CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE

Sciences du Vivant - Environnement et Développement durable

CONFÉRENCES JACQUES-MONOD

Roscoff (France), 22-26 septembre 2007

Génétique Evolutive des Relations Hôte-Parasite

Evolutionary Genetics of Host-Parasite Relationships

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Rapport sur la conference

Conference report

RESUME du RAPPORT

Conférence Jacques Monod intitulée : Génétique évolutive des relations hôte-parasite

Organisée par Dieter Ebert, Président et Gabiele Sorci, vice-Président.

Objet de la conférence

La conférence « Génétique évolutive des relations hôte-parasite » a eu lieu à Roscoff du 22 au 26 septembre 2007. Elle a réuni 90 chercheurs, post-docs et étudiants de 13 pays différents. Vingt-sept conférenciers invités ont présenté leurs travaux ainsi que 10 jeunes chercheurs sélectionnés parmi les inscrits. A cela, il faut rajouter 44 présentations sous la forme d'affiches.

La conférence s'est articulée sur 5 sessions portant sur des niveaux d'organisation biologique croissante.

Session I : Génétique des parasites et épidémiologie

Les exposés de cette session ont porté essentiellement sur la dynamique virale et l'évolution de la virulence.

Session II : Génétique des hôtes

Cette session a couvert plusieurs aspects de l'organisation génétique des hôtes permettant de faire face à des microorganismes au très grand potentiel d'évolution.

Session III : Coévolution

La théorie de la reine rouge et le rôle de la recombinaison génétique dans le processus de coévolution hôte – parasite ont été au cœur des exposés présentés dans cette session.

Session IV : Interactions plantes - virus

La session IV a porté sur les interactions entre les mécanismes des défenses des plantes et l'évolution virale.

Session V : Systèmes hôtes – parasites complexes

Enfin, dans cette dernière session nous avons assisté à plusieurs exposés portant sur des interactions complexes, impliquant soit plusieurs espèces d'hôtes soit des hôtes, des vecteurs et des microparasites.

De l'avis de tous les participants, la conférence a été un très grand succès. L'adhésion des participants au projet porté par les Conférences Jacques Monod s'est traduite par la volonté explicitement exprimée de renouveler cette expérience lors d'une nouvelle conférence en 2010. A cette fin, les participants ont voté à l'unanimité pour que Gabriele Sorci (CNRS, Université de Bourgogne) et Manfred Milinski (MPI, Ploön, Allemagne) jouent le rôle de président et de vice-président, respectivement.

CONFERENCE REPORT

In September 2004 a Jacques Monod Conference on the topic "EVOLUTIONARY ECOLOGY OF HOST-PARASITE RELATIONSHIPS" was held in Roscoff, organized by Thierry Rigaud (President) and Dieter Ebert (Vice-President). This conference was a big success and the participants voted in favour of a follow up conference to be held 3 years later. Dr. Gabriele Sorci was elected as the new Vice-President. The follow-up conference took place in roscoff from 22-26 September 2007. This document summarizes the key issues of the 2007 JMC.

Part 1: Programme overview

The original proposal listed three topics:

Topic 1. Understanding the genetic interactions between hosts and parasites.

Topic 2. Host and parasite evolution and the maintenance of sexual reproduction

Topic 3. The evolutionary genetics of immune defence.

For the program of the conference we used a different structure:

Session I	Parasite genetics and epidemiology
	Génétique des parasites et épidémiologie
Session II	Host genetics
	Génétique des hôtes
Session III	Coevolution
	Coévolution
Session IV	Plant – virus interactions
	Interactions plantes - virus
Session V	Complex host-parasite systems
	Systèmes hôtes – parasites complexes

For the poster sessions we used an open format, i.e. we did not allocate posters to topics. There were a total of 44 posters.

Part 2: Participants

Invited speakers by topic as outlined in proposal. Each invited speaker gave a 30 minute presentation about her/his work.

