

ECO-SOL

Initiative for the advancement of international and integrative research into the biodiversity, natural history and ecology of Solanaceae in regions of their highest generic and species diversity.

Summary

ECO-SOL is an international and integrative research network of scientists to share and enrich resources, visions and capacities relating to biodiversity, ecology, conservation, breeding and sustainable agriculture of Solanaceae in the centers of their biodiversity, especially South America. The objective of this virtual umbrella is to link the tremendous SOL genomic efforts (Solanaceae Genomics Network) to basic and applied biological research of Solanaceae in their native habitats. This will be achieved by facilitating and coordinating networks between researchers and funding agencies to achieve a multidisciplinary long-term “expedition” into the study of biodiversity and adaptation and by supporting the creation of permanent *in situ* conservation sites in regions of high Solanaceae biodiversity.

Building for the future of plant science depends upon the development of an integrated, collaborative and diverse research community. The ECO-SOL network will help to provide the framework for the establishment of a shared vision that will enhance both biological and cultural diversity. Partnerships integrating knowledge of wild plants across a broad scientific spectrum and forged across biological disciplines that have traditionally been separated have the real potential to take plant science to a new and promising level.

Description

The Solanaceae or nightshade family is of great importance to humans e.g. as foods (potatoes, tomatoes, eggplants, peppers), drugs and medicines (tobacco, henbane, belladonna, *Datura*) and ornamentals (*Petunia*, velvet tongue, butterfly orchid). The family is the third most important plant taxon economically, and the most valuable in terms of horticultural crops (Müller et al. (2005) *Comp. Funct. Genom.* **6**, 153–158). Due to this utility to humans, national and international programs have significantly advanced Solanaceae research in fields such as taxonomy, plant breeding, genomics, metabolomics

and proteomics, and recently launched initiatives such as the International Solanaceae Genomics Project (SOL), the European (EU-SOL), and Latin American (LAT-SOL) SOL initiatives and the Planetary Biodiversity Inventory (PBI) Program for the genus *Solanum* will further accelerate this process. In contrast to these advances we encounter a critical shortfall of in-depth *in situ* field research concerning the ecology and natural history for most Solanaceae. Although we know a great deal about those members of the Solanaceae that are directly and economically useful to humans, many wild species are only known from a few collections in museums. Discovery of new species and of new populations of poorly known species is by now means over, in 2004-2005, for example, 37 new species of *Solanum* were described and dedicated field work by Solanaceae biologists in Bolivia has uncovered 11 additional species new to science. Field and museum research is essential to the discovery not only of new taxa, but also to the discovery of new patterns of distribution or new and previously undescribed ecologies. This constant and potentially increasing rate of discovery is especially exciting when we consider that: “Discoveries of new organisms and new facts about organisms often reset the research cycles of hypothesis testing and theory refinement that underlie good progressive science.” (Greene (2005) *TREE* 20, 23-27). ECO-SOL aims to close this field research gap by **establishing an international and integrative research network to share and enrich resources, visions and capacities relating to biodiversity, ecology, conservation, breeding and sustainable agriculture, using the Solanaceae as a case study.**

The ECO-SOL network will be integrative in three different ways. First, the initiative will **facilitate communication and collaboration between scientists working on applied and basic aspects of natural history and ecology** of solanaceous plant species in their native habitats, in the regions of highest species diversity, especially South America.

Second, integrating this initiative into the already existing programs, such as SOL, EU-SOL and PBI *Solanum* will create a platform to foster synergies from complementary research approaches. Therefore, the scientific significance and substance of ECO-SOL lies in the **merging of research domains such as genetics and molecular biology with ecology and evolutionary biology, thus linking fields that have been historically**

separated. This integrative approach should be attractive to basic and applied biologists concerned with a variety of related research areas and is likely to attract early career scientists and those not currently involved in research on Solanaceae.

Third, the success of the initiative will strongly depend on close collaboration with scientists from countries that harbor the largest native biodiversity of solanaceous plants (e.g. Latin America). Scientists from this region are currently underrepresented in the International Solanaceae Genome Network, but are carrying out dynamic and essential research into many aspects of Solanaceae biology. The multidisciplinary approach of ECO-SOL allows and requires the **involvement of scientists from different research fields and nationalities - particularly from Latin American countries.** Therefore, by using **native habitats as a laboratory** for multidisciplinary research the ECO-SOL initiative will create a truly international collaborative research network with invaluable future potential, both scientifically and culturally. Such capacity building for the next generation of integrative biologists is of critical importance to the development of a truly sustainable world.

