IMPRS Exploration of Ecological Interactions with Molecular and Chemical Techniques

Project no 8

"Chemical defense strategies of plants and evasion strategies of feeding insects – A systems biology approach"

Supervisors:
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Background: In plant-herbivore interactions, plants frequently produce toxic defense compounds, while insect herbivores frequently develop counter-defenses. But, what is the best strategy for each side going forward? Should a plant make more defenses once a herbivore has counter-defenses or develop a different strategy? How should an insect herbivore respond? Theoretical systems biology can provide a unique approach to understand and manipulate such interactions (Dühring et al., *Front. Microbiol*. 6, 2015, 625). We will use these methods to investigate defenses and counter-defenses in Brassicaceae plants that protect themselves from insect herbivores with glucosinolates, also known as mustard oil glucosides (Mumm et al., *J Chem Ecol.*, 2008, 34: 1311-1321).

Project Description: We will investigate under which conditions it pays for a plant to establish a counter-counter defense rather than to intensify or widen existing defense mechanisms. Mathematical models (e.g. differential equations, agent-based modeling, or Game Theory) describing the interaction between Brassicaceae and herbivorous insects will be developed. Based on computer simulation of these models and experimental results, we will gain insight into the coevolution and ecology of plants and insects. The project should also have applications in crop protection.

The project is subdivided into the following four work packages (WPs):
WP1: Delineation of various defense and evasion mechanisms of plants and insects at various levels. Developing mathematical models for selected interactions, which will be refined in an iterative cycle experiment-theory-experiment.
WP2: Computer simulations and analyses of the models established in WP1.
WP3: Experimental measurement of quantities characterizing the defense and evasion mechanisms analysed in WP1.
WP4: Based on WP2 and WP3, validation and refinement of the models established in WP1. Planning of new targeted experiments for WP3.

Collaborations: Günter Theißen (Jena University), Thomas Dandekar (Würzburg University)

Candidate profile: Master in bioinformatics, mathematics, computer science, biology or biochemistry; interest for, and preferably basic skills in computer and mathematical methods describing biological processes and experimental techniques of chemical ecology.