Topic	Speaker	Gender	Institution	Country
1	Bensch, S.	m	Lund University	Sweden
1	Du Pasquier, L.	m	Universität Basel	Switzerland
1	Ebert, D	m	Universität Basel	Switzerland
1	Fleury, F.	m	Université de Lyon	France
1	Schulenburg, H.	m	Universität Tübingen	Germany
1	Quintana-Murci, Lluis	m	Institute Pasteur,	France
1	Rainey, P.B.	m	Uni. Auckland	NZ
1	de Meeus, T.	m	CNRS-IRD Montpellier	France
2	Blanc, S.	m	INRA, Baillarguet	France
2	de Boer, R.	m	Utrecht University, Utrecht	Netherlands
2	Elena,S.	m	CSIC Valencia	Spain
2	Gandon, S.	m	CNRS-IRD, Montpellier	France
2	Lipsitch, M.	m	Harvard School of Public Health	USA
2	Lively, C.	m	Indiana University	USA
2	McCoy, K	f	Montpellier	France
2	Rigaud, T.	m	Uni. Bourgogne, Dijon	France
2	Schmid-Hempel, P.	m	ETH-Zürich	Switzerland
2	Turner, P.	m	Yale University	USA
3	Bonhoeffer, S.	m	ETH Zürich	Switzerland
3	Altizer, Sonia	f	Uni. Georgia, Athens	USA
3	Milinski, M.	m	Max Planck Inst Limnol, Plön	Germany
3	Penn, D.J.	m	Konrad Lorenz Institute, Vienna	Austria
3	Zoorob, Rima	f	CNRS-Villejuif	France
3	Grenfell, B.	m	Penn.State	USA
3	Hahn, Caldwell	f	Patuxent Wildlife Center, Maryland	USA
3	Sorci, G.	m	Uni. Bourgogne, Dijon	France

Oliver Tenaillon, INSERM-Bichat Paris had to cancel its participation in the last minute, for personal reasons. This resulted in 26 talks by invited speakers.

Only 4 out of 27 invited speakers, were females. All our attempts to increase female participation failed because the chances that an invited female speaker would not accept the invitation was several times higher than it was for males.

8 (= 30%) of the 27 invited speakers had been at the previous JMC (Sept. 2004) on a similar topic.

10 invited speakers were from France, 10 invited speakers were from Europe, outside France and 7 were from outside Europe (6 of them from the USA).

Besides the invited speakers, the following people were selected based on their abstract to give 15 minute presentations:

BROWN James

CLAIN Jérôme

FELLOUS Simon

GABA Sabrina

GARAMSZEGI Laszlo

IBELINGS Bas

KOELLE Katia

KOUYOS Roger

REFARDT Dominik

WEILL Mylène

Non-invited participants

A total of 64 non-invited people from 13 countries took part in the conference. Of those, 21 were from France, 35 were from Europe outside France and 8 were from outside Europe.

44 posters were presented. The average quality of the posters was very high.

Part 3: Scientific program

There is growing awareness that neither "hosts" nor "parasites" are static entities, that their populations are composed of a variety of interacting and competing genotypes, and that this genetic variation is not only important for humans, but also for agriculture and natural populations of plants, animals and microbes. Understanding the genetics of host and parasite evolution and coevolution is particularly important at a time when new diseases affecting humans or animals are emerging around the world, while old, well-understood diseases like tuberculosis are acquiring broad resistance to traditional drugs. Several million tons of crops are lost every year due to attack by rapidly adapting plant parasites. Around the world, whole ecosystems are being changed or threatened by epidemics of introduced parasites, e.g. Rinderpest, Dutch elm disease and Phytophthora root disease. The great impact of disease producing organisms stands in strong contrast to our limited knowledge of the basic mechanisms, which govern their evolutionary dynamics.

The conference started from the premise that parasites and pathogens are ubiquitous and influence almost every conceivable level of biological organisation, including human health, animal welfare and agriculture. Infectious diseases have been implicated either directly or indirectly influencing community composition, host densities and dynamics, host behaviour, host life history, genetic polymorphism for resistance, hypermutability and many other phenomena.