The initiative is **outlined in accordance with the United Nations' Convention on Biological Diversity** (CBD – see www.biodiv.org), and adheres to the principles laid out therein; principles to which more than 180 countries have committed themselves. In this sense ECO-SOL provides a practicable approach to “the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources.” (CBD, Rio de Janeiro, June 5, 1992 – see www.biodiv.org). In addition, all projects covered under the initiative are required to accept that “there is an inalienable and inprescriptible right of each nation over its genetic resources” (CBD, Rio de Janeiro, June 5, 1992), and have to follow the legal procedures, which were constituted by the Andean Community Commission (DECISION 391: Common Regime on Access to Genetic Resources).

Currently, the ECO-SOL network anticipates connecting scientists through three major objectives: (1) characterizing, mapping, and conserving Solanaceae biodiversity, (2) advancing natural history and ecology research, and (3) improving the efficiency and sustainability of Solanaceae breeding and cultivation.

Describing, conserving, and utilizing Solanaceae biodiversity

The economic importance of the Solanaceae crops increases the necessity of preserving the genetic diversity of their wild relatives for a variety of reasons, including the development of new varieties or the utilization of new species for the global food market. Therefore, cataloging and protecting the natural biodiversity of the Solanaceae in both native habitats and in agricultural systems in the traditional growing regions is of great economic and scientific value. Moreover, long-term research into the functional biodiversity of Solanaceae, including the identification and cataloging of both wild species and their associated communities (e.g. plants, arthropods, fungi, pathogens etc.), will build the basis for further research in evolutionary biology, population biology, ecology and agro-ecology.

ECO-SOL will, supplementary to the taxonomically focused PBI for the genus *Solanum* and in accordance with the CBD and Decision 391 of the Andean Community Commission, create a common network for taxonomists, plant breeders, ecologists and specialists from associated disciplines (e.g. entomology, plant pathology) to map the current biodiversity of Solanaceae and that of associated organisms. As a result of this synthesis of baseline diversity and distribution data, the initiative will accelerate the identification of Solanaceae biodiversity hotspots, primarily in Latin America. This sound scientific knowledge will enable groups to focus international and national efforts for sustainable management and conservation of these areas of key high biodiversity. Such protected areas can function as both refuges for wild species (not exclusively Solanaceae) in their native habitats and sustainable “natural history and ecology laboratories” for future study and development (see next objective).

Focusing field research on particular regions, such as the biodiversity hotspots, will make it easier to coordinate research efforts and to sustain long-term research projects.

Natural History and Ecology

Basic research on plants in their native habitats and the understanding of their interactions with biotic and abiotic factors leads to a profound understanding of

underlying ecological and evolutionary mechanisms for the generation of diversity of life on Earth. This understanding is crucial for identifying methods and arguments to conserve and use biodiversity and to develop new and more sustainable agricultural practices. The high synteny of Solanaceae genomes readily allows the application of newly developed molecular and genetic tools in a number of different species, occupying a diversity of habitats and interacting with a yet-to-be-discovered number of other organisms. Moreover, the continuing identification of the extraordinarily high diversity of solanaceous secondary metabolites (metabolomics) and the study of their protein expression (proteomics) have increased the attractiveness of Solanaceae plants for integrative research fields such as chemical and molecular ecology, evolutionary developmental biology (evo-devo) and ecological developmental biology (eco-devo) etc. These diverse characteristics of ecological importance identify Solanaceae as an ideal plant model system in various fields of basic and applied plant biology including evolutionary and ecological functional genomics (Federer & Mitchell-Olds (2003) *Nature Reviews* **4**, 649-655).

ECO-SOL will provide a research umbrella for the advancement of field ecological research on Solanaceae plants in their native habitats. It will facilitate interdisciplinary and international collaborations in field ecology and seek to attract and support scientists specifically in the countries with high Solanaceae biodiversity through collaboration, student exchange and support for a variety of levels of education. Currently the ECO-SOL initiative has under its umbrella the following fields of ecological research:

- Adaptation to abiotic stress (e.g. drought, nutrients etc.)
- Biotic interactions (e.g. plant-insect, plant pathogen, multitrophic interactions etc.)
- Population ecology
- Metapopulation ecology/ Gene flow
- Functional Biodiversity

