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THE ROOTS OF PROGRESS

THE CONTINUING EVOLUTION OF ENVIRONMENTAL RESEARCH IN THE FACE OF ESCALATING GLOBAL CHALLENGES

EUROPEAN PLANT SCIENCE ORGANISATION

FRENCH NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INRA)

FRENCH FOUNDATION FOR RESEARCH ON BIODIVERSITY

RESEARCH SPOTLIGHT: INTERNATIONAL COUNCIL FOR THE EXPLORATION OF THE SEA • UNESCO WATER EC COMMISSIONER FOR ENERGY • US DEPARTMENT OF ENERGY – BIOLOGICAL SYSTEMS SCIENCE DIVISION BIOVERSITY INTERNATIONAL • EUROPEAN ASSOCIATION FOR PLANT BREEDING RESEARCH

Natural balance

A collection of evolution-driven research projects conducted by the **French National Institute for Agricultural Research** is attempting to boost the effectiveness of the way biological control of invasive pest species is used, ultimately protecting European agriculture and enhancing research and development in this field

As the world's population booms, so the demand for food increases. As such, invasive species post an increasing risk to agricultural crops that continues to grow. In the past, a vast array of pesticide-, herbicide- and fungicide-based controls have been used to manage invasive pests, but with growing environmental and health concerns associated with many of these practices, attention is now turning to the benefits offered by biological controls. Researchers at the French National Institute for Agricultural Research (INRA) are coordinating a number of projects searching for innovative ways to improve the use of biological control of invasive pest species in an agricultural context.

Principal Investigator Thibaut Malausa explains that, "whilst conventional control of invasive species relies mainly on large-spectrum pesticide molecules it is reasonable to believe that alternative methods, more respectful to the environment and human health, could prove valuable options for decreasing the agricultural sector's reliance upon chemicals". The required depth of understanding of the disciplines of physiology, ecology, genetics and economics means that even in such a highly skilled international consortium there are many challenges to overcome. Nevertheless, the teams are confident that viable solutions can be developed. Their efforts revolve around four key projects which all share very similar objectives.

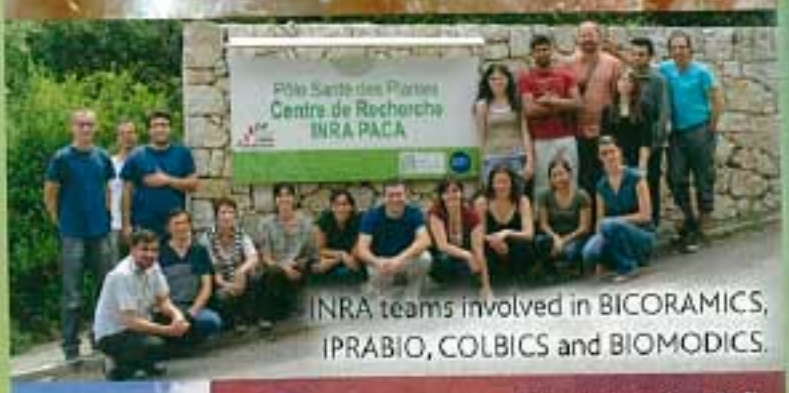
The teams involved carry out research and development in biological control against arthropod crop pests using macro-organisms (predatory or parasitoid insects, predatory mites, parasitic nematodes, etc.). Studies involve searching for, characterising or evaluating natural enemies of pest species, with the ultimate objective of promoting the use of biological control as a crop protection method. A common feature of all projects is the aim of simultaneously performing two types of research. The first is applied research: the development or improvement of new biocontrol products. The second is academic research in entomology and evolutionary biology: the characterisation of still unknown biodiversity and the investigation of the genetic processes that influence the performance of living organism populations when facing new environments (eg. artificial mass-rearing conditions).