Evolving pathogens and parasites have become a main stream topic in science and also in the public awareness. The JMC in Sept. 2007 in Roscoff saw many examples of the way how host and parasite evolve or coevolve. The conference covered the entire field of host and parasite evolutionary genetics and coevolution. The confernce was structured in 5 sessions, which were organized to move from lower to higher biological complexity. This was in particular for the younger people in the audience very helpful.

Session I Parasite genetics and epidemiology / Génétique des parasites et épidémiologie

The first season covered field from viral dynamics to the evolution of virulence. The common theme of this session was the amazing speed with which parasites are able to evolve to exploid their hosts. This holds true for bacteria infecting humans, phages infecting bacteria and protozoa infecting butterflies. From an applied point of view it is encouraging to see that simple concepts even work to explain phenomena in complex systems. On the other hand the infinite number of ways parasites and pathogens have come up with to escape the hosts and our means to control them continues to frustrate researchers. We are still a long way from being able to control many of the big infectious diseases, which still kill millions of people every year.

Session II Host genetics / Génétique des hôtes

The other side of the system are host adaptations to control pathogens and parasites. Louis Du pasquier highlighted the lates research in diversity generating mechanisms, which hosts use to recognize their antagonists. Interesting here is the taxonomic diversity. Different taxa invented different ways to create the diversity necessary to recognize a moving object. The following talks highlighted examples of this, mainly in the vertebrates. The presented talks gave a good overview over the diverse technologies used today to study host parasite

interactions, ranging from concept driven approaches, via hard core molecular techniques, geneomics to behavioural experiments using peptide engineering and smell preferences.

Session III Coevolution / Coévolution

Coevolution describes the reciprocal evolutionary interactions between populations (or species), which lead to adaptive changes in the involved participants. It is a change in the genetic make-up of a population in response to a genetic change in an interacting population. The adaptive values of these changes depend critically on the genetic composition of the other population and as pointed out by P. Schmid Hempel are therefore often very specific. Coevolution (or coadaptation) has been suggested to occur in many situations, ranging from coevolving guilds (e.g. pollinators - plants), mutualism (e.g. aphids and their bacterial symbionts; ants - acacia), warning signals (e.g. mimicry), sexual antagonism (male - female conflict), predators - prey associations (e.g. ants - ant lions) and host - parasites associations (e.g. human - malaria). Antagonistic interactions have the potential to produce ongoing coevolutionary dynamics, because an evolutionary advantage gained by one antagonist is often associated with a disadvantage for the other antagonist, and may therefore prompt a counter adaptation. The JMC focussed entirely on such antagonistic interactions between hosts and parasites.

In the last two decades specific antagonistic coevolution between hosts and parasites has been a leading theme in evolutionary biology, parasitology, ecology, epidemiology, and lately also in applied fields, such as human and veterinary medicine, agriculture and biocontrol. Antagonistic coevolution has been suggested to underlay a large number of well known phenomena, some of which are still poorly understood, such as genetic recombination (and sexual reproduction (talks by S. bonhoeffer, S. Gandon, C. Lively)), sexual selection based on the Hamilton-Zuk hypothesis (talk by M. Milinski), autumn colours of trees, hypervariability loci, the extraordinary genetic diversity at genes related to immune function or resistance (e.g. MHC, R-genes), spatial divergence and local adaptation in host-parasite systems, high rates of amino-acid replacements in resistance and virulence genes, restriction enzymes in bacteria, parasite virulence, multiple mating in social insects, polyploidy, RNA interference (RNAi), and host and parasite specialisation and speciation. Some of these phenomena require coevolution to be very rapid and specific. Possibly the most extreme in this respect, but also the most spectacular, is the parasite hypothesis for the maintenance of sexual reproduction. Based on mathematical models it was suggested that the sign of epistasis among genes under selection must fluctuate continuously over time periods of only 2–5 generations. Evolutionary dynamics of this kind and speed had not been observed so far. After years of discussion about coevolution, recent years saw the first examples of experimental evidence for rapid antagonisitc coevolution under natural conditions. Several talks at the JMC pointed out that Red Queen dynamics are not as unlikely as had been claimed only a few years ago.

