Functional Ecology

BRITISH ECOLOGICAL SOCIETY

Phytochemical changes in milkweed induced by elevated CO_2 alter wing morphology but not toxin sequestration in monarch butterflies

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Environmental change has the potential to influence ecological interactions by altering the defensive physiology, morphology and behavior of prey. Certain drivers of environmental change may alter the chemistry of plants which, in turn, can affect the chemical defenses and morphological development of herbivores.

We examined the effects of a pervasive environmental change driver, elevated atmospheric concentrations of CO_2, on toxin sequestration and wing morphology of a specialist herbivore. We fed caterpillars of monarch butterflies, *Danaus plexippus*, foliage from four milkweed, *Asclepias*, species of varying chemical defense profiles grown under either ambient or elevated CO_2. We also infected a subset of these herbivores with a parasite, *Ophryocystis elektroscirrha*, to understand how infection and environmental change combine to alter herbivore defenses. We measured alterations in plant chemistry induced by elevated CO_2 and assessed the subsequent toxin sequestration and wing morphology of adult butterflies.

Monarchs compensated for lower plant toxin concentrations under elevated CO_2 by increasing toxin sequestration rate. As a result, monarchs maintained the same composition and concentrations of toxic cardenolides in their wings under the two CO_2 treatments. Monarch wing shapes were more suitable for sustained flight (more elongated) when caterpillars were reared on plants grown under

Monarch butterfly on Asclepias syriaca flower. Photo Credit: Leslie Decker

elevated CO_2 or when caterpillars were reared on *A. syriaca* or *A. incarnata*. Parasite infection engendered wings less suitable for sustained flight (wings became rounder) on three of four milkweed species. Wing loading (associated with powered flight) was higher in monarchs fed *A. syriaca*, whereas wing density was lower on *A. curassavica*. Overall, monarchs that fed on high cardenolide milkweed developed rounder, thinner wings, which are less efficient at gliding flight.

Ingesting foliage from milkweed high in toxins may provide protection from enemies through sequestration yet come at a cost to monarchs manifested as lower quality flight morphology: rounder, thinner wings with lower wing loading values. Small changes in morphology may have important consequences for enemy escape and migration success in many animals.