Eco-evolutionary dynamics in fragmented landscapes: theoretical and experimental evolution approaches

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Dispersal is a key parameter in spatially structured populations (Clobert 2012). The movement of individuals between populations does not only impact the population dynamics at the local and spatial scale, but also influence the spatial distribution of genes and thereby patterns of adaptation.

We have some understanding of how rates of dispersal influence the evolutionary potential of a species, when adapting to variable environments or natural enemies (Ronce 2007, Gandon 2002). However, we still know only little about the ecological factors driving the evolution of dispersal itself. How does dispersal evolve in response to spatio-temporal environmental heterogeneity? Do natural enemies (parasites, predators) select for increased or decreased dispersal? Does dispersal coevolve among species within a community? How does dispersal evolution feed back on the evolution of other traits, involved in species interactions? Recent work has demonstrated that dispersal can easily be studied for experimental microcosms of various small organisms, such as bacteria, ciliates, or arthropods (Legrand et al., 2017).

Our group proposes **experimental and theoretical master projects on the eco-evolutionary dynamics of dispersal evolution**. The aim of the projects is to investigate the joint effects of environmental forcing (disturbance) and biotic forcing (parasites, predators, competitors) on demographic dynamics and epidemiology in structured populations, and the consequences for the evolution of dispersal traits and the traits involved biotic interactions (resistance, virulence…). We use protists (*Tetrahymena, Paramecium*) as experimental model systems (**refs**).

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Reading:

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Possible projects:

Does evolution kill the spatial hydra?

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Experimental Evolution of Communities

Metapopulation dynamics are characterized by the dynamic equilibrium of local patch extinctions and recolonizations due to dispersal (Hanski 1999, Hanski & Gaggiotti 2004). Reclonizations of extinct patches and metapopulation persistence are of course only possible if local patch dynamics are not synchronized. Recently, Fox et al. (2017 Nature Ecology & Evolution) proposed that, counter-intuitively, catastrophic patch extinctions should increase metapopulation persistence (the "spatial hydra effect"), because local extinctions, by default, lead to asynchrony between patches.

However, the "spatial hydra effect" does not take into account that ecological metapopulation dynamics and evolutionary change can occur on similar time scales (e.g., Legrand et al. 2017 Ecography). Local patch extinctions are a well known and very strong selective agent which impact the evolution of disperal (e.g., Comins et al. 1980, Roff 1994, Friedenberg 2003, Fronhofer et al. 2014). We therefore hypothesize that in the real world, where ecology and evolution are by default entangled, the spatial hydra effect will be cancelled by the evolution of increased dispersal rates due to local patch extinctions. We want to test this verbal model using both theory and experimental evolution. Theoretical work will be based on developing an eco-evolutionary metapopulation model that includes the evolution of dispersal (e.g., Fronhofer et al. 2012, Fronhofer & Altermatt 2017). Experimental evolution work will use "small worlds" (Altermatt et al. 2015), that is protist microcosm metapopulations of the model predator-prey system Paramecium-Didinium (e.g., Banerji et al. 2015).

Parasite evolution in dynamical landscapes: optimizing local transmission and global dispersal

In classic theory, parasite fitness is maximal for an optimal balance between virulence (= host exploitation) and transmission [1]. However, in spatially structured populations, there may be an additional trade-off between local transmission and long-distance dispersal. This may cause shifts in optimal virulence, but could also produce specific adaptations enhancing dispersal [2,3] in particular when parasites disperse with their host. The issue of such parasite adaptations may be very important in highly dynamic landscapes, e.g., when host undergo a range expansion [4].

In simple two-patch systems [5], we can mimic range expansions of *Paramecium caudatum*, infected with the bacterial parasite *Holospora undulata*. Infection with this parasite reduces host dispersal [5], thereby limiting the potential for epidemic spread in a metapopulation. Over the course of the range expansion, we will track changes in the impact of the parasite on host dispersal as well as changes in parasite life-history (infectivity, virulence…). As dispersal is advantageous during range expansion, we predict that parasites evolve to interfere less with host dispersal or to even enhance dispersal. Evolutionary costs of such trait changes may generate trade-offs with virulence and transmission efficiency.

Companion experiments may investigate the impact of parasites on the evolution of dispersal in the host.

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