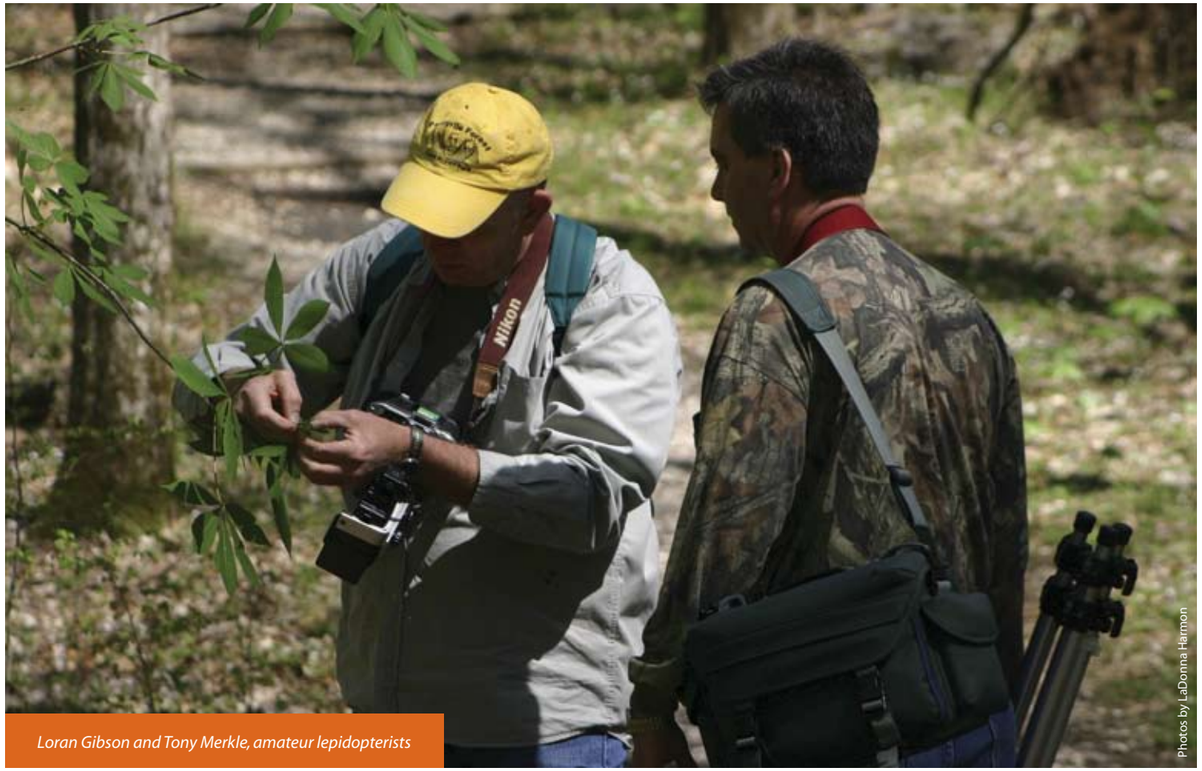
In one project, he's looking at gene expression in the wings of luna moths. "My research so far seems to indicate they're using the same genes that butterflies use to make these color patterns, but they're using them in some unusual ways," he said. "As I put the pieces together, I can make some interesting comparisons of what's going on with moths and with butterflies."

Another project is a study of the signaling system in fruit fly wings. Marcus and Travis Evans, a senior undergraduate from Orlando, Florida, are looking at how the cells communicate with each other to organize themselves and build wing structures. Fruit fly wings don't have color patterns so the research focuses on interactions of cell signaling pathways in a wing vein that is important in determining flexibility.



Jeffrey Marcus

Monarch Butterflies



Loran Gibson and Tony Merkle, amateur lepidopterists

"As we find new genes in that system, we can actually also look and see what's going on in butterflies with the same genes. Once we identify what a gene is, we can look at it in all sorts of different organisms. These things interface at a number of different levels."

Dr. Marcus also finds satisfaction in working with WKU students. In the fall of 2004, he had five students working with him and had seven in the spring of 2005. "Without students, it would be just me doing the work," he said. "I've been fortunate in that I've had a number of terrific students."

Student assistance isn't limited to the laboratory in the new Complex for Engineering and Biological Sciences. Students travel to Florida to collect samples and they help out in butterfly and moth surveys at the Upper Green River Biological Preserve.

In 2004 at the 671-acre preserve, Marcus and his group identified sixty-two species of moths and forty-seven species of butterflies, including some rare species. The group, which also includes members of the Society of Kentucky Lepidopterists, expects to find even more species in 2005.

