SICK SOCIETIES: DISEASE DYNAMICS IN THE WISSENSCHAFTSKOLLEG AND IN INSECT COLONIES

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Born on 24 April 1973, Dr. Cremer studied Biology at the University of Erlangen with a main focus on Evolutionary Biology. During her Ph.D. (1998–2002) at the University of Regensburg, she studied sexual selection and chemical communication in an ant species characterized by the simultaneous presence of two alternative male morphs: peaceful disperser males and local fighter males. During her postdoc training at the University of Copenhagen (2002–2006), she addressed the topic of invasive species and worked on the evolutionary history, population dynamics, and host-parasite interactions of the invasive garden ant, a recently detected pest ant that is currently spreading throughout Europe. The main focus of her recent work and her time as a member of the Evolutionary Immunology Focus Group at the Wissenschaftskolleg is "Social Immunity", i. e. the question how individual members of insect societies collectively prevent disease spread within the group. – Address: Evolution, Genetics and Behaviour, Biology I, University of Regensburg, 93040 Regensburg.

When I arrived in Berlin, the Wiko with all its assiduous and lively activities looked to me a bit like a big anthill. Though I have to admit I might be biased in this respect, the parallels in social organisation were eye-catching. Like an ant colony, the "Wiko colony", too, was characterized by communal housing, shared food intake, an overlap of generations, and – to some extent – common brood care, not to speak of the exchange of frequent social interactions.

It is well known from epidemiological studies that all these factors facilitate disease transmission between group members. It might thus not have been surprising that in the first weeks of Wiko life, infectious diseases quickly spread throughout the group, which was both observed and also experienced by the members of the evolutionary immunology group. It seemed, however, that the resistance of the Wiko group increased over time, most likely through the combination of large amounts of high-quality food and sport activities such as running, yoga, or table tennis, depending on personal preferences.

I could thus address my planned task of theoretical studies on the disease dynamics in insect societies. Social insects have an enormous diversity of sophisticated defence strategies to prevent parasite entrance and spread in a colony. I was able to make great use of the excellent Wiko library to build my own literature collection on this topic, including papers from obscure journals or older periods (the 1980s or earlier, that is, for Natural Scientists, who these days rely mostly on the convenient electronic libraries).

This literature survey made it more and more obvious that, despite the large number of studies describing the amazing and highly complex defences that specific groups of social insects have evolved to fight diseases in their colonies, a comprehensive summary and a conceptual framework was missing. I therefore started writing a literature review on "Social Immunity" together with Paul Schmid-Hempel and with great support from Steve Frank and all others in our group.

The abovementioned characteristics of sociality and group living are not the only factors making social insect colonies highly vulnerable to diseases. Moreover, these are very long-lived societies that build and maintain large nests that are, for example, temperature controlled, which creates a valuable resource for parasites to exploit. Reproduction is split between group members, with only the queen being able to mate and lay eggs that develop into workers, daughter queens, and males; this makes the queen the most important member of the society; she thus must be protected against disease with great effort. This is especially so because daughter queens and thus daughter colonies can only be produced after a long growth phase of the colony, comparable to vertebrates that require several months or years to reach sexual maturity.

We found that the defence strategies of social insects simultaneously work at several levels 1) to avoid picking up parasites outside the colony, 2) to control incoming individuals for contamination with infectious material, and 3) to prevent transmission to nestmate workers, the brood, and the queen in particular. Social insects not only fight infection once a parasite has entered the colony, they continuously clean their nest with antimicrobial substances that they either produce themselves or collect from outside the colony, for example tree resin.

Social insects do not typically expel infected individuals from their group, even though this can happen in some cases, for example in termites that may build walls around infected individuals, thereby putting them in quarantine. The most common response, however, is increased care for infected individuals, such as removing infectious material from their body surface in a process similar to delousing monkeys. The collective nature of these social defences is exemplified by the "social fever" of honeybees, in which many bees simultaneously raise their body temperature by wing fanning to heat-kill bacteria in their hive, an endeavour that is successful only in the collective.

Given the enormous range of specific defence mechanisms that can be employed by a social insect colony, knowledge of how these collective defences are regulated within colonies is still elusive. Such defences require a large amount of information both about the parasite and about the internal status of the colony itself; and this data needs to be integrated and processed in a decision-making process hitherto not completely understood. I hope that the provided literature review, which appeared in print on August 21, 2007 might help attracting more studies to resolve some of these underlying mechanisms.

My three-month stay at the Wiko was not only rewarding in terms of direct scientific output; the long discussions during coffee breaks, lunches, and the colloquia also broadened my view in many ways. The daily evolutionary immunology group coffee was a brilliant opportunity to not only discuss invertebrate immunology, but also many daily life research problems and to get a comparative view on the distinct university and grant application systems in different countries. I also very much enjoyed the lively atmosphere of the *Neubau* phylogenetics group, which made me feel comfortable in this building that was my home for these months. Also, the fact that most partners of the biologists were working in the same field created a large enough critical mass of people all interested in different angles of evolutionary biology, so that the "bioloquium" was one of the best seminars I have ever attended.

The Tuesday colloquia and lunches opened my eyes toward the non-science world and helped me realize how much each of us lives in our own little world. Whereas every single non-scientist topic of the colloquium I listened to was about a subject I hadn't given much thought before, I was on the other hand also astonished how little other people knew about evolutionary biology, a topic so familiar to me that it shapes my way of thinking completely.

I realized for example that there seems to be a big misconception about the process of evolution and that most people still see it as the struggle for life. I hope I was able to disseminate the idea that not only conflict but also cooperation plays a major role in evolutionary processes. Also, many people seem to have the false impression that evolution leads to an "optimal solution" for a given problem. However, this is not generally the case, because there are two important principles acting in evolution: 1) the outcomes are indeed the best possible, but only relative to all other options present in the same time and space, and 2) organisms always have to be able to live – even if this sounds like a very simple condition, it means that changes in evolution are typically small and may be circuitous, because – unlike in machines – single parts cannot be replaced by some completely different construction all in one go.

When leaving the Wiko after three months and going back to my lab, I was very inspired to run experiments in which I could implement the thoughts I had during the time in Berlin. However, it was hard for me to let go completely, so I used every opportunity I had to come back for short visits. Already in February, we had the Wiko workshop on comparative immunology, which was very informative and inspiring and I think everyone enjoyed it equally, be they Wiko Fellows or external visitors. Since quite a few people of our evolutionary immunology group only stayed for periods shorter than the whole year, we decided it would be a good idea to all meet again towards the end of the year for what I would like to call a "Wiko revival". The real event, however, was of course the big end-of-the-year party organized mostly by the full-year Fellows. It was such an amusing and lovely party, reminding us that we have all breathed in the *Berliner Luft* during our stay.

In addition to the meetings in Berlin, the whole evolutionary immunology group participated in a workshop in the Austrian Alps in April, also organized by the conveners of our group, Joachim Kurtz and Paul Schmid-Hempel, together with Sophie Armitage, a colleague and friend of mine. She characterized the Wiko group during the meeting as: "There seems to be an invisible bond between all of you that works like a magnetic force to bring you all together from time to time." I think one couldn't have phrased it better, and I am sure this invisible bond will continue to be present with the whole Wiko for the rest of my life and I am very happy to have been a part of it.