BICORAMICS

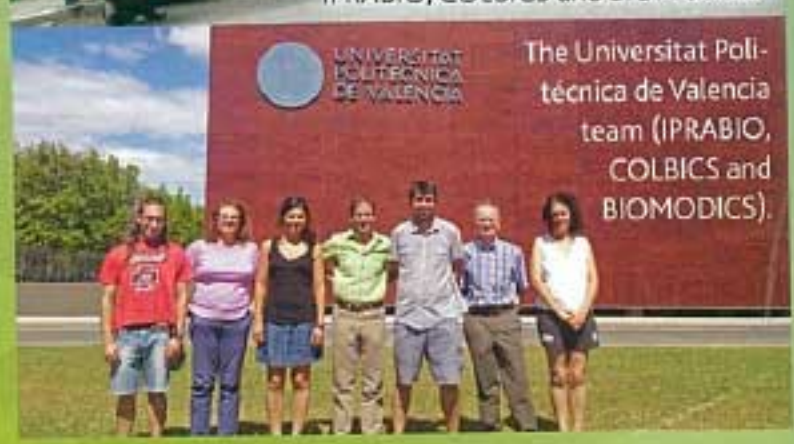
The BICORAMICS team intends to build a clearer understanding of the key genetic and demographic factors affecting the success of introduced populations that either optimise the success of bio-control agent introductions, or enable preventative measures to effectively manage bio-invasions that have foreseen negative impacts. They achieve this through the development of a biological control programme against a mealybug infesting European apple orchards. "One example of experiment carried out in BICORAMICS involves mixing various biological control agent populations to obtain new populations with more or less genetic diversity. We then introduce greater or fewer individuals from these populations in laboratory, semi-field or field settings. Comparing the performances of the various types of introduced populations enable the group to determine which characteristics are important," explains Malausa.

The researchers are also developing procedures to rapidly measure phenotypic traits or create cost-effective molecular tools that can then be used in the biological control programme. "The project is also a benchmark of several types of tools that could be used in other programs" notes Malausa's colleague, Nicolas Ris.

A mealybug parasitoid used as biological control agent by the INRA researchers.



INRA teams involved in BICORAMICS, IPRABIO, COLBICS and BIOMODICS.



The Universitat Politécnica de Valencia team (IPRABIO, COLBICS and BIOMODICS).

IPRABIO

Three of the projects involve developing important international relationships to help foster the research. IPRABIO is a Marie Curie International Research Staff Exchange Scheme (IRSES) involving 13 participants from 10 countries. It is helping to link teams specialising in ecology and evolution and those specialising in biological control against crop pests. Ris highlights their objective: "The aim of IPRABIO is to promote the use of innovative practices in biological control, based on the methods and concepts of ecology and evolution". The intended immediate outcome is an integration of tools and methods derived from ecology and evolution into eight biological control programmes. In addition, the long-term aim is to convince biological control practitioners about the benefits of these methods, and train junior scientists in their design and use. The interactions and activities created by IPRABIO gave birth to the projects COLBICS and BIOMODICS.

BIOMODICS

Another Marie Curie IRSES project, BIOMODICS, is supporting and linking several national projects with scientific objectives similar to BICORAMICS but testing different hypotheses and biological models. The biological control programmes considered in BIOMODICS target three invasive pests (one Lepidoptera and two scale-insects) and the hypotheses have been defined based on the experience acquired by the teams in BICORAMICS.

The key to success is collaboration. For example, one of the partners is embarking on a biological control programme of a specific pest and will be supported by a team performing analyses of field-monitoring genetic data. Also, in each biological control programme considered, teams from at least two different countries will merge their efforts and expertise to better develop biological control solutions, while addressing academic research questions in a more comprehensive way.

COLBICS

The COLBICS project is based on an academia-industry partnership revolving around the development of biological control solutions. It aims to support the R&D programmes of three companies in their work developing biological control solutions against crop pests. "We plan to use the scientific background from the researchers who are working on the different projects and link these with the R&D activities," outlines Ris.

In Colbics, innovation is expected from two types of deliverables. First, new products designed to effectively control crop pests. Second, results of experiments testing new technical procedures for the research, production and release of biological control agents.

By addressing research questions within the industrial context, the project will address some of the big challenges facing the industry. "From all the results of these projects, we believe some of the novel approaches we are developing will be adopted by the commercial sector," anticipates Malausa. "For the growers, the net result will be the availability of new pest control solutions and an increased quality of already commercialised products."

Tania Zaviezo's team and students at the Universidad Catolica de Chile, Santiago (IPRABIO, COLBICS and BIOMODICS).

Anasac-Xilema team, Quillota, Chile (COLBICS).

