radar to record the complete flight paths of bees that had been recruited by the waggle dance. In the harmonic radar technique, a small 'transponder' is attached to the bee that is to be tracked, and this device returns signals to the radar at twice the frequency of the outgoing radar pulse. The radar is equipped with a receiver that can pick up this unique signal, but will ignore the very much larger reflections from topographical features and vegetation (clutter), so the transponder, and therefore the bee, can be detected and its position recorded. The transponder has to be very small and light, of course, and this is made possible because no battery is required – the energy required to operate the transponder is picked up from the outgoing radar signal. The transponders used in the waggle dance studies weighed about 12 mg.

The field study was carried out in collaboration with with Professor Randolf Menzel of the Free University of Berlin, and took place in Germany at a large (1 × 2 km) site where the ground was flat and relatively free from obstructions that would have obscured the radar's field of view. Foragers were trained to an unscented artificial food source 200 m from the hive, and then recruits were observed through the glass panel of the observation hive as they followed the foragers' dances. When these recruits left the hive they were fitted with transponders and released. The radar showed that these bees flew straight to the vicinity of the feeder, exactly as von Frisch's theory predicted, but then spent a lot of time in the local area searching trying to find it – hence the flight-time anomaly that caused the original controversy. Recruits that were displaced 250 m south of the hive before being released also made straight flights to where the food source would have been, had they not been displaced, a result that provided overwhelming support for von Frisch. The wind field over the study site was recorded with a network of anemometers, and the team were able to show that the recruits compensated for cross winds, in spite of the fact that they were flying to destinations that they had never previously visited.

Reference

1. RILEY, J R; GREGGERS, U; SMITH, A D; REYNOLDS, D R; MENZEL, R (2005) The flight paths of honeybees recruited by the waggle dance. *Nature* 435: 205–207.

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BRAVE: Bee Research and Virology in Europe

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The BRAVE project is the result of a call under the European Commission's 6th Framework Research and Development Programme in the area of policy-orientated research. The primary focus assigned to this Specific Support Action was 'to assess the level of risk and the likely consequences for bees and other closely related pollinators of the introduction of bee viruses into European bee colonies and ecosystems, and to provide advice to the EC on appropriate protective measures to prevent further incursions and spread.' Building on initiatives arising from the European Association for Bee Research (EurBee), a response to this call was formulated by a Steering Committee comprising Dr Michel Aubert, AFSSA, France (co-ordinator); Brenda Ball, Rothamsted Research, UK; Prof. Ingemar Fries, Swedish University of Agricultural Sciences, Uppsala; Prof. Norberto Milani, University of Udine, Italy; and Prof. Robin Moritz, University of Halle, Germany.

The aims of BRAVE are firstly, to facilitate knowledge and skills transfer between researchers and advisors within the European Research Area of bee virus diseases through the establishment of closer contacts and collaborations, and secondly to identify significant gaps in the essential scientific knowledge required to support the formulation and integration of policy on the endemic and emergent diseases of bees. The project duration is one year and the EC funding provided will be used for two expert meetings.

The first scientific meeting was held at Sophia-Antipolis, Provence, France, from the 24th to 26th April 2005 was attended by 55 scientists, advisors and policy makers specifically invited because of their specialist knowledge and skills. Participant expertise ranged from insect virology, virus taxonomy, immunology, epidemiology, disease risk assessment and international trade, to fundamental and applied research on pollinators and their pathogens. Delegates represented 14 European countries as well as Australia, Canada and the USA, together with representatives of the European Commission and the OIE (Office International des Epizooties), and young scientists and students had the opportunity to apply for additional places.

The study of bee viruses has previously been limited to relatively few researchers, perhaps due to the difficulties in identifying these agents, a lack of distinctive symptoms in the diseases they cause, or a perception that they were of little economic importance. This situation has changed recently with the establishment and spread of *Varroa destructor* throughout the beekeeping world and the discovery that the devastating damage to colonies is not caused directly by the mite but by a number of unrelated honey bee viruses which it can vector.

The first sessions of the meeting explored the complex and evolving taxonomy of bee viruses, placing them into context with other similar insect and plant viruses. There was discussion of the often considerable genetic variability which may exist within virus 'species', especially within single-stranded RNA viruses, like many of those affecting the honey bee. A series of presentations then covered the range of diagnostic techniques now available for virus detection. Various serological techniques and infectivity tests have been used for many years, and have now been joined by a range of molecular techniques that offer the prospect of much greater sensitivity. The complete or partial RNA sequences of six of the 20 or so honey bee viruses have been elucidated in the last few years. Discussion explored the appropriateness of the techniques for particular applications. For example, the lack of sensitivity of serological techniques may still make them relevant in the recognition of biologically significant, overt, virus infections against a background of inapparent and perhaps unimportant infections. On the other hand, molecular techniques now offer powerful tools for teasing out the complex taxonomic relationships between virus strains from around the world. It is also clear, however, that there is a need for the standardization of diagnostic techniques, and validation of methodologies using established

protocols with known reference strains of viruses. A major barrier to more detailed bee virus research at the cellular level, and one which was repeatedly mentioned, remains the lack of a bee cell line, essential for such studies.