Advancement of Solanaceae breeding and cultivation

Although being the centre of origin for the two most economically important solanaceous plants, tomato and potato, the Andean countries have a relatively low impact

on commercial Solanaceae domestication and breeding. Small farmers use a remarkable number of local species and landraces for cultivation but larger farms are frequently dependent on seeds from US and European companies, for commercial produce. The scientific community has been able to explore genes that are involved in quantitative traits of Solanaceae, like fruit quality, stress resistance and yield. Although this genomics research has great potentials it is so complex and expensive that it can only be successfully achieved in international collaborations. ECO-SOL aims to integrate field research efforts in countries that harbor most of the solanaceous biodiversity with modern breeding programs, which will enhance with the progression of the Solanaceae Genome Project. This scientific collaboration will enhance the study of commercially important plant traits (e.g. yield, product quality, drought, disease and pest resistance) in wild Solanaceae and allows a faster development of new and improved cultivars coupled with an understanding of the biological basis of key traits. The knowledge on genotypic and phenotypic variation of Solanaceae from centers of origin and domestication will provide the raw material for the utilization of biodiversity in environmentally sound breeding programs. In addition the mapping and cataloging of Solanaceae biodiversity and an advanced understanding of their ecology will enhance agricultural practices towards more sustainability.

Ideally all countries should have the capacity to develop their own strategy for establishing a prosperous industry, including cultivation, extension, scientific research and breeding. So far, many completely rely upon activities that are supported by international donors. They do not have the capacity to implement new technologies via their own research organisations, nor to start with commercial breeding programmes. ECO-SOL aims to join forces to support the Andean countries to establish their own high quality Research & Development (R&D) programmes in order to participate in the international research community and at establishing a sustainable production system.

Through the ECO-SOL initiative farmers, plant breeders, agro-biologists and ecologists will find a discussion platform to exchange knowledge and experiences to identify and solve problems associated with the cultivation of Solanaceae in traditional and industrialized agriculture. The increased communication between these groups in combination with modern breeding techniques will likely result in a more rapid and

sustainable development of new cultivars as well as economically and ecologically sound pest control and cultivation practices.

A sampling of current research projects associated with ECO-SOL

Diversification of Andean crop systems at local and landscape scales: enhancing biological control of potato pests. Katja Poveda, Georg-August University, Goettingen/ Germany (Funding: DFG pending)

Ecological consequences of herbivory-induced metabolic responses of wild tomato species. Andre Kessler, Cornell University, Ithaca, NY/ USA (Funding: Cornell University)

Herbivore-induced changes in wild tomato (*Solanum habrochaites*, *S. peruvianum*) flower morphology and pollinator behavior. Andre Kessler, Cornell University, NY/ USA (Funding: NSF, resubmission)

Development of EST databases for the Andean fruit species lulo and tree tomato. Steven D. Tanksley, Cornell University, NY (USA), Luz Stella Barrero, CORPOICA, Bogota (Colombia) (Funding: NSF supplement DCC-PGR)

Revision of *Solanum* section *Geminata* in Colombia. Juan Carlos Granado-Tochay, Universidad Nacional de Colombia.

Revision of *Solanum* section *Regmandra* in western South America. Jonathan Bennett, The Natural History Museum, London (Funding PBI *Solanum*, NSF)

Improving Micronutrient content of potato for reduced malnutrition. HarvestPlus Challenge Program; CIP

Genomics and Biodiversity Providing New Opportunities for smallholder **Potato Farmers**

Government of Germany (CIP, U Nac. Colombia, UNAM Peru, INIAP Ecuador, PROPINAPA Bolivia)

Conservacio uso sostenible de la Agrobiodiversidad de las Papas Nativas

Government of Spain- CIP, NEIKER, Spain

Mejoramiento participativo y produccion escentralizada de semilla de cultivos andinos.

Government of Peru- CIP, INIA Peru

Assess environmental risks of gene technologies

CIP core funding

Exotic strains of *Phytophthora infestans* in the Andes genetically isolated curiosities or time bombs for native *Solanaceous* crops?

Research Fellow Partnership Programme (RFPP), Ricardo Oliva, Greg Forbes from CIP, and Cesare Gessler from ETH Zurich. (Funded by ZIL Research Fellow Partnership Programme)

Revision of the vining *Solanum* species of the Americas.

Sandra Knapp, The Natural History Museum, London (PBI Solanum)

Red Lists for the endemic Solanaceae of Peru and Ecuador.

Sandra Knapp, The Natural History Museum, London. In press.