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Title of Symposium

Eco-evolutionary Feedback Loops in Theory and Practice: an Assessment of How Synthetic the Newest Synthesis Has Come to Be

Main organizer of the symposium

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Session description

Eco-evolutionary feedback loops (EEFLs) occur when fast trait evolution alters ecological interactions and, from there, reshapes natural selection acting back on the evolving traits. Theoretically, EEFLs offer a unifying concept that bridges the traditional gap between ecology and evolution. From an empirical perspective, EEFLs potentially provide a key to understanding complex ecological dynamics, and to predicting ecosystem response to major perturbations. Despite some recent advances, however, we are still in need of synthetic theoretical tools transferable to the study of real ecosystems. The aim of this symposium is to provide an overview of how synthetic the theory of EEFLs has come to be so far, and how further progress can be made to implement theory on the field to ultimately solve applied ecology problems. Our first three talks will provide us with an overview of recent progress towards building a synthetic and empirically-testable theory of EEFLs that accommodates realistic ecological complexity. Emanuel Fronhofer will present a novel approach to incorporating EEFLs in classical ecological models, François Massol will explore the effects of spatial heterogeneity on EEFLs, and Régis Ferrière will focus on connecting theory with the study of EEFLs in the real world. Our fourth talk by Simon Blanchet will give an empirical synthesis of how intraspecific trait variability acts as a hub that drives the occurrence, strength and direction of EEFLs in communities and ecosystems. Luc De Meester will present

experimental results in zooplankton communities that quantify the ramifications of fast evolution to the structure and functioning of ecosystems. Finally, Eric Edeline will put a spotlight on how EEFLs may potentially determine productivity, dynamics and recovery in harvested populations, a special case of anthropogenic perturbations and a major cause of biodiversity loss.

Speakers

Talk 1. FRONHOFER Emanuel, CNRS, Université de Montpellier
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"**The theory of eco-evolutionary dynamics"**

A conceptual synthesis of eco-evolutionary dynamics is beginning to emerge, however, the theoretical basis is still highly dispersed across different disciplines. Starting from reviewing theoretical work that demonstrates eco-evolutionary feedbacks, including work that has not traditionally been labelled as such, we will outline how feedbacks between ecological and evolutionary dynamics are currently integrated in theory and highlight the underlying assumptions of these models. Our work aims at facilitating the integration of phenomenological models of evolution with models that describe the ecological dynamics of natural selection, hopefully enabling a shift toward a mechanistic understanding of eco-evolutionary feedbacks. We will specifically focus on how including these feedbacks in a more theoretical context will eventually change our understanding of the role that eco-evolutionary feedbacks play for population and community dynamics in relation to relevant environmental and biotic selection pressures. We propose that incorporating eco-evolutionary feedbacks into more traditional ecological models will impact their predictive power and accuracy.

Talk 2. MASSOL François, CNRS, Université de Lille
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"**Eco-evolutionary dynamics of food webs in model metacommunities"**

Metapopulation dynamics, i.e. the dynamics of population growth, extinction and re-colonization at a large spatial scale, has been a useful concept to explain signatures of genetic differentiation or to understand the persistence of species in environments submitted to random perturbations. However, the ecological consequences of adaptive evolutionary changes in metapopulations, or on the contrary the evolutionary changes induced by environmental modifications in habitat patches, have only recently garnered the interest of both theoreticians and empiricists through the concept of eco-evolutionary feedback loops.

Here, I will first synthesize the state-of-the-art on the question of ecoevolutionary dynamics and feedbacks in spatially structured food webs, with consequences on the topology of the networks and their spatial structure. I will also present some recent results that have emerged from applying models of trait evolution to patch-occupancy metapopulation models. I will show that, when species colonization rates are allowed to evolve, the

combination of ecological constraints on suitable habitat (e.g. the presence of suitable prey in food webs) and trade-offs, linking the species' ability to colonize new patches, resist perturbations and compete with other colonizing species, leads to eco-evolutionary feedbacks and predictions on metacommunity occupancy, food chain length and experienced extinction rates. I will discuss some of the testable predictions emerging from these metapopulation models in the context of recent experimental findings on metacommunity dynamics.

Talk 3. FERRIERE Régis, Ecole Normale Supérieure/Paris Sciences Lettres University and University of Arizona
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"Modeling eco-evolutionary feedback loops: Towards an empirically useful theoretical synthesis"

In this talk, we will review current approaches to modeling ecoevolutionary feedbacks. We will examine how different approaches can be used to address questions that focus on different aspects of eco-evolutionary feedbacks, such as how does trait evolution impact the structure and dynamics of an ecological system? And how can different networks of ecological interactions explain different adaptive trajectories. We will focus on the issue of connecting modeling approaches to empirical data, and outline the major challenges that modeling of eco-evolutionary feedbacks face to bridge the gap between theory and the study of real systems.