Session IV Plant – virus interactions / Interactions plantes - virus

In this small session on virus-plant interactions S. Elena and S. Blanc presented work on host defence and virus - vector - host interactions.

Session V Complex host-parasite systems/ Systèmes hôtes – parasites complexes

The last session made it clear that not even host-parasite pairs are alone on this planet. Biological diversity in all its complexity becomes visible when you have a close look at natural systems. Parasites may have multiple host species and hosts may become infected by many different parasite species. A combined approach using molecular and epidemiological tools characterized all talks in this session. All speakers stressed that we see only the tip of the ice berg and that the true diversity is still below the water. Evolutionary predictions are so far not possible for such systems. We are a long way from understanding the biodiversity of such systems and their long term implications for stability of ecosystems.

Final Comments

The goal of this conference was to support good and innovative research in the field of evolutionary genetics of infectious diseases. We wanted to stress those fields from which we believe that they are the most promising for the future development of the entire field. We wanted to bridge the gap between theory and empirical work. We believe that worked well. It fostered communication among researchers and helped younger people to obtain an overview over this rapidly growing field.

As evidenced by the cutting edge and largely unpublished research described at the conference, a conceptual framework is beginning to emerge which allows us to better understand the way in which hosts and parasites evolve and coevolve. While modern techniques using genomics or protein engineering cleary made their way into the field, traditional methods have been shown to be able to produce still new and exciting data and are able to answer questions. Evolutionary biology is more than ever a growing field, which allows us to bring many biological disciplines under one umbrella. The unifying concept of evolution privides a framework to bring these disciplines together and to reach overarching conclusions.

Perspectives

The participants felt there is a need for organizing another meeting on the issue in 2009 or 2010. They elected on the last day of the Conference Dr Gabriele Sorci (Dijon) to act as the next president and Prof. Dr. Manfred Milinski (MPI, Ploön, Germany) to act as vicepresident for the next conference. Together they are asked to apply for another Jacques Monod Conference on host - parasite interactions and evolution.

Detailed program

Sunday, September 23rd / Dimanche 23 septembre

Session I: Parasite genetics and epidemiology / Génétique des parasites et épidémiologie

08:30-08:45 Dieter EBERT (Basel, Switzerland)

Welcome and opening

Accueil et ouverture

08:45-09:20 Paul TURNER (New Haven, USA)

Evolutionary ecology of RNA virus emergence

Ecologie évolutive de l'émergence des virus à ARN

09:20-09:55 Olivier TENAILLON (Paris, France)

Ecological and genetic determinants of phage bacteria co-evolution

Déterminants écologiques de la co-évolution entre phages et bactéries

09:55-10:30 Marc LIPSITCH (Boston, USA)

Why are there so many serotypes of Streptococcus pneumoniae?

Pourquoi y-a-t il plusieurs sérotypes de Streptococcus pneumoniae?

10:30-11:00 Coffee break – Pause café

11:00-11:35 Sonia ALTIZER (Athens, USA)

Temperature, toxins and transmission: infection in a migratory butterfly host

Température, toxines et transmission: infection chez un papillon migrateur

11:35-12:10 Thierry RIGAUD (Dijon, France)

Sources of variation in parasite-induced behavioural changes: cases studies with acanthocephalan infecting amphipods

Sources de variation dans les changements comportementaux induits par les parasites: cas d'études avec les acanthocephales infectant des amphipodes

12:10-12:45 Bryan GRENFELL (University Park, USA)

Immune escape and the spatiotemporal dynamics of infectious disease

Evasion du système immunitaire et la dynamique spatio-temporelle des maladies infectieuses