ADDRESSING BIOLOGICAL CONTROL, AND BIOLOGICAL INVASIONS

Using biological control to understand the mechanisms at play when species are introduced supports innovation and benefits research in invasion biology. It also contributes to a better overall management of invasive species. The investigations on biological control and invasion involve applied research addressing the development or improvement of natural enemies and academic research in entomology and evolutionary biology, characterising as yet unknown biodiversity and exploring the genetic processes that affect how living organism populations react when faced with new environments. The researchers hope they can achieve the integration of biological control as an effective solution to manage invasive species and support the growth of Europe's agricultural sector.

There are, of course, risks posed by introducing exotic control species into a new habitat; however, Malausa points out those negative impacts on non-target species are rare: "Out of thousands of biological control agents introduced, negative impacts have only been observed in a few cases. Like any other pest control method, the relevance of introducing an exotic biological control agent must be assessed from a detailed risk-benefit evaluation and its comparison to the risk-benefit of other crop protection methods". The group's work to limit unintended effects is focused on host specificity through surveying scientific literature, studying ecological interactions in the native area and laboratory or semi-field experiments evaluating the host-specificity of the insects.

Building links to **fight pests**

A unique academia-industry partnership is exploring biological control solutions. Scientists-in-charge **Thibaut Malausa** and **Nicolas Ris** discuss the importance of this collaboration for supporting the introduction of pest control populations

What is the focus of the Intersectoral Collaborations to Boost Research and Development Dynamics in Biological Control of Agricultural pests (COLBICS) project and how does it fit in to your wider range of programmes on pest control?

TM: In terms of overall strategy, COLBICS displays the same common aims as our other projects. However, as a Marie Curie Industry-Academia Partnerships and Pathways (IAPP), the focus is on strong partnership with the commercial sector. This is designed to overcome barriers to the development of biological control activities.

Research institutes alone are limited in their ability to carry out biological control initiatives effectively. The commercial sector must play an important role in developing solutions and ensuring their diffusion. However, the growth of the biological control commercial sector has been slower than expected given the societal and political demand for environment- and health-friendly pest control solutions. Among the many factors accounting for this situation, we have identified two that can directly be addressed by researchers: the lack of investment for innovation and an insufficient adoption of the most state-of-art techniques. COLBICS is our response to this state of affairs.

Why are biological controls an important area for investigation at present?

NR: European agriculture is increasingly impacted by exotic pests or outbreaks of local pests. The management of these biological invasions could partly be ensured through biological control. Biological control is a strategy based on regulating pests using their natural enemies. This approach also meets requirements for a more sustainable agriculture. Indeed, the generalised use of chemical control has shown some limits in terms of efficiency, and environmental and sanitary impacts. Furthermore, biological control can be applied to environments where chemical control is not applicable. Its optimisation nevertheless relies on a better understanding of the evolutionary ecology of both pests and their natural enemies.

How are you fostering collaboration between industry and academia through this initiative?

TM: We integrate our research activities directly within the R&D programme of three commercial companies. In practice, the work is carried out by 'mixed teams' composed of staff from both academic and commercial participants in very close collaboration. This cooperation takes place either in industrial R&D facilities or in the research institutes. It contrasts with classical projects in which each participant is responsible for a deliverable, performs the work on their own and eventually shares it with the consortium. This way, the project directly supports industry R&D while offering researchers opportunities to address questions which are of interest not only for a few companies but for the whole biological control community.

Can you outline the intended impact of COLBICS and the key activities required in order to ensure its success?

NR: We anticipate three types of impact. First, COLBICS creates or strengthens long-term collaborations between academic teams and companies developing bio-control solutions. The input of academy into R&D programmes in the commercial sector is currently low, which considerably limits our global innovation capacities. Second, the project will test innovative methods and provide them – together with knowledge on organisms used in biological control – to the biological control community. Finally, the project will improve the competitiveness of the three commercial organisations involved, via the development of new products and production techniques. In practice, the key activities involved in these R&D programmes are mainly fieldwork to collect biological material, molecular biology analyses and laboratory experiments to characterise the studied organisms and design or test techniques.

