TITLE: Indirect effects of microclimate on plant reproductive performance via an antagonistic interaction

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ABSTRACT

Climatic variation can influence plant reproduction directly, but also via changes in plant traits, interactions with animals, and the surrounding environment. Such indirect effects can often be complex and involve multiple steps. While the joint effects of climatic variation and indirect effects in terms of plant-animal interactions have sometimes been assessed at larger spatial scales, little is known about how microclimatic variation affects within-population variation in reproductive performance. Here, we studied the direct and indirect effects of microclimate on reproductive performance of the plant *Gentiana pneumonanthe* in presence of the butterfly seed predator *Phengaris alcon*. We found that microclimatic effects on plant performance were mainly indirect. The number of seeds per flower of *G. pneumonanthe* decreased in warm microsites, and this effect was mediated by increased seed predation by *P. alcon*. The effect of soil temperature was particularly pronounced in sites with high soil moisture. Effects of soil temperature and moisture on the incidence of predation and plant performance were also mediated by effects on plant phenology, density and phenology of neighboring host plants and host ant abundance. Plants that flowered earlier and where host ants were more abundant, and plants surrounded by fewer and later-flowering neighbors, produced fewer seeds per flower because of a higher incidence of predation. Our results demonstrate that effects of microclimatic variation on plant reproductive performance are mostly indirect and largely mediated by species interactions. These findings highlight that among-individual variation in small-scale environmental conditions within populations can cause variation in individual plant performance through multiple pathways.

KEYWORDS: micro-climatic variation, plant reproduction, plant-animal interactions, butterflies, *Myrmica*, environmental variation, environmental context

DECLARATIONS

- Author contributions: A.V. and J.E. designed the study. A.V. collected the data. A.V. analyzed the data with inputs from J.E. A.V. and J.E. wrote the manuscript. Both authors gave final approval for publication.

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