Vidi for butterflies' sense of taste

Cabbage whites only eat and lay eggs on plants that produce glucosinolates. But the green-veined white is an exception. This butterfly has learned to use wallflowers (Erysimum) as a host plant. That is surprising, as it is a plant that produces not only glucosinolates but also toxins that can be fatal to the butterfly. Text Roelof Kleis

The group of organic compounds in question are the cardenolides. The wallflower produces them to protect itself against insects. Caterpillars of the large white and small white would rather starve to death than feed on the wallflower. So how did the green-veined white acquire its taste for this plant? Alexander Haverkamp has secured a Vidi grant to find out.

'Tasty' and 'poisonous'

Haverkamp, an entomologist, has a theory, of course. He thinks a mutation in the butterfly's taste processes is responsible for this major change. 'Caterpillars have neurons (nerve cells) that indicate "tasty" and "poisonous". I think a mutation in this cabbage white turned that back to front.' Taste neurons detect chemical compounds when receptors (proteins) on the cell's surface bind with substances. Haverkamp thinks that in the case of the green-veined white, the 'wrong' receptor proteins are expressed. The neuron that signals 'tasty' actually binds the toxin. Butterflies taste with their forelegs rather than their mouths. 'A butterfly at rest usually has its forelegs pressed against its body. Butterflies don't use those legs to stand on, they use them for tasting. Caterpillars taste things via four hairs that protrude when they open their mouths.' But why would this cabbage white fool itself like this? 'Cardenolides may be toxic, but they aren't hugely toxic,' says Haverkamp. 'Three-quarters of the caterpillars on the plant survive.' And that downside is offset by a big plus: 'You have the plant entirely to yourself.'

Rewiring

Natural selection does the rest. Over the course of time, the butterfly evolved to become immune. The first step in that process was to rewire the detection process. That is the theory. 'Essentially, a kind of mutation took place in the butterfly's perception. This project will investigate whether that change in the taste perception could have been the first step in the evolutionary process.'

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Haverkamp will use CRISPR-Cas technology to switch the expression of receptors in the neurons on or off. 'We will look at what the taste neurons do then and see if that's the same in both the caterpillar and the imago. Then we will apply the same change in other cabbage whites to see whether that really was the decisive step in the adaptation to the wallflower.'
'We are basically investigating how the taste process works at the neurobiological level,' says Haverkamp. 'How do plant-eating insects choose between different plants? Ultimately, we want to know what the deciding factor is in explaining why an insect eats a particular crop. Perhaps we could even change that decision process.'

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The Vidi grant Haverkamp was awarded for this research is worth 850,000 euros. That will let him take on two PhD candidates and a postdoc. Six other WUR researchers received Vidi grants from the Dutch Research Council in the latest round in addition to Haverkamp.