Course M2 Experimental Ecology (BIO-M2-E03-S1)

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Overview:

The course provides an overview of mechanistic approaches to the dynamics of biological populations. The accent will be set on theoretical models and their qualitative and quantitative test.

The course presents a series of topics in ecology and eco-evolutionary dynamics.

Focusing primarily on quantification and prediction of ecological determinants, the course will discuss the correspondence between theoretical predictions and observations derived from controlled experiments.

The teaching will be complemented by a hands-on experience on microbial populations, in the form of simple experiments conducted on paradigmatic bacterial organisms.

Place :

Room 502, 5th floor, IBENS

46 rue d'Ulm, 75005 Paris

Schedule:

Monday November 2

9-12 am: *Paul Rainey*

Origin and maintenance of biological diversity: lessons from experimental evolution.

Thanks to their fast demographical dynamics, microbial populations allow exploration of ecological and evolutionary processes in real time. I will outline ecological and genetic theories of adaptive radiation, discuss them in the context of typical models such as Darwin's finches and cichlid fish, and show how experimental microbial populations have been used to test specific predictions of theory.

2-5 pm: Planning and setting up an experiment with *P. fluorescens* (*Sandrine Adiba, Silvia De Monte, Paul Rainey*).

Tuesday November 3

9-11 am: *Corina Tarnita*

Ecology and evolution of social behavior: from multicellularity to eusociality.

The evolutionary trajectory of life on earth is one of increasing size and complexity. I will begin to outline a theoretical framework that might help to explore how evolution can be constructive, how natural selection can lead from lower to higher levels of organization. I will distinguish two fundamental operations, which I call 'staying together' and 'coming together'. Staying together means that individuals form larger units by not separating after reproduction, while coming together means that independent individuals form aggre-

gates. Staying together can lead to specialization and division of labor, but the developmental program must evolve in the basic unit. Coming together can be creative by combining units with different properties. I give examples that that show that staying together and coming together can be found at every level of biological construction and moreover that they face different evolutionary problems. I will spend most of the time comparing multicellularity, eusociality and social behavior.

11-12 am, salle Favard (IBENS)

IBENS seminar by Corina Tarnita

Ecology and the evolution of social behavior: case study, *Dictyostelium discoideum*

Studies of cooperation in microbes often focus on one fitness component, with little information about or attention to the ecological context and this can lead to paradoxical results. The life cycle of the social amoeba *Dictyostelium discoideum* includes a multicellular stage in which not necessarily clonal amoebae aggregate upon starvation to form a possibly chimeric (genetically heterogeneous) fruiting body made of dead stalk and spores. The lab-measured reproductive skew in the spores of chimeras indicates strong social antagonism; this should result in low genotypic diversity, which is inconsistent with observations from nature. Two studies have suggested that this inconsistency stems from the one-dimensional assessment of fitness (spore production) and that the solution lies in tradeoffs between multiple traits, e.g.: spore size versus viability; and staying vegetative versus becoming dormant. I will discuss a unifying ecological framework in which the two tradeoffs above, as well as novel ones, arise collectively in response to uncertainties in the environment. Furthermore, I will argue that all existing experimental results regarding chimeric mixes can be qualitatively recapitulated without needing to invoke social interactions, which allows for simple resolutions to previously paradoxical results. To conclude, I will argue that the complexities of life histories, including social behavior and multicellularity, can only be understood in the appropriate multidimensional ecological context. I will discuss examples from all major groups in which social behavior has been studied -- vertebrates (cooperatively breeding birds), invertebrates (ants and spiders) and microbes.

2-5 pm: Follow up of the experiment with *P. fluorescens* (Sandrine Adiba, Silvia De Monte, Paul Rainey).

Wednesday November 4

9-12 am: *Corina Tarnita and Rob Pringle*

Causes and consequences of spatial patterning at different scales.

Self-organized spatial vegetation patterning is widespread and has been described using models of scale-dependent feedback between plants and water on homogeneous substrates. As rainfall decreases, these models yield a characteristic sequence of patterns with increasingly sparse vegetation, followed by sudden collapse to desert. Thus, the final, spot-like pattern may provide early warning for such catastrophic shifts. In many arid ecosystems, however, termite nests impart substrate heterogeneity by altering soil properties, thereby enhancing plant growth. In addition, due to competition for resources, termite mounds are also spatially patterned. We show that termite-induced heterogeneity interacts with scale-dependent feedbacks to produce vegetation patterns at different spatial grains. Although the coarse-grained patterning resembles that created by scale-dependent feedback alone, it does not indicate imminent desertification. Rather, mound-field landscapes are more robust to aridity, suggesting that termites may help stabilize ecosystems under global change. Furthermore, the spatial patterning induced by termite mounds scales up to the rest of the ecosystem and increases its productivity.

2-3h30 pm: Follow up of the experiment with *P. fluorescens* (*Sandrine Adiba, Silvia De Monte, Paul Rainey*);

3h30-5 pm: *Corina Tarnita*

Game theory lab: The mathematics of social behavior.

Thursday November 5

9-11 am: *Rob Pringle*

Food webs and other species interactions in real ecosystems.

I will discuss two large scale experimental manipulations and what they teach us about species interactions, from food webs to mutualisms and niche partitioning. One experiment is an herbivore exclusion in the African savanna; the other is an experimental manipulation of species composition in a Bahamas island system.

11-12 am, salle Favard (IBENS)

IBENS-Pepinière seminar by Rob Pringle

Biotic regulation of African savanna ecosystems.

The distribution of the savanna biome at continental and global scales is determined by the interplay of climate, nutrient availability, and fire. Preoccupation with the influence of these abiotic factors has caused ecologists to underestimate the importance of species interactions in governing the structure and functioning of savanna ecosystems at local and regional scales. In this talk, I will show that three key guilds of consumers — fungus-cultivating termites, large herbivores, and large predators — play a crucial role in determining the following attributes of African savanna ecosystems: (a) net primary productivity, (b) ecosystem stability and resilience, (c) patterns of species diversity and abundance, (d) the extent of tree and shrub cover, and (e) the strength and outcome of plant-plant interactions. Moreover, these biotic factors often interact with abiotic factors in cryptic but profound ways, such that the effects of rainfall, soil properties, and fire can only be understood with reference to species interactions. These findings suggest that the current framework for understanding savannas, which tends towards abiotic determinism, must be revised to accommodate the scale-dependent influences of both biotic and abiotic drivers.

2-3h30 pm: Follow up of the experiment with *P. fluorescens* (Sandrine Adiba, Silvia De Monte, Paul Rainey).

Friday November 6

9-12 am: *Jean-François Le Gaillard*

Challenges and contributions of the experimental approach in ecology.

The dependence of ecosystem properties on the scale of observation poses significant challenges to the experimental testing of general theories. Lab-scale investigations are indeed insufficient explore the structural and dynamical complexity of natural ecosystems, that are characterized by the interplay of multiple actors involving different spatio-temporal scales. In this lecture, I will discuss how the reach of controlled experiments on ecosystems can be enhanced by the use of large-scale infrastructures, such as the Ecotron-Ile de France, and how these tools can be used to test theoretical prediction, with the aim of increasing the predictive power of ecological models.

2-5 pm: Analysis of the result of the experiment with *P. fluorescens* (Sandrine Adiba, Silvia De Monte, Paul Rainey).