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Too much of a good thing: excess nitrogen makes plants more toxic to monarchs

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If you have ever taken vitamins or other dietary supplements, you probably have followed the dose specifications on the label. Even nutrients that promote health at moderate doses can be bad for us at high doses. The same is true for other animals, including the caterpillars that feed on plants. For example, plant tissues are especially low in nitrogen in comparison to animal tissues and caterpillar performance and abundance often increase when plant nitrogen concentrations are high. However, can caterpillars ever suffer from eating too much nitrogen?

In our study, we found that monarch butterflies, *Danaus plexippus,* grow more slowly when the nitrogen concentrations in their milkweed host plants get too high. The reason for this negative effect of nitrogen was a surprise. When milkweed plants have too much nitrogen, monarch caterpillars are negatively affected by cardenolides, which are toxic chemicals that occur in milkweed plants. At low and medium nitrogen levels, monarchs are able to minimize the deleterious effects of cardenolide toxins. But when nitrogen levels get too high, each gram of cardenolide becomes increasingly toxic to monarchs.

Our results show that the components of animal diets interact with one another to determine the overall quality of food for consumers. "Good food" is not simply measured by the sum of the individual components in the diet, but rather how those components interact with one another. Even nutrients that are beneficial to health when consumed on their own can prove to be bad for us in combination with other chemicals in the diet.

Monarch butterfly caterpillar. Photo provided by authors.

And human activities may be making life more difficult for animals that eat plants. As a result of making fertilizers and burning fuel, humans are adding large amounts of nitrogen to ecosystems. Over time, that added nitrogen might make other dietary components more toxic.