12:45-14:00 Lunch

14:20-14:55 Paul RAINEY (Auckland, New Zealand)

Spatial structure and the evolution of species interactions

Structure spatiale et l'évolution des interactions entre espèces

14:55-15:30 Thierry DE MEEÛS (Montpellier, New Zealand)

Levels of population genetics structuring of hosts, parasites and vectors and the role played by host's home, sex, genetics and individuality

Les niveaux de structuration génétique des hôtes des parasites et des vecteurs et le rôle joué par le domicile, le sexe, la génétique et l'individualité des hôtes

15:30-15:45 Dominik REFARDT (Auckland, New Zealand)

Experimental evolution of inducibility of phage λ

Evolution expérimentale de l'inducibilité chez le phage λ

15:45-16:00 Mylène WEILL (Montpellier, France)

High diversity of cytoplamic incompatibilities induced by Wolbachia within the Culex pipiens mosquito complex

Diversité des incompatibilités cytoplasmiques induites par Wolbachia au sein du complexe Culex pipiens

16:00-16:30 Coffee break – Pause café

16:30-16:45 Jérôme CLAIN (Paris, France)

Parallel evolution of adaptive mutations in Plasmodium falciparum mitochondrial DNA during atovaquone-proguanil treatment

Evolution parallèle des mutations adaptatives dans l'AND mitochondrial de Plasmodium falciparum pendant le traitement avec atovaquone-proguanile

16:45- 17:00 Simon FELLOUS (Ascot, United Kingdom)

Transgenerational interactions between parasite strains in a mosquito

Interactions trans-générationnelles entre souches de parasites dans un moustique

17:00-17:15 Laszlo GARAMSZEGI (Wilrijk, Belgium)

The evolutionary ecology of primate malaria parasites

Ecologie évolutive de la malaria chez les primates

17:15-17:30 Katia KOELLE (Durham, USA)

An analytical framework for understanding influenza's dynamical, phylogenetic, and antigenic patterns in human hosts

Approche analytique pour la compréhension des patrons de dynamique, phylogénétique et antigénicité de la grippe chez l'homme

17:30-19:10 Poster session I and Wine tasting

Session de communications affichées I et dégustation de vins

Monday, September 24th / Lundi 24 septembre

Session II: Host genetics / Génétique des hôtes

08:30-09:05 Louis DU PASQUIER (Basel, Switzerland)

Diversification of immune repertoires in Metazoa

Diversification des répertoires immunitaires chez les métazoaires

09:05-09:40 Gabriele SORCI (Dijon, France)

Is immunopathology an unavoidable cost of immunity?

Immunopathologie et le coût de l'immunité

09:40-10:15 Rima ZOOROB (Villejuif, France)

Genetic architecture of the MHC

Architecture génétique du CMH

10:15-10:50 Lluis QUINTANA-MURCI (Paris, France)

Searching for the footprints of pathogen pressures in the human genome

A la recherche des traces des pressions de parasitisme sur le génome humain

10:55-11:20 Coffee break – Pause café

11:20-11:55 Manfred MILINSKI (Plön, Germany)

Signalling MHC immunogenetics to conspecifics

Signalisation de l'immunogénétique du CMH aux congénères

11:55-12:30 Dustin PENN (Wien, Austria)

Experimental pathogen evolution testing whether Salmonella adapts to host genetics

Evolution expérimentale des pathogènes: l'adaptation de Salmonella à la génétique de l'hôte

12:30-13:05 Caldwell HAHN (Laurel, USA)

Elevated exposure to parasites and effects on the immune system

Exposition aux parasites et effets sur le système immunitaire

13:05-14:05 Lunch

Free afternoon : boat trip to Batz Island

18:00-19:30 Poster session II Session de communications affichées II

Tuesday, September 25th / Mardi 25 septembre

Session III: Coevolution / Coévolution

08:30-09:05 Rob DE BOER (Utrecht, The Netherlands)