"Knowing what's out there, knowing what it looks like, knowing where to find it is very important," Marcus said.

Survey work is important as WKU scientists restore the preserve's natural habitat. Marcus also has been asked to assist Mammoth Cave National Park with an insect survey.

The buckeye butterfly used for his research is among the species found at the Upper Green River Biological Preserve. "What's really great about becoming familiar with the diversity of butterflies and moths that are out there is that the patterns found on the buckeye butterfly are different from patterns on the swallowtail and monarch," he said. "If we become interested in a certain pattern, we can find it and look at gene expression in that species."

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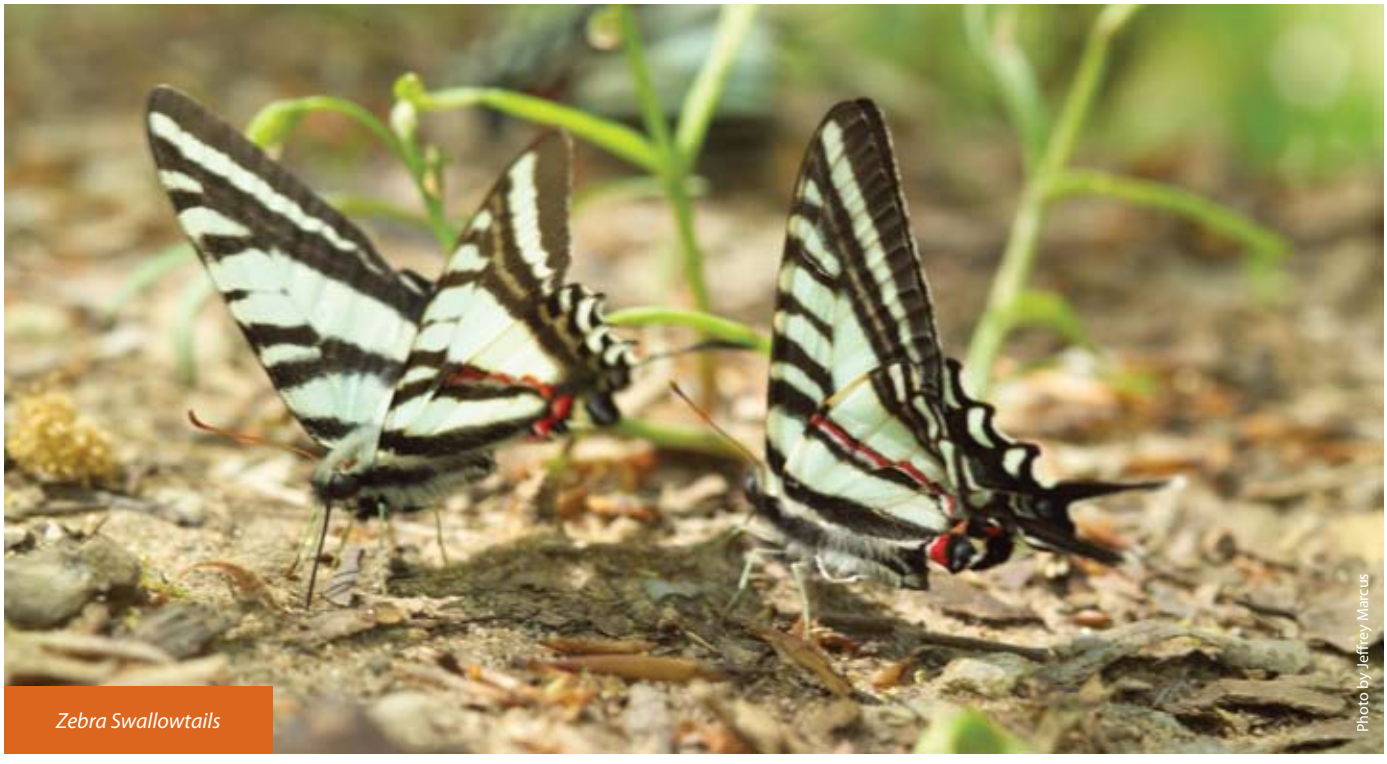
For example, Marcus shows a photograph of a three-inch green caterpillar. Spots on the caterpillar make it look like eyes on a green snake. "We know a lot about how patterns like this are made on the wings of adult butterflies but we know nothing about how patterns like this are made on larval butterflies," he said.

And, as his NIH-funded work continues over the next five years, Dr. Marcus might find more clues about how the wing patterns play a role in colon cancer. "I've been really excited about what we've been able to do so far," he said.



Zebra Swallowtails

Photo by Jeffrey Marcus