Vorburger lab: Possible topics for MSc & BSc Projects (updated January 2021)

⇒ 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: Temperature-dependence of the cost of infection with *Hamiltonella* in black bean aphids

Aphids a frequently infected with the heriable bacterial endosymbiont *Hamiltonella defensa*. In the Swiss populations of black bean aphids (*Aphis fabae*) we study, approx. 40% of individuals carry this symbiont. *Hamiltonella* strongly increases aphid resistance to parasitoid wasps, but this protection comes at a cost. In the absence of parasitoids, aphids carrying *Hamiltonella* have a reduced lifespan and lifetime reproduction. From our standard rearing of aphids in the laboratory, we have anecdotal evidence that the magnitude of this cost might be dependent on the rearing temperature. To thoroughly investigate whether this is indeed the case requires an experiment in which the survival and reproduction of aphids with and without *Hamiltonella* is measured under different temperatures. Laboratory experiment suitable for a 6-month project.

NEW: 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 conspicuously 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.

NEW: Cross-infectivity of experimentally evolved parasitoids

Using experimental evolution, our laboratory has shown that parasitoid wasps (*Lysiphlebus fabarum*) are able to adapt to the presence of the resistance-conferring endosymbiont *Hamiltonella defensa* in their aphid hosts (Dennis et al. (2017), Evolution 71: 2599-2617). Interestingly, counter-adaptation by parasitoids was strain specific. When reared on aphids carrying one strain of *Hamiltonella*, the wasps evolved an improved ability to parasitize aphids protected by that strain, but this did not increase their infectivity on another strain (and *vice versa*). Such genotype-specificity between parasitoids and the protective symbionts of their hosts has important consequences for host-parasitoid coevolution: It has the potential to promote cyclical genetic dynamics driven be negative frequency-dependence (i.e. a selective advantage for rare genotypes, see Kwiatkowski et al. (2012) PLoS Comp Biol 8(8): e1002633). To obtain a better estimate of the degree of specificity in this interaction, we would now like to test the ability of experimentally evolved parasitoids on additional strains of *Hamiltonella* that we have collected since. Ideally, this would be followed up by genetic analysis of the different *Hamiltonella* strains to try and identify the determinants of the observed specificity. Laboratory experiment suitable for a 6 or 12 month project.

The genomic basis of parasitoid infectivity on symbiont-protected hosts (QTL mapping)

Parasitoids can adapt to the presence of defensive endosymbionts in their aphid hosts. We have evolved parasitoids (*Lysiphlebus fabarum*) on aphids with and without the defensive symbiont *Hamiltonella*. These evolved lines are now available for QTL mapping of genomic loci involved in this adaptation. The work will involve experimental crosses with parasitoids wasps, followed by RAD-tag sequencing of a mapping population.

Local adaptation to defensive symbionts in aphid parasitoids?

The aphid parasitoid *Lysiphlebus fabarum* exhibits host-associated genetic differentiation (HAD). Wasps collected from different aphid hosts are typically less related than wasps collected from the same aphid host, which is suggestive of local adaptation. Most of their host species from the genus *Aphis* are protected by heritable bacterial endosymbiont called *Hamiltonella defensa*. It is possible that different species of *Aphis* harbour different strains of *Hamiltonella*, and that parasitoids exploiting these species are locally adapted to the *Hamiltonella* found in 'their' host. This can be tested by genotyping (multi-locus sequence typing, MLST) *Hamiltonella* from different aphid species to verify their distinctness, introducing them into a common genetic background (a single clone from the species *Aphis fabae*), and comparing the infectivity of wasps collected from the different hosts on aphids containing the different symbiont strains.
This project is better suited for a 12-month MSc.

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 conservation

NEW: *Wolbachia* in *Asellus aquaticus*: Genetic characterization and effects on the host

The 'water louse' *Asellus aquaticus*, an isopod crustacean, is an abundant and ecologically important species in various freshwater habitats. Similar to terrestrial isopods (and many other arthropods), *Asellus* can be infected with *Wolbachia*, a maternally transmitted, endosymbiotic bacterium. Multiple clades of this bacterium have been described, and they comprise strains with very interesting effects on their hosts. Some strains manipulate their hosts' reproduction in favor of females (e.g. by feminization or male killing), and some strains protect their hosts against other infections. *Asellus*-infecting *Wolbachia* are so far unstudied, but their analysis is urgently needed because *Asellus* is being developed into a model study system at Eawag. In a first step, this project will estimate the frequency of infection with *Wolbachia* in natural populations of *Asellus* and characterize these infections genetically: Which clade of *Wolbachia* infects *Asellus*? What is the strain diversity in natural populations? In a second step, we will test for reproductive manipulation by comparing sex ratios between infected and uninfected females and by conducting reciprocal crosses between infected and uninfected lines of *Asellus*.
This project would take place in collaboration with Dr. Katja Räsänen, Dr. Elvira Lafuente and Dr. Claudia Buser from Eawag.

Genetic population structure at the limit of a species' geographic range: the endangered stone crayfish (*Austropotamobius torrentium*) in central Switzerland

Central Switzerland is the natural range limit of the stone crayfish, *Austropotamobius torrentium*, one of three native freshwater crayfish species in Switzerland. It is red-listed as 'endangered' due to habitat degradation, competition by introduced crayfish species, and a deadly disease (crayfish plague) vectored by these introduced species. To inform and support the conservation of the remaining stone crayfish populations in central Switzerland, the MSc candidate will analyze their genetic population structure using molecular markers. The goal is to quantifiy the connectivity of the still exisiting populations, to potentially detect distinct gene pools that should be treated as separate conservation units, and to identify suitable source populations for possible re-introductions, e.g. populations still possessing a high genetic diversity.