

Precise Manipulation Through a Modeling Study

Editorial Preface (Papers by M.E. Puente, G.G. Kennedy, F. Gould, and K. Magori)

Marcel Dicke

Published online: 2 May 2008
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Organisms are characterized by a suite of characteristics that collectively constitute a phenotype. Interactions with the biotic and abiotic environment result in modifications of the phenotype, and consequently in modifications of the interactions of the individual with community members. Chemical ecologists have a keen interest in the information component of phenotypes. They unravel the mechanisms that underlie phenotypic changes in terms of the emission of information-conveying chemicals and the ecological consequences of such phenotypic changes. For instance, feeding by a pierid caterpillar on a brassicaceous plant results in the production of a complex bouquet of volatiles that include fatty-acid-derived compounds, terpenoids, and glucosinolate-derived compounds (Geervliet et al. 1997). The induced volatiles can evoke a range of behavioral responses. They result not only in the attraction of parasitic wasps that attack the caterpillars (Scascighini et al. 2005), but also in the attraction of *Plutella xylostella* moths for whom the *Pieris*-infested plant provides enemy-free space (Shiojiri et al. 2002).

Induced phenotypic changes allow organisms to adjust to local conditions. However, this requires that an individual perceives environmental changes and responds to them at a speed that results in timely phenotypic change. The expression of phenotypic plasticity is usually thought to be an indication of costs related to the expressed characteristics, either in terms of energy or in terms of ecology (Agrawal 2001). The ecology of herbivore-induced plant volatiles (HIPV) has shown a rapid development since the

late 1980s (Dicke and Sabelis 1988; Turlings et al. 1990). In the past decade, molecular genetic tools have been embraced by students in this field (Van Poecke and Dicke 2002; Kessler et al. 2004; Halitschke et al. 2008). In doing so, certain characteristics could be eliminated from or enhanced in plants with a chirurgic precision at the level of individual genes. This approach has allowed us to study individuals that had been modified in the expression of individual genes, usually in a digital method where the gene of interest was knocked out or silenced or where the expression of the gene of interest was enhanced. These methods have revolutionized the field of insect–plant ecology (Dicke et al. 2004; Kessler et al. 2004). They allow the investigation of the effects of individual characteristics on species interactions as well as community dynamics.

Apart from molecular genetical tools, mathematical modeling is another powerful tool that allows researchers to investigate the effects of individual characteristics on species interactions. If sufficient knowledge about a system has been gathered to develop an adequate model, the model parameters may be modified to assess their effects on species interactions. Within the field of chemical ecology, modeling has not been a tool that has been exploited frequently (but see e.g., Vos et al. 2001; Kobayashi et al. 2006). Analytical tools have mainly dominated the field. The following two papers by Puente and colleagues have taken a detailed modeling approach to the study of herbivore-induced parasitoid attraction. They especially address the temporal and spatial aspects of plant–parasitoid interactions through HIPV. Timing of HIPV emission relative to herbivore presence is likely to be important, as it determines the reliability of the cues. The induction dynamics of volatile emission vary with the type of volatiles and their biosynthesis. However, after herbivores have been eliminated, continuation of the emission is no

M. Dicke (✉)
Laboratory of Entomology, Wageningen University,
P.O. Box, 8031, 6700 EH Wageningen, The Netherlands
e-mail: marcel.dicke@wur.nl

longer needed for the plant, and if the emission continues, this is likely to devalue the volatiles as a signal to carnivorous arthropods. In the research field of HIPV, more attention has been paid to the induction of volatiles (Scascighini et al. 2005; Maffei et al. 2007) than to the relaxation of their production and emission (Fatouros et al. 2005). To investigate the effects of genetic variation in parasitoids, fewer tools are available at present. Although this may change with the rapid development of molecular genetic tools for parasitoids, at present a modeling approach is one of the few options.

In their papers, Puente and colleagues take a behavioral ecological approach to the role of HIPV in plant–parasitoid interactions. In doing so they modify characteristics of the emission dynamics as well as the response characteristics of parasitoids. This results in an interesting approach that yields new insight into the role of HIPV in the foraging success of parasitoids and in the success with which plants improve the effectiveness of herbivore attack by parasitoids. In this manner, they can modify the dynamics of HIPV signaling in ways that molecular geneticists can only dream of. For instance, Puente et al. (2008a, b) can investigate the effect of the time interval between herbivore attack and HIPV emission by comparing five plant types that differ in the induction delay in a linear manner. Their approach results in new hypotheses that can be investigated through an experimental approach. This approach is a valuable, yet not often employed, tool to chemical ecologists that complements analytical, molecular genetic, and behavioral approaches.

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