Host immune responses and viral evolution

Réponse immunitaire et évolution virale

09:05-09:40 Dieter EBERT (Basel, Switzerland)

The interactions between Daphnia and its parasites

Interactions entre les daphnies et leurs parasites

09:40-10:15 Hinrich SCHULENBURG (Tübingen, Germany)

Experimental test of the consequences of host-parasite coevolution

Test expérimental des conséquences de la co-évolution entre hôtes et parasites

10:15-10:55 Paul SCHMID-HEMPEL (Zürich, Switzerland)

Host-parasite interactions and genetic architecture

Interactions hôte-parasite et l'architecture génétique

10:55-11:20 Coffee break – Pause café

11:20-11:55 Curtis LIVELY (Bloomington, USA)

Host-parasite coevolution and the evolutionary stability of sex

Co-évolution entre hôtes et parasites et la stabilité évolutive du sexe

11:55-12:30 Sylvain GANDON (Montpellier, France)

The evolution of recombination and fluctuating epistasis (with or without host-parasite coevolution)

Evolution de la recombinaison et de l'épistasie fluctuante (avec ou sans co-évolution hôte-parasite)

12:30-13:05 Sebastian BONHOEFFER (Zürich, Switzerland)

An ODE to the queen

Une ODE à la reine

13:00-14:30 Lunch at the Conference Centre (Gulf Stream Hotel)

Déjeuner au Centre de Conférence (Hôtel Gulf Stream)

Session IV: Plant - virus interactions / Interactions plantes - virus

14:55-15:30 Santiago ELENA (Valencia, Spain)

The evolution of silencing suppression and other ways viruses have to escape from silencing

L'évolution de la suppression silencieuse

15:30-16:05 Stéphane BLANC (Montpellier, France)

Helper-dependent vector-transmission: a non-parsimonious strategy adopted by the majority of plant viruses

Transmission par vecteur dépendant de l'aide d'un autre organisme: une stratégie non parcimonieuse adoptée par la majorité des virus de plantes

16:05-16:30 Coffee break – Pause café

16:30-16:45 James BROWN (Norwich, United Kingdom)

Space: the final frontier for gene-for-gene interactions

L'espace: l'ultime frontière pour les interactions gène pour gène

16:45-17:00 Roger KOUYOS (Zürich, Switzerland)

Red queen dynamics and the evolution of recombination

Dynamique de la Reine Rouge et l'évolution de la recombinaison

17:00-17:15 Sabrina GABA (Basel, Switzerland)

To which extend do experimental designs affect host parasite coevolution detected patterns?

Dans quelle mesure les designs expérimentaux affectent-ils les patterns de co-évolution observés entre hôtes et parasites?

17:15-17:30 Bas IBELINGS (Kastanienbaum, Switzerland)

Does genetic diversity of the diatom Asterionella hinder evolution of parasitic (chytrid) fungi?

La diversité génétique de la diatomée Asterionella empêche-t-elle l'évolution de champignons parasites?

17:30-19:10 Gabriele SORCI

General Discussion

Discussion générale

Wednesday, September 26th / Mercredi 26 septembre

Session V: Complex host-parasite systems / Systèmes hôtes – parasites complexes

08:30-09:05 Karen McCOY (Montpellier, France)

Cascading host effects in the marine cycle of lyme borreliosis

Effets d'hôte en cascade dans le cycle marin de la borreliose

09:05-09:40 Staffan BENSCH (Lund, Sweden)

Host-parasite evolution in bird malaria

Evolution hôte-parasite de la malaria aviaire

09:40-10:15 Frédéric FLEURY (Villeurbanne, France)

Evolutionary genetics of insect host-parasitoid interactions: the importance of multipartite interactions and predominant role of symbiotic micro-organisms

Génétique évolutive des interactions hôte - parasitoïde: importance des interactions multiples et rôle prédominant des micro-organismes symbiotiques

10:15-10:25 End of the Conference

Fin de la conférence