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The French touch in entomological biology: synthesis of the "16th Colloque Biologie de l'Insecte"

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The present paper represents a synthesis of communications collected in the "*16e Colloque Biologie de l'Insecte*" which gathered about 160 researchers from France and other European countries at Lyon in October 2010 (on-line reports of the symposium http://www.insavalor.fr/CBI2010). Because insects are some of the most familiar organisms of global ecosystems and because of their diversity, they are suitable models to investigate a broad spectrum of questions, in genetics and ecology as well as on populations and physiological responses to environmental changes. Molecular ecology approaches, spurred on by the recent advances in genomics, were omnipresent during this congress and revealed their relevance for the study of specific proximal mechanisms. As a consequence, most of presentations were focused on functional and mechanistic biology rather than conceptual approaches, following several of the recent trends outlined below.

From physiology to integrative physiology

Spectacular advances have been made in numerous disciplines of biological sciences that focus on genes, cells, individuals, populations and ecosystems. In this context, the communications presented clearly showed the need for integrative physiology studies to determine the underlying control mechanisms in phenotype expression and plasticity. For example, a functional characterization of the frost gene (*Fst*) implicated in cold tolerance in *Drosophila melanogaster* demonstrated that silencing *Fst* by transgenic RNA inference impaired the recovery process from chill coma (Colinet *et al.* 2010). Another study focused on post-mating sexual abstinence in the male moth, *Agrotis ipsilon* (Barrozo *et al.* 2010). By an experimental approach, the authors demonstrated that the behavioural responses of mated males to flower odors were inhibited by pheromone dose artificially heightened above the detection threshold of central neurons. Mated male moths have thus evolved a strategy based on selective central processing of transient odour, which prevents them from rapidly remating, in order to refill their reproductive glands for a potential new ejaculate. *Acyrthosiphon pisum* is an important model for physiology studies: critical stages of developmental changes during morphogenesis between embryo and larva exhibit an important role of aromatic amino acids (Rabatel *et al.* com. **O07**).

Importance of the studies of virus-insect interactions

Because numerous viruses infect insect species and often manipulate the physiology of their hosts, interactions between viruses and insects potentially impact populations functioning. The determinisms of the phenotypic effects of these viruses on their hosts, as well as their origins and their epidemiology are central issues. Through the example of the LbFV virus, manipulating the behaviour of superparasitism in the parasitoid *Leptopilina boulardi*, a study investigated

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the contribution of host and virus genotypes on the variability of the phenotypic effect induced by the virus but also how environmental factors influence epidemiology of the virus (Patot *et al.* 2010). In another study, Clavijo *et al.* (com. **O32**) analyze the spatio-temporal expression of the vankyrins (IKappaB-like proteins of the endosymbiont *Hyposoter didymator Ichnovirus, HdIV*) which could play an important role in the parasitism success of the wasp *Hyposoter didymator*. Plants-virus interactions were also discussed with, for example, the ability of a polerovirus to bind to phloem proteins in order to be transmitted during aphids' meals (Bencharki *et al.* 2010). The increase of the viral transmission could be correlated with a decrease in plant infestation. And last, many thousands of endoparasitic wasp species are known to inject polydnavirus particles into their caterpillar host during oviposition, causing immune and developmental dysfunctions that benefit the wasp larva. An analysis of the genes involved in Ichnovirus particles of *Hyposoter didymator* demonstrated that the ancestor of Ichnovirus differs from that of Brachovirus (Volkoff *et al.* 2010). These data provide an example of convergent evolution where different groups of wasps have independently domesticated viruses to deliver genes into their hosts.

Insect Ecology studies: contributing to new application fields

Because ecological paradigms are complex, they are nowadays studied through a wide diversity of scientific disciplines. Thanks to this plurality, application fields are numerous. The insights of insect ecology can be used to improve the control of pests and disease vectors, as well as in forensic entomology. Models seem today chosen not for their great contributions to scientific knowledge, but with the aim of finding a direct application for researches.

Mosquitoes: a model in medical entomology

Mosquito models were very representative of the congress, due to the great need to control these vectors of human diseases. A study on the gut flora of *Anopheles gambiae* suggested that *Plasmodium falciparum* was able to infect secondary hosts in relation with the composition of the mosquito flora (Boissière *et al.* com. **O33**). On the same model, another study showed that two carboxypeptidases are required for the development of this parasite, giving new potential targets for strategies limiting malaria transmission (Fougère *et al.* com. **O37**). In the other well-known mosquito, *Aedes aegypti*, a genomic study reinforced the hypothesis that a cadherine gene plays an important role in the resistance phenomenon emerging against the insecticide *Bacillus thuringiensis* subsp. *israelensis* (Bonin *et al.* 2009). In a similar way, the study of the transcription profiles of several P450 genes in *A. aegypti* show different transcription profiles according to xenobiotic exposure, life stage and sex (Poupardin *et al.* 2010). Authors identified particular genes likely to have chemo-protective functions in this insect.

Pest control and urban entomology

Although inherent to any research work, interaction between researches performed in the laboratory and the application of acquired knowledge in the field must be particularly developed. By this dynamic, biological pest control can be implemented while considering the practical and economic pressures met by farmers, as was done in the control of the sugar cane borer *Chilo sacchariphagus* in La Réunion Island (Tabone *et al.* com. **O14**). Another way to control pests is the use of natural substances. For example, dicaffeoylquinic acids (diCQ), derived from caffeic acid, presents a high potential for repulsion and toxicity against insects. These proprieties have been tested and confirmed on different species of aphids, like *Myzus persicae* (Servier *et al.* com. **O09**).

Insect pollinators, necessary to the reproduction of many plant species, are essential at an ecological and economic level. At the end of this international year of biodiversity, a European program Life+ Biodiversité called "Urbanbees" for URBAN BEE biodiversity actionplanS (2010-2014) has been launched to protect the stupendous diversity of wild bees living in urban and suburban environment (Mouret *et al.* com. **O11**). Moreover, chemical ecology is one of the approaches allowing the understanding of the functioning of pollinators, and it has been studied with the analysis of the mutualistic interactions between coleopterans (genus: *Elaeidobius*) and the African oil palm *Elaeis guineensis* (Frérot & Ollivier, com. **O12**).

Impact of human activities on insect ecology

The consequences of anthropogenic activities on ecosystems confront scientists to new and complex problematic illustrated by the studies respectively on climate changes and invasive and pest species. To bring up original questions, these studies profited from particularities of insect models, namely their sensitivity to temperature, their various interactions with others species, and their adaptability in response to a resource change. Thus, by focusing on populations of the parasitoid *Leptopilina boulardi* in the Rhone valley, (Delava *et al.* com. **O22**) investigated the relative contribution of migration, phenoytpic plasticity and genetic adaptation to cope with increasing temperature; while Kaufmann *et al.* (com. **O24**) attempted to assess, through the ecological system *Fallopia* spp. and *Lasius neglectus*, the effects of mutualistic interactions between invasive species on their capacity to colonize a new habitat. From the pest species of the genus *Sesamia*, Chouquet *et al.* (com. **O17**) studied the ability of insect populations to preferentially exploit wild-host plants or cultivated host-plants due to the extension of agricultural areas, by the analysis of the cGMP-dependent protein kinase (PKG) encoded by the *foraging* gene.

The missing: symbioses, behavioural ecology and ecology of community

Surprisingly, few presentations discuss about symbiosis and insect ecology. A study on four *Curculio* spp. brought the hypothesis that species and prevalence of symbiont have a major implication in the different ways used by insects for ressources' exploitation. The ability of specific symbiont to digest particular compounds should allow the coexistence of host species on a resource changing qualitatively with time (Merville *et al.* com. **O38**). Another study also suggests that *Wolbachia* symbiotes can contribute to feeding behaviors by directly interacting with plants. Indeed, the leaf-mining herbivorous insect *Phyllonoricter blancardella* that use deciduous leaves to fuel growth and reproduction even beyond leaf fall is able to block the senescence of a leaf after its infestation in order to keep a lasting pantry (Kaiser *et al.* 2010). Bacteria impacted plant physiology through manipulation of cytokinin levels. Furthermore, the scientific community working on symbiosis has been thrilled by an innovating result from a study on *Acyrthosiphon pisum* secondary symbiosis. Here, in addition to their obligatory symbiont *Buchnera aphidicola*, populations of these aphids live with a great diversity of facultative symbionts. The symbiont *Spiroplasma* presents an important effect of male-killing whereas a new facultative symbiont, close to *Rickettsiellas* induces a change of aphid colour, from pink to green (Tsuchida *et al.* 2010).

Few communications focused on behavioural and community ecology. First, Froissart *et al.*(com., **O20**) investigated, in the parasitoid *Venturia canescens,* the dynamic of memory in relation to resources distribution in environment. Secondly, Pélisson *et al.* (com. **021**) explored theories developed in community ecology (niche versus neutral theories) to explore the coexistence mechanism of four insect species of genus *Curculio*, in competition for a same resource.

As the "*16e Colloque Biologie de l'insecte*" demonstrated, insects are exciting in vivo models at the molecular or organism level to enhance knowledge of the integrative physiology of insects. Another point raised during the congress is the involvement of members of others communities, like medicals ones, mainly on the emerging mosquitoes' model. Due to these new points of view, the "Colloque Biologie de l'Insecte" showed depth approaches at the molecular level to lighten the understanding of functional pathogens-insects interactions mechanisms. But as the professor A. Nappi from the University of Loyola, Chicago, said "things are not always what they seem" and this assertion leads the community to question at a wider focus, on the global conception of the insect biology, with poorly explored fields such as symbiosis, behavioural ecology and ecology of community to enlarge. Moreover, most of speakers were young scientist showing the present dynamism of French entomology.

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