IMPRS CHEMICAL COMMUNICATION IN ECOLOGICAL SYSTEMS

Application Call 2024 - Project 2

The molecular basis of aphid resistance to cereal defensive compounds

Supervisors:

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Background:

All plants mediate their interactions with the environment through chemical signals, and gramine and hordenine are examples. These two allelopathic compounds are found most often in Poaceae, but occur sporadically amongst the angiosperms as well. Some evidence suggests they confer protection against herbivorous insects, grazing animals and inhibit the growth of neighboring plants. Generalist aphids such as *Myzus persicae* are able to colonize gramine producing cereals, however, their growth and development are stunted[1]. On the other hand, specialist aphids such as *Rhopalosiphum padi* L. seem to thrive on these plants seemingly unaffected[2]. The ability of aphids to resist plant toxic compounds is a major obstacle to realizing their potential as natural pest controls, therefore we are interested in describing the barley-aphid interactions and understanding the mechanisms underlying the insect's resistance to gramine and hordenine.

Project description:

We have established that gramine and hordenine are present in the phloem of barley plants. In addition, we have also constructed CRISPR mediated knockout lines of the barley accession Tafeno, which normally makes high amounts of gramine in the early and mid-vegetative tissues. The utilization of Tafeno WT and Tafeno KO plants avoids issues with differences in other accessions' different phytochemical profiles.

This project will focus on several specific questions/hypotheses:

- Can gramine be found in aphid honeydew?
- Is gramine present in the aphids themselves, or is there evidence of breakdown products/detoxification?
- What is the biochemical basis for gramine resistance in the specialist versus the generalist aphids?
    - Is there evidence of microbe symbiosis?
    - Is there evidence for receptor-mediated resistance?
- Are the mechanisms of tolerance/resistance similar between Poaceae specialists versus those that feed on members of the Fabaceae (e.g. Genista or Lupins)?

Understanding of the dynamics of the barley-aphid interaction can be utilized to better shape sustainable agricultural practices. The D'Auria lab has successfully developed a method for

the detection of gramine [3] and characterized its pathway of biosynthesis [4]. This project will employ cutting edge technologies including GC- and LC-TOF metabolomics. Synthetic biology using CRISPR based systems in both plants and microorganisms will be used to investigate biological and ecological biotic interactions. The group of Dr. Kunert will supervise the student's work with aphids and artificial diets as well as technologies including the collection and analysis of honeydew.

Candidate profile:
An ideal candidate will be team oriented and possess knowledge in analytical chemistry and insect ecology/biology. Successful candidates will possess an MSc in Biochemistry, Chemistry, Chemical Ecology, or a related discipline. Experience with molecular biology and a foundational background in synthetic biology are considered advantageous. Proficiency in English, both written and oral, are required. This project will include work both at the MPI-CE in Jena and at the Leibniz Institute of Plant Genetics and Crop Plant Research in Gatersleben.

Reading (optional):

1 Davis, J. A. & Radcliffe, E. B. Reproduction and feeding behavior of *Myzus persicae* on four cereals. *J Econ Entomol* 101, 9-16 (2008). https://doi.org:10.1603/0022-0493(2008)101[9:rafbom]2.0.co;2
2 Delp, G., Gradin, T., Åhman, I. & Jonsson, L. M. V. Microarray analysis of the interaction between the aphid *Rhopalosiphum padi* and host plants reveals both differences and similarities between susceptible and partially resistant barley lines. *Molecular Genetics and Genomics* 281, 233-248 (2009). https://doi.org:10.1007/s00438-008-0409-3
3 Leite Dias, S. *et al.* A New Fluorescence Detection Method for Tryptophan- and Tyrosine-Derived Allelopathic Compounds in Barley and Lupin. *Plants (Basel)* 12 (2023). https://doi.org:10.3390/plants12101930
4 Leite Dias, S., Chuang, L., Liu, S., Seligmann, B., Brendel, F.L., Chavez, B.G., Hoffie, R.E., Hoffie, I., Kumlehn, J., Bültemeier, A., Wolf, J., Herde, M., Witte, C., D'Auria, J.C., Franke, J. Biosynthesis of the allelopathic alkaloid gramine in barley by a cryptic oxidative rearrangement. *Science* in press (2024).