COLBICS PARTICIPANTS AT A GLANCE

Academic sector:

French National Institute for Agricultural Research (INRA)

The INRA teams involved in COLBICS is located in Southern France (INRA PACA centre). Their research focuses on the development of biological control solutions using macroorganisms and the investigation of the population biology of biological control agents.

Universitat Politècnica de València

UPV is a Spanish technological university dedicated to researching and teaching. The group involved in COLBICS aims to improve the use of biological control for pest management in Mediterranean crops such as citrus and table grapes.

Pontificia Universidad Católica de Chile

UC has been ranked among the top five universities in Latin America. The UC team involved in COLBICS investigates the ecology of crop pests and biological control agents to develop sustainable crop protection strategies.

Industrial sector:

Biobest NV

Biobest is a pioneer and leading authority in pollination and biological pest control. It aims to be at the forefront of innovation and research in sustainable crop production developing new pollination and biological control solutions to meet the increasing demand for sufficient, safe and healthy food.

InVivo AgroSolutions

InVivo (the Union of the French agricultural cooperatives) has structured its added value services into its subsidiary InVivo AgroSolutions (IAS). One of the missions of IAS is the R&D of innovative biocontrol agents, eg. macroorganisms, microorganisms and semiochemical compounds.

Anasac-Xilema

ANASAC-Xilema is the main biological control company in Chile. The aim of the company is to develop the use of biological control in Chile, notably through the development of control strategy packages allowing the reduction of pesticide residues in exported fruits.

Advancing bio-control development expertise

By targeting the optimisation of bio-control undertaken by industry, the COLBICS alliance is attempting to improve knowledge about the way in which biological control agents work against arthropod pests

THE FRENCH NATIONAL INSTITUTE FOR AGRICULTURAL RESEARCH (INRA) is responsible for a number of cutting-edge projects addressing biological control of invasive pest species. One such effort is more specifically attempting to address knowledge gaps around the barriers to expanding bio-control activities. In addition, they are hoping to foster opportunities where public-private interactions can bring greater benefits to private sector bio-control.

Known as the Intersectoral Collaborations to Boost Research and Development Dynamics in Biological Control of Agricultural pests (COLBICS), this initiative has grown from biological control agent manufacturers' need for a transfer of competencies and to build research capabilities. Scientist-in-charge Thibaut Malausa outlines how their priority objectives include sharing public sector knowledge about bio-control agent characterisation and identification, developing and benchmarking the genetic and phenotypic measurement methods used in production techniques and promoting bio-control products: "We plan to achieve this last goal by providing pest control efficiency data to end-users and developing methods to improve the integration of bio-control products in the target agricultural settings," he explains.

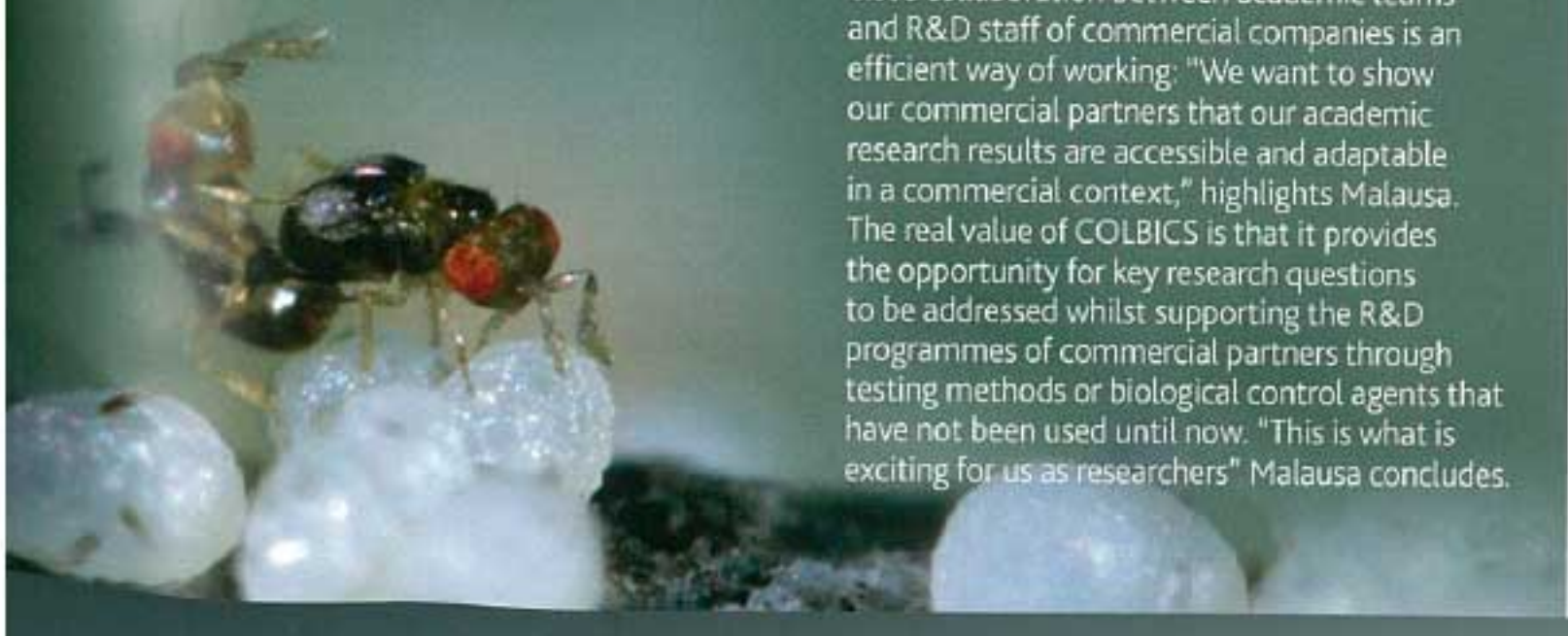
SHARING KNOWLEDGE

COLBICS is a Marie Curie Industry-Academia Partnerships and Pathways (IAPP) project, which fosters public and private research. This is being achieved through a unique collaboration between three academic research institutes and three private industry companies. The intention is to draw on the scientific background of the research teams who are working on ecology and evolution related projects, such as BICORAMICS and BIOMODICS. "Moreover, the R&D activities planned in COLBICS give us the opportunity to conduct experiments where we can investigate the factors affecting the establishment and performances of introduced populations," Malausa points out.

One of the anticipated outcomes will be the sharing of simple tools and methods from the public sector. These can then be directly incorporated into the routine practices of the private sector. Through a number of case studies these partners will be testing the relevance and added value of such tools and practices as it is currently thought that the private sector is reluctant or unable to use these because of a lack of financial support or access to the relevant expertise.

Cross-fertilisation of knowledge plays a key role within this project and also in the communication of linkages with other INRA programmes to enable the effective sharing of ideas and findings. The IAPP initiative is specifically designed around the transfer of information among teams with different scientific cultures. Malausa observes that this aim is particularly relevant in the context of biological control for two main reasons. Biological control relies on various disciplines, meaning the collaboration between scientists is important to achieve the project's goals. Furthermore, invasive pests generally move across country borders, so a great deal of value can be derived from working together and communicating new ideas and findings among teams working on the same problem in different places. "In our project, this transfer is mainly ensured by the international mobility of researchers between academic and commercial organisations". These staff movements and the diffusion and training events, such as seminars and workshops, are managed by a common coordination cell.

The ultimate goal of COLBICS is to effectively utilise the knowledge gained through the various projects currently designing and generating innovative solutions in biological control. Moreover, they aim to demonstrate that the close collaboration between academic teams and R&D staff of commercial companies is an efficient way of working: "We want to show our commercial partners that our academic research results are accessible and adaptable in a commercial context," highlights Malausa. The real value of COLBICS is that it provides the opportunity for key research questions to be addressed whilst supporting the R&D programmes of commercial partners through testing methods or biological control agents that have not been used until now. "This is what is exciting for us as researchers" Malausa concludes.



INTELLIGENCE

BICORAMICS, IPRABIO, COLBICS AND BIOMODICS

PARTNERS

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THIBAUT MALAUSA is a researcher at INRA. He investigates the genetic and demographic factors that affect the short-term evolution of biological control agents. His work also contributes to the development of support tools for biological control programmes (eg. molecular identification tools).

NICOLAS RIS is an engineer at INRA. He coordinates a team devoted to the development of biological control programmes against crop pests. His aim is to make bio-control benefit from innovations coming from research in evolutionary biology, molecular ecology or ecophysiology.