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FOCUS

PROJECT

The Evolution of Disease Transmission

Parasite success is largely determined by transmission from an infected host to an uninfected. In many studies of parasite evolution and epidemiology, transmission is considered the key fitness component. Ever since I encountered in my empirical work parasites that differ in their mode of transmission I have asked myself what influence the mode of transmission has on parasite fitness. Why are some parasites horizontally transmitted, while others are vertically transmitted? Why are some horizontally transmitted parasites airborne, others vector-borne, and yet others sexually transmitted? Why do most parasites have only one mode of transmission? Most evolutionary considerations of parasite evolution take the mode of transmission as given, while here I wonder why different modes of transmission evolve.

In particular, the observation that most parasites have only one mode of transmission is intriguing and is at the center of my interest here. In 1995 we published two articles in which we worked out that the fitness effects of vertical and horizontal transmission add up to the total parasite fitness. From this it becomes clear that, everything else being equal, a parasite with two modes of transmission has an advantage over a parasite with only one mode of transmission. In analogy, the same is true for other combinations of transmission modes, as long as transmission occurs from the same individual host. (It is not true for parasites that alternate their mode of transmission across hosts.) Given these benefits of having more than one mode of transmission, why are there so few parasites with more than one mode of transmission?

To address this question I want to explore a family of models for the evolution of transmission modes. First I want to explore the role of trade-offs among transmission modes. Different modes of transmission may constrain each other in their evolution. Second, I want to explore the role of environmental conditions. Modes of transmission differ in their epidemiology. For example, sexually transmitted diseases need not meet any minimum host density threshold to persist, while conventional horizontally transmitted parasites need a minimum host density for persistence. At high densities, horizontally transmitted parasites can spread much faster than vertically transmitted diseases, while it is the other way around at low densities.

I hope that during my stay at the Wissenschaftskolleg in Berlin, I will be able to develop models to address these problems.

Recommended Reading

Ebert, Dieter. 2008. "Host-parasite coevolution: insights from the Daphnia-parasite model system." Current Opinions in Microbiology 11: 290-301.

COLLOQUIUM, 27.01.2011

The Endless Evolutionary Struggle Against Infectious Diseases

We estimate that more than fifty percent of all species on earth have a parasitic lifestyle. So it is hardly surprising to find that most natural populations of plants and animals suffer from various diseases that are caused by infective agents like parasites and pathogens (in the following just called "parasites"). Parasites harm their hosts and as a result both hosts and parasites coexist in permanent conflict. Therefore, hosts evolve to minimize the damage caused by the parasites, for example by evolving resistance, whereas parasites evolve to optimize the exploitation of their hosts. A consequence of this antagonism is a potentially endless arms race. Theoretical models predict that such arms races lead to very rapid evolutionary changes and to a high specificity in the interaction between hosts and parasites, i.e. parasites specialize in certain host types. This specificity is driven by the reciprocal selection of the antagonists while at the same time itself driving the co-evolutionary process; it is an endless struggle for existence. Today we still know relatively little about the mechanisms of co-evolution. However, we are becoming increasingly aware that co-evolutionary processes play an important role not only in natural populations but also in human health (medicine, global health) and in the health of our domesticated plants and animals (veterinary medicine, agriculture). Antibiotic-resistance, HIV, SARS and bird-flue are just a few of the catchwords highlighting this.

My research group at the University of Basel has worked for fifteen years on the topic of co-evolution. In my presentation I will highlight some of the studies we conducted to learn more about the details of host-parasite co-evolution. I show that host-parasite interactions indeed evolved high degrees of specificity and that populations evolve very rapidly. I will further stress the role of sexual reproduction in the co-evolution between hosts and parasites and I will support the hypothesis that sex evolved as a tool to accelerate evolution.

Before discussing co-evolution, I will give a general introduction into the logic of adaptive evolution. From there I will move into the more complex picture which modern evolutionary biology paints with regard to the permanent co-evolutionary struggle for life.

Ebert, Dieter (London,2020)

Host-parasite co-evolution and its geneomic signature

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1759913308

Ebert, Dieter (Amsterdam [u.a.],2017)

The evolutionary consequences of stepwise infection processes

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1011817721

Ebert, Dieter (2013)

The epidemiology and evolution of symbionts with mixed-mode transmission

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=1043660852

Ebert, Dieter (2013)

The origin of specificity by means of natural selection : evolved and nonhost resistance in host-pathogen interactions

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=104328205X

Ebert, Dieter (2011)

A genome for the environment

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=832540609

Ebert, Dieter (2010)

Intensive farming : evolutionary implications for parasites and pathogens

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=757118690

Ebert, Dieter (2010)

The reduced genome of parasitic microsporidian enterocytozoon bieneusi lacks genes for core carbon metabolism

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=757117627

Ebert, Dieter (2009)

Comparative metagenomics of Daphnia symbionts

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=757109667

Ebert, Dieter (2008)

The evolution and expression of virulence

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=832540137

Ebert, Dieter (London,2008)

Host-parasite coevolution : insights from the Daphnia-parasite model system

https://kxp.k10plus.de/DB=9.663/PPNSET?PPN=757116701