Further sessions covered aspects of the genetics, physiology and behaviour of honey bees in relation to their resistance to virus infections. A better understanding of the mechanisms of immune responses in insects in general has been aided by genome sequencing and studies of gene function. It is to be hoped that similar progress in these areas may be afforded by the sequencing of the honey bee genome. The genetic basis of disease resistance in bees was explored, and an alternative genetic map produced by the use of microsatellites may be of future value in the breeding and selection of bees that are more resistant to disease. Several papers then considered the persistence of virus at sub-lethal levels in honey bees, and it became clear that there is little agreement and consistency in the use of terms such as 'latent', 'inaparrent', 'persistent' and 'sub-lethal' infections, and very little understanding of what these terms mean in relation to the number of virus particles present in the different tissues of individual bees. The question of viruses being 'triggered' by mite feeding, the association of virus infections with other parasites such as *Nosema apis*, and the possible depression of the honey bee immune response by exposure to sub-lethal doses of pesticides were also raised.

The evolutionary epidemiology of virus diseases and their virulence was considered in relation to the different routes of transmission available within social insect populations and the degree to which this picture has been changed in the honey bee system by *V. destructor*, and also perhaps by other exotic mite species. Current information on the incidence, distribution and impact of honey bee viruses was reviewed, revealing large gaps in our knowledge. Although recent studies have provided more information on the incidence and prevalence of viruses in Europe, in many countries elsewhere, often those with large and economically important beekeeping industries, there is little or no information available. With increasing world trade and movement of stocks of social and solitary species of bees, this lack of knowledge of the pathogens present in populations is clearly a crucial deficiency. The management of bee diseases was then considered, mainly in relation to *V. destructor*. The effect of acaricides on the behaviour and pollinating efficiency of bees, a consideration of economic treatment thresholds and the development of tolerance in bees to mites and resistance of mites to acaricides were all covered.

The final session concerned the current regulatory mechanisms governing the movement of honey bees into the EU and the assessment of the risk of pathogen introduction related to trade issues. The recent widespread commercial movement of various bumble bee species around the world, the virus pathogens of which are virtually unknown, was highlighted as a current cause of concern. It became apparent that at present there is insufficient knowledge of the distribution, epidemiology and economic impact of honey bee viruses to contemplate the introduction of legislation to regulate bee movement. It is however possible that the introduction of honey bee viruses to new locations has already occurred, although the implications of this are still largely unknown.

Bee scientists who are not virologists, the virologists who do not normally work on bees, and those involved in the regulatory aspects of bee and disease management, all should have left the meeting with a much greater understanding of the challenges faced and of the possibilities for future fruitful collaboration. Following the scientific meeting, a proceedings of the papers presented will be produced, and recommendations for the focus of future research efforts, formulated during the discussion sessions of the working groups, will be made available to the EC and posted on the BRAVE website:

http://www.entom.slu.se/brave/

A smaller expert workshop meeting will take place later this year at which the session rapporteurs of the first meeting will prepare a synthesis of current knowledge in the different subject areas in the form of a book chapter. This workshop will also make recommendations about the means of achieving the identified research priorities at both the fundamental and applied levels, with the aim of putting in place a framework for integrating European research effort into bee viruses in support of Community policy.

The intensive schedule of the meeting was relieved by the excellent food and pleasant setting of the Club Med village, Opio. Those travelling from a cold and wet British spring were initially disappointed to find similar weather in the south of France, but things changed for the better in time for an enjoyable trip out to the island of Sainte-Marguerite near Cannes, with its surviving relics of original Mediterranean flora and fauna unencumbered by high rise apartment blocks and marinas. Two species of *Xylocopa* and a number of other solitary bee species were observed busily foraging on the bushes. The day was completed by a fine recital of baroque music held in the old Fort, followed by a sociable apéritif and local snacks. Considerable thanks are due to Michel Aubert and his hard working colleagues for organizing the meeting so efficiently.

If you have an interest in bee pathogens and the diagnosis of bee diseases, a symposium to consider some of the issues related to bee movement is being organized by the OIE Reference Laboratory in Freiburg/Germany and the Apimondia Standing Commission for Bee Pathology to be held in Dublin Ireland, on 19th and 20th of August 2005. The meeting will take place in the Jurys Ballsbridge Hotel. The number of participants is limited, therefore please register as soon as possible to: wolfgang.ritter@cvuafr.bwl.de

THE EUROPEAN BEE PATHOLOGISTS' GROUP

At the recent EurBee Conference held in Udine Italy, the aims of the Group were outlined as follows:

- To facilitate contact and collaboration between bee pathologists across Europe.
- To share information and expertise.
- To provide opportunities for students and to encourage the mobility of researchers.
- To provide a forum for special interest groups.

The scope of the Group covers the pathology of all bees, not just *Apis* species, and membership is open to all individuals involved in a research, diagnostic, or advisory capacity with bee pathogens. For further information and to receive the newsletter contact: the Acting Secretary: norman.carreck@bbsrc.ac.uk

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