Program of the SIMBAD seminar, second session

March 10, 2017

Location

Room 109 (conference room), first floor
IMAG, University of Montpellier, building 9

Program

9h	9h30	Accueil - Welcome	
9h30	10h15	**Yoann Anciaux**	Eco-evolutionary dynamic of evolutionary rescue in large population of asexual with strong mutation rate
10h15	11h	**Martin Strugarek**	Hindrances to bistable front propagation: application to artificial Wolbachia invasion
11h	11h15	Pause - Break	
11h15	12h	**Marie-Ève Gil**	Mathematical properties of an integro-differential model from population genetics
12h	13h30	Pause déjeuner Lunch Break	
13h30	14h15	**Nils Caillerie**	Kinetic models for the cane toad's expansion and their statistical validation
14h15	15h	**Ariane Trescases**	Cross-diffusion and competitive interaction in Population dynamics
15h	15h15	Pause - Break	
15h15	16h	**Thibault Bourgeron**	Maladaptation of a sexual population to a changing environment
16h	16h45	**Samuel Nordmann**	Dynamics of concentration in a population model structured by age and a phenotypical trait

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Titles and abstracts

In alphabetical order.

Yoann Anciaux

Title : Eco-evolutionary dynamic of evolutionary rescue in large population of asexual with strong mutation rate
Abstract : Evolutionary rescue occurs when a population genetically adapts to a new stressful environment that would otherwise cause its extinction. Forecasting the probability of persistence under stress, such as emergence of drug resistance or invasion of a new environment is a major concern in ecology and evolution.

Models which are describing the eco-evolutionary dynamics of evolutionary rescue consider the stochastic apparition of new alleles and their fixation (origin-fixation models) or the creation of genetic variance in a polymorphic population by recombination or mutation. However none of them allow us to forecast the dynamic of the whole distribution of fitness of the population and mutation are often independent of the genetic background where they appear.

Here, we explore the use of partial differential equation to model the dynamic of the distribution of fitness in large asexual populations, through their generating function. This allows following the effect of selection among many co-segregating types and of background-dependent mutation effects (epistasis) under Fisher's geometric model (1930). Analytical results based on diffusion approximations for the probability of evolutionary rescue are confronted with individual based simulation in different scenario such as adaptation from standing variance and of de novo mutation.

Thibault Bourgeron

Title : Maladaptation of a sexual population to a changing environment
Abstract : The adaptation of a population to a changing environment can be modeled by a birth and death process. Two natural questions can be studied: the existence and the concentration in the phenotype variable of the stationary states. Sexual reproduction can be modeled using Fisher's infinitesimal operator, which is nor linear nor monotone. Thus, the existence of principal eigenelements cannot be treated using the classical Krein-Rutman theory and another method has to be developed. The methodology of the WKB expansion can be adapted to this context to quantify maladaptation in a specific regime. A non linear effect appears when aging is taken into account.

Nils Caillerie

Title : Kinetic models for the cane toad's expansion and their statistical validation
Abstract : Since it was introduced in Australia in the 1930s, the propagation of the cane toad (Rhinella marina) has accelerated, threatening the local biodiversity. This propagation was studied by Australian biologists who conducted a 10-year statistical study on the toads' daily trajectories. Their work showed that the diffusive models classically used in ecology underestimate the species' expansion.

In this presentation, we will substitute those models with kinetic (i.e structured in velocity) ones. We will evaluate their validity on their capacity to give an accurate theoretical speed of propagation. To do this, I will present how to estimate the models' parameters from the data and how to numerically compute the theoretical speed of propagation.

Marie-Ève Gil

Title : Mathematical properties of an integro-differential model from population genetics
Abstract : In this talk I will discuss a mathematical analysis of an integro-differential model arising in population genetics. The model describes the dynamics of fitness distribution in an asexual population under the effect of mutation and selection. These two processes are represented by two nonlocal terms.

First, we prove the existence and uniqueness of the solution, and we derive asymptotic estimates of the distribution as the fitness tends to $\pm\infty$. Based on these asymptotic estimates, we then show that the cumulant generating function of the distribution is well-defined and satisfies a linear nonlocal transport equation that we solve explicitly.

This explicit formula allows us to characterize the dependence of the long time behavior of the distribution with respect to the mutation kernel. On the one hand, if the kernel contains some beneficial mutations, the distribution diverges, which is reminiscent of the results of [Alfaro and Carles, 2014] who analysed a mutator-replicator equation with a diffusive mutation term. On the other hand, if the initial fitness distribution admits some upper bound,

purely deleterious kernels lead to the convergence of the distribution towards an equilibrium. The shape of the equilibrium distribution strongly depends on the kernel through its harmonic mean $-s_H$: the distribution admits a positive mass at the best initial fitness class if and only if $s_H \neq 0$. The talk is based on a joint work with François Hamel (I2M, AMU), Guillaume Martin (ISEM, CNRS) and Lionel Roques (BioSP, INRA).

Samuel Nordmann

Title : Dynamics of concentration in a population model structured by age and a phenotypical trait
Abstract : We study a mathematical model describing the growth process of a population subject to aging, competition between individuals and rare non-local mutations. Our goal is to describe the asymptotic behaviour of the population. In a short time scale, the population density concentrates around the fittest traits i.e it concentrates as a Dirac mass (or a sum of Dirac masses) in the trait variable when a rescalling parameter ϵ tends to 0. On a longer time scale, the Dirac mass converges to an evolutionary stable state.

We begin with a model without mutations, much simpler, which allows us to introduce the main ideas and state the full result. Then we discuss the general model and its limits.

Our approach uses an eigenproblem that defines implicitely an effective fitness. It can be seen as an alternative to the usual WKB method. We also use a Generalized-Entropy method to show strong convergence. For the problem with mutations, a Hamiltonian arises with an exponential growth, for which we construct an entire viscosity solution thanks to unsual a priori estimates and a new uniqueness result.

Joint work with V.Calvez, B.Perthame and C.Taing.

Martin Strugarek

Title : Hindrances to bistable front propagation: application to artificial Wolbachia invasion
Abstract : Bistable reaction-diffusion can model how an invading biological population propagates and replaces an existing population. Such invasion fronts are known to be ”pushed”, i.e. the invading population has to reach a critical threshold (or ”propagule”) in order to initiate propagation. In its simplest form, this model has only two stable asymptotic behaviors: solutions converge either to 0 or to the unique traveling wave.

However, in several real-life situations, stable blocked fronts appear. In this joint work with G. Nadin and N. Vauchelet we investigate how variations in population size can explain front blocking.

We quantify the propagules and show that infection-dependent population size cannot trigger stable blocked fronts while a heterogeneous environment can. We characterize the critical population jump sufficient to stop propagation. We also prove the existence of unstable fronts above the stable (blocking) fronts. In particular, being above the maximal unstable front enables an invading front to clear the obstacle and propagate further.

This finding is especially relevant in the case of artificial Wolbachia infection, used as a tool to fight arboviruses.

Joint work with G. Nadin and N. Vauchelet

Ariane Trescases

Title : Cross-diffusion and competitive interaction in Population dynamics
Abstract : In Population dynamics, reaction-cross diffusion systems model the evