Plant
Adaptation-in-action Group

Bachelor thesis project

Effects of the pond snail, *Lymnaea stagnalis* on the population dynamics in the great duckweed, *Spirodela polyrhiza*

Background: Plants are the backbone of most ecological interactions, and their evolution under herbivory affects the majority of the ecosystems on our planet. As herbivores can cause more than 15% losses of the worldwide annual crop production, understanding how plants adapt to herbivory is also highly important for the development of sustainable agriculture. However, our current knowledge on the processes and mechanisms of plant adaption to herbivores is largely limited to indirect assessments of evolutionary changes, which constrains not only our understanding of the evolutionary processes of plant defense, but also our ability to predict the consequences of plant evolution under the increasing herbivory pressure associated with a warming climate. Additionally, very few studies have directly measured the multigenerational fitness effects of plant defense traits, due to the long life cycles of many plants. Here we will use the diploid hydrophyte, *Spirodela polyrhiza* (Araceae, Lemnoideae), one of the fastest growing angiosperms with generation times of approximately 3 days and the phytophagous great pond snail *Lymnaea stagnalis* as a model system. Both organisms are widely distributed and importantly, also encounter each other in a plant-herbivore relation in nature.

Objectives: The aim of this project is to analyze the effect of herbivory on the population dynamics within genotypically diverse *S. polyrhiza* populations. This will be done by (*i*) analyzing the herbivory resistance of different genotypes in an isolated setup, by (*ii*) monitoring the genotype composition changes in mixed populations in the presence and absence of pond snails and finally by (*iii*) investigating the resistance level changes of the evolved populations.

Figure 1: *L. stagnalis* feeding on *S. polyrhiza*

Requirements: -interest in plant-herbivore interactions
-good English skills
-disposition to bring in own ideas

Methods: -microsatellite genotyping of *S. polyrhiza* populations in the presence and absence of *L. stagnalis*
-resistance measurement of different *S. polyrhiza* genotypes/populations to *L. stagnalis* herbivory
-defense compound analysis of different *S. polyrhiza* genotypes/populations (e.g., via HPLC-DAD)

Supervision: Prof. Dr. Shuqing Xu (Room 216, shuqing.xu@uni-muenster.de) and Dr. Martin Schäfer (Room 219, mschaefer@uni-muenster.de), Plant Adaptation-in-action Group, IEB, https://www.uni-muenster.de/Evolution/plantadapt/groupmain.shtml

Selected Literature:

Agrawal AA, Hastings AP, Johnson MTJ, Maron JL, Salminen J-P. (2012) Insect herbivores drive real-time ecological and evolutionary change in plant populations. *Science* 338(6103): 113-116

Xu N, Hu F, Wu J, Zhang W, Wang M, Zhu M and Ke J. (2018) Characterization of 19 polymorphic SSR markers in *Spirodela polyrhiza* (Lemnaceae) and cross-amplification in *Lemna perpusilla*. *Applications in Plant Sciences* 6(5): e1153

Xu S, Stapley J, Gablenz S, Boyer J, Appenroth KJ, Sree SK, Gershenzon J, Widmer A, Huber MSC. (2018) Low genetic variation is associated with low mutation rate in the giant duckweed. *bioRxiv* 381574

Plant
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Bachelor thesis project

Effects of plant-associated microbes on the population dynamics in the great duckweed, *Spirodela polyrhiza*

Background: All plants in nature live with microbes that populate their close proximity, live on their surface or even directly within them. The plant microbiota includes living fungi and bacteria and can profoundly change the metabolism, physiology and fitness of the host plants. Microbes might act as pathogenic, beneficial or neutral interaction partner. In particular, microbes with growth promoting affects get more and more attention, in particular since they are proposed as a way to improve agricultural yields in a sustainable way. Microbes can promote plants in different ways, they can improve the nutrient uptake, produce growth hormones or help the plants to cope with particular environmental conditions (e.g., competition, heat or salt stress). However, only few studies have directly measured the multigenerational fitness effects of plant-associated microbes, due to the long life cycles of many plants. Here we will use the diploid hydrophyte, *Spirodela polyrhiza* (Araceae, Lemnoideae), one of the fastest growing angiosperms with generation times of approximately 3 days, in the presence and absence of microbes collected from natural populations.

Objectives: The aim of this project is to analyze the effect of plant-associated microbes on the population dynamics within genotypically diverse *S. polyrhiza* populations. This will be done by (*i*) analyzing the effect of the microbes on the different genotypes in an isolated setup, by (*ii*) monitoring the genotype composition changes in mixed populations in the presence and absence of particular microbes and finally by (*iii*) investigating the fitness level changes of the evolved populations.

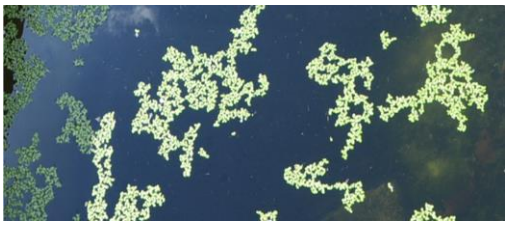

Figure 1: *S. polyrhiza* population in an outdoor pond

Requirements: -interest in plants-microbe interactions
-good English skills
-disposition to bring in own ideas

Methods: -growth and fitness measurements of *S. polyrhiza* genotypes/populations in the presence and absence of microbes
-microsatellite genotyping of *S. polyrhiza* populations in the presence and absence of microbes

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Selected Literature:

Ishizawa H, Kuroda M, Morikawa M and Ike M. (2017) Evaluation of environmental bacterial communities as a factor affecting the growth of duckweed *Lemna minor*. *Biotechnology for Biofuels* 10:62

Xu N, Hu F, Wu J, Zhang W, Wang M, Zhu M and Ke J. (2018) Characterization of 19 polymorphic SSR markers in *Spirodela polyrhiza* (Lemnaceae) and cross-amplification in *Lemna perpusilla*. Applications in Plant Sciences 6(5): e1153

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Plant
Adaptation-in-action Group

Bachelor thesis project

Effects of plant-associated microbes on the anti-herbivore defense of the great duckweed, *Spirodela polyrhiza*

Background: All plants in nature live with microbes that populate their close proximity, live on their surface or even directly within them. As the plant microbiota, which includes living fungi and bacteria, can profoundly change the metabolism, physiology and fitness of the host plants, the intimate interaction between plants and their microbiota may affect the defensive capabilities against herbivores. For example, the plant microbiota can promote plant growth to tolerate herbivory, elevate/suppress the induction of specialized plant defense compounds and/or effect the nutritious value of the plant material. Here we will use the diploid hydrophyte, *Spirodela polyrhiza* (Araceae, Lemnoideae) in the presence and absence of microbes collected from natural populations. As herbivore we will use the phytophagous great pond snail *Lymnaea stagnalis,* which is widely distributed and feeds on *S. polyrhiza* in nature.

Objectives: The aim of this project is to analyze the effect of microbes on the anti-herbivore defense of different *S. polyrhiza* genotypes. This will be done by (*i*) measuring defensive metabolites (e.g., flavones anthocyanins and hydroxycinnamic acids), (*ii*) by determining the nutritious value (sugar and protein contents) and (*iii*) by analyzing the herbivory resistance of *S. polyrhiza* each in the presence and absence of particular microbes.

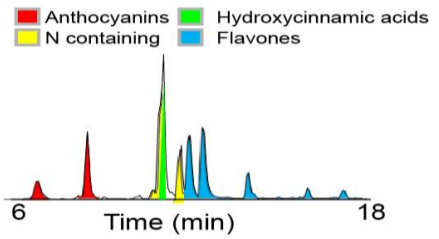

Figure 1: Representative HPLC-MS chromatogram showing different secondary metabolites in *S. polyrhiza*

Requirements: -interest in chemical ecology
-good English skills
-disposition to bring in own ideas

Methods: -secondary metabolite measurements via HPLC-DAD in *S. polyrhiza* in the presence and absence of microbes
-plate reader assays (sugar and soluble protein analysis) with *S. polyrhiza* in the presence and absence of microbes
-resistance measurement of *S. polyrhiza* to *L. stagnalis* herbivory in the presence and absence of microbes

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Selected Literature:

Simon J-C, Biere A, Sugio A. (2017) The promises and challenges of research on plant–insect–microbe interactions. *Insect Science* 24: 904–909

Ishizawa H, Kuroda M, Morikawa M and Ike M. (2017) Evaluation of environmental bacterial communities as a factor affecting the growth of duckweed *Lemna minor*. *Biotechnology for Biofuels* 10:62

Qiao X, He W-n, Xiang C, Han J, Wu L-j, Guo D-a, Ye M. (2011) Qualitative and quantitative analyses of flavonoids in *Spirodela polyrrhiza* by high-performance liquid chromatography coupled with mass spectrometry. *Phytochemical Analysis* 22: 475–483