Bachelor research projects 2012 & upcoming Master project opportunities

Molecular Ecology & Evolutionary Genomics group

Group leader: Christian Lexer

We are interested primarily in the genetics of adaptation and speciation, that is, in the genetic mechanisms responsible for the origin of new, ecologically divergent phenotypes and even entirely new species in nature. These issues are of central interest to evolutionary biology. They also offer many connections to molecular biology (e.g. finding "speciation genes"), and have broad implications for the applied sciences (e.g. conservation genetics of wild species; predicting genetic responses of keystone or foundation species to climate change; domestication of the crop plants that we use as sources of food, fuel, and fiber).

Project 1: Does assortative mating contribute to reproductive barriers in hybridizing forest trees (*Populus* spp.)?

Hybrid zones between divergent species are **natural laboratories for studying speciation** and **barriers to introgression**. We have recently discovered several large natural hybrid zones between *Populus alba* and *P. tremula*, two ecologically divergent European forest trees that benefit from the availability of a complete genomic sequence. Hybridisation between these species is frequent and results in viable and fertile crosses, but **mating patterns** in hybrid zones are highly unusual: hybrids mate with each other to form advanced crosses, but they only rarely backcross to their parents. This results in a very strong "genetic filter" which has allowed hybrids to evolve partial **reproductive isolation (RI)** from their parental species, potentially leading to speciation. Building on results from a previous Bachelor work, the project will test whether **assortative mating** among hybrids contributes to RI. You will address this question by studying mating patterns with **molecular genetic markers** in open pollinated seedling families from the Ticino river floodplain forest in Italy. For more information see ***Genetics*** 186: 699–712, 2010.

The project can be carried out as either **Bachelor** or **Master** project, depending on the amount of molecular genetic data collected and depth of the analysis.

Project 2: Testing for potential trade-offs between defence and growth in *Populus alba* (white poplar), a riverine forest tree

Successful **defence** against pathogens is crucial for the survival and fitness of sessile organisms such as trees. Nevertheless, defence mechanisms in plants are often costly because they require the synthesis of large quantities of **bioactive secondary compounds**. Thus, chemical ecology studies in trees sometimes uncover a **trade-off between defence and growth (biomass accumulation)**, the latter being strongly correlated with leaf traits. You will measure important leaf traits (e.g. size and shape) for a riverine population of *Populus alba* (Ticino river, Italy) using digital image analysis of available specimens, and you will study biochemical defence compounds by quantifying condensed tannins in the same trees. This will provide a simple way **to test for potential trade-offs** (negative relationships) between defence and growth, using tannin concentrations and leaf traits as surrogates. Available molecular genetic data for the same trees will allow you to test the degree to which these important traits are heritable, that is, you will test their potential to evolve. For more information see ***Oecologia*** 163: 283-290, 2010.

The project is available as either **Bachelor** or **Master** project. If carried out as a Bachelor project, you will study one population of *P. alba* (Ticino river, Italy) using available leaf specimens. If carried out as a **Master** project, you will study the relationships between defence and growth in multiple populations, which involves field work in natural populations and a common garden, and analytical chemistry or molecular genetic work, depending on your interests.

Project 3: Molecular systematics of *Arenaria bernensis*, an alpine plant endemic to the Western Prealps

The Western Prealps are one of the most important areas of plant diversity in Switzerland. The extraordinary richness of this region has been attributed to its unique biogeographic history which involves both, peripheral refugia during the Quaternary ice-ages and colonization cross-roads during warm periods. Molecular systematics based on genetic (DNA) markers can help shed light on species` **biogeographic history** and on efficient strategies to **conserve their genetic diversity**. *Arenaria bernensis* is an alpine plant described from the Bernese and Fribourg Prealps, but its genetic relationships to other taxa in the *Arenaria* species complex are unclear. In this project, you will **develop molecular genetic markers** located in the chloroplast (cp) DNA genome of this species. You will use these markers to (1) assess genetic diversity in *Arenaria bernensis*, (2) test for biogeographic structure in this species, (3) test genetic relationships between *Arenaria bernensis* and related species. The project will be carried out in collaboration with the **Musée d'histoire naturelle Fribourg**.

This **Bachelor project** is expected to lead to a **Master project** to be started in 2012. The Master project will build on the genetic markers developed here and will involve additional field sampling of *Arenaria* spp. in the Alps, and possibly in other European mountain systems.