Talk 4. BLANCHET Simon, CNRS, Laboratoire d'Ecologie Théorique et Expérimentale
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"The ecological consequences of intraspecific diversity: A synthesis"

Intraspecific diversity is at the core of eco-evolutionary feedbacks as this biodiversity facet is affected by evolutionary processes and is affecting ecological dynamics. A pre-requisite for eco-evolutionary feedbacks to occur is that intraspecific diversity affects ecological dynamics in a substantial manner so that new selective pressures can feedback on the evolution of original population. It is therefore of prime importance to quantify to which extent intraspecific diversity affect ecological dynamics and how the effect of intraspecific diversity on ecological dynamics vary among organisms. Here we provide a general synthesis of the effects of intraspecific diversity on the dynamics of communities and ecosystems. We focus on two facets of intraspecific diversity; one reflects variation in genetic or phenotypic attributes between populations (intraspecific variation) and the other reflects the genetic or phenotypic richness within populations (intraspecific richness). We demonstrated that – across species and ecosystems- both intraspecific variation and richness substantially alters ecological dynamics, and that these effects can be as strong as the effect of interspecific variation and richness. We further highlight strong variation in the effect sizes of intraspecific variation, especially between the trophic level of the target species (primary producer vs. consumer) and the type of response variable (community vs. ecosystem

metrics). Finally, we found that the relationship between intraspecific richness and ecological dynamics followed a positive saturating curve, as observed for interspecific biodiversity-function relationships. This suggests complex interactions among genotypes and phenotypes in rich populations. Our findings provide novel avenues to predict the strength of ecoevolutionary dynamics in natural systems.

Talk 5. DE MEESTER Luc, KU Leuven
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"Rapid evolution in Daphnia and its feedback on top-down control of algae"

Rapid evolutionary change is receiving increasing attention, amongst others because it may feedback on ecological dynamics. In the context of global change, insights in these feedbacks may be crucial to better predict ecological responses to human-induced environmental change. Evolution can occur in response as well as effect traits, and both evolutionary responses may in principle impact ecosystem dynamics. In the lecture, I will present data documenting rapid evolutionary change in response to environmental change in the water flea Daphnia, to then focus on feedbacks of evolutionary trait changes on ecosystem processes. I will present data on two experiments that quantify the impact of evolution on an important ecosystem function in standing waters, top-down control of algae by zooplankton. One experiment quantifies ecosystem consequences of evolution as it occurred in nature and was reconstructed through resurrection ecology, while the other experiment involves a follow-up of an experimental evolution trial. The results of both experiments suggest that rapid evolution in Daphnia can strongly impact ecosystem features. The results of the first experiment also illustrate, however, that adaptive evolutionary change in a herbivore does not necessarily result in a stronger suppression of primary producers. The results of the second experiment illustrate that effect sizes of the impact of evolution on ecology do not necessarily decline with increasing complexity as one moves from the population to the community and ecosystem level.

Talk 6. EDELINE Eric, INRA Rennes
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"**Size-dependent eco-evolutionary feedback loops in harvested ecosystems"**

Harvesting generates high mortalities and is often selective regarding ecology-important traits such as body size. Hence, ecoevolutionary feedback loops (EEFLs) are highly likely in harvested systems. However, harvest-induced EEFLs and their consequences for the management of exploited populations remain unexplored. Here, we investigate potential pathways taken by such size dependent EEFLs. The fact that exploited populations often evolve smaller body sizes, as predicted when EEFLs are absent, should not be taken as a proof for the effective absence of EEFLs. In turn, harvest-induced body upsizing should not be systematically interpreted as a plastic response to increased food availability in survivors. We identify scenarios under which natural selection may act in concert with harvest

selection in driving evolution towards smaller body sizes, while under other ecological settings harvest triggered EEFLs may result in natural selection favouring larger body sizes. We then discuss how coevolution among species may affect the expected distribution in selected sizes among predators and prey. We show that, depending on the relative evolvability of predators and prey species, different eco-evolutionary outcomes can be expected, with important consequences for the persistence of the community. Predicting the direction of natural selection in EEFL and its consequences for ecosystem structure requires a detailed knowledge of the nature and strength of trophic interactions.