Vorburger lab: Possible topics for MSc & BSc Projects (updated January 2024)

⇒ We suggest to first have a look at https://homepages.eawag.ch/~vorburch/research.html to have the context of these project suggestions.

Projects related to insect host-parasitoid interactions

NEW: Gene-flow of a pest insect (*Aphis fabae*) along a latitudinal gradient

The black bean aphid, *Aphis fabae*, is an important agricultural pest. It occurs all across Europe and shows interesting latitudinal clines in its reproductive mode (cyclical parthenogenesis in the north, obligate parthenogenesis in the south) and in its association with bacterial endosymbionts that provide resistance against parasitoid wasps. To understand how these clines form and what role potential dispersal barriers like the Alps play in their maintenance, we require an estimate of gene flow across latitudes in *A. fabae*. To estimate infection rates with bacterial symbionts, we have sampled black bean aphids along a > 3000 km long N-S transect across Europe in 2023. These samples are now available for analysis with genetic markers to estimate latitudinal gene flow in black bean aphids. Suitable for a 6-12 month project, in collaboration with a postdoc (Cameron Hudson) and a PhD student (Dominic Stalder).

NEW: Strain diversity of the defensive symbiont *Hamiltonella defensa* in close relatives of *Aphis fabae*

Hamiltonella defensa is a heritable bacterial endosymbiont of aphids that increases aphid resistance to parasitoid wasps. To describe the genomic basis of this remarkable trait, we aim to compare a large number of different *H. defensa* strains. In our main study species, *Aphis fabae*, strain diversity of *H. defensa* is very limited, but we expect to find more strains by screening additional species of *Aphis* that are closely related to *A. fabae*. This project would include fieldwork, laboratory husbandry of insects, as well as molecular genetic analyses. Suitable for a 6-12 month project.

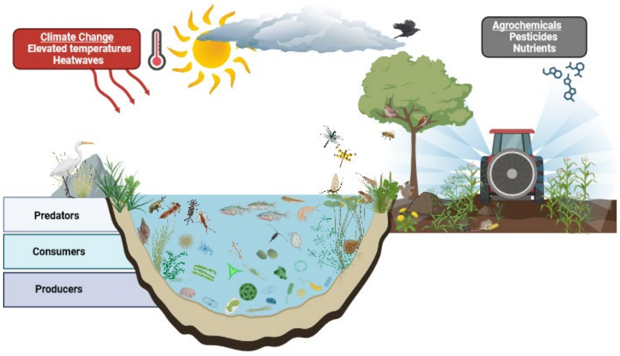
Induced costs of resistance to parasitoids in symbiont-protected aphids

The bacterial endosymbiont *Hamiltonella defensa* protects black bean aphids (*Aphis fabae*) against parasitoid wasps, including *Lysiphlebus fabarum*, their most abundant parasitoid in the field, and *Aphidius colemani*, an important biocontrol agent employed against aphid infestations in greenhouses. In a recent experiment using population cages, we made the surprising observation that the presence of *A. colemani* selected against aphids carrying *Hamiltonella*, even though these aphids were highly resistant to the parasitoid. A conspicuosly low amount of aphid reproduction in these cages suggested that aphids protected by *Hamiltonella* can avoid getting killed by the parasitoid, but still suffer strong negative effects of the attack. This would be tantamount to an ‘induced’ cost of resistance that is high enough to annihilate the benefit of resistance. Following up on this surprising but anecdotal observation will require an experiment in which we carefully observe attacks by *A. colemani* on aphids with and without *Hamiltonella* and measure the fitness of survivors from both groups. Laboratory experiment suitable for a 3-6 month project.

The specificity of chemical mimicry in aphid parasitoids of the genus *Lysiphlebus*

Aphid parasitoids of the genus *Lysiphlebus* are specialized on ant-tended aphid species. These aphids engage in a symbiosis with ants, which provide protection against predators and parasitoids in exchange for honeydew from the aphids. To exploit such aphids despite their protection by ants, *Lysiphlebus* parasitoids have evolved chemical mimicry. The chemical profile of the hydrocarbons coating their cuticula closely matches that of the aphids, 'fooling' ants into 'believing' they are aphids and leaving them unmolested (Liepert & Dettner, 1996, J Chem Ecol). However, it is still unknown how precise this mimicry needs to be to be functional. As a first attempt to answer this question, the student will exchange *Lysiphlebus* parasitoids between different ant-tended aphid species, to test whether parasitoids remain undetected by ants even against a 'background' consisting of different aphid species. Field experiment suitable for a 3-month project.

Projects related to aquatic ecology and biodiversity



<u>**NEW:** Climate Change and Freshwater Biodiversity (CCFB):</u>
<u>Multiple stressor effects of climate change and other stressors on aquatic food webs</u>
Global climate change brings on rising temperatures and more frequent and extreme weather events, such as heatwaves and warm spells. These will have both immediate and lasting impacts on freshwater ecosystems. There is still a limited understanding of how these ecosystems will respond to higher mean temperatures and temperature extremes, particularly when unpredictable interactions with other stressors occur. These stressors include agricultural inputs such as pesticides, nutrients or fine sediment, as well as structural habitat degradation. To study multiple stressor effects on aquatic food webs, we use various types of mesocosms as experimental units (ponds and flumes), comprising semi-natural communities of differing complexity. The overall project goal is to deepen our knowledge on how multiple stressors in the context of global warming affect freshwater communities as well as ecosystem processes and function. Since studies that examine the underlying mechanisms of multiple stressor effects are scarce and often lack environmental realism, full-factorial experimental designs in the field will be used to disentangle interaction effects.
Field and laboratory work suitable for a 3 to 12-month project, depending on participation in planned field experiments and/or laboratory work. This project would take place in collaboration with Dr. Markus Hermann (Research Scientist and Program Coordinator of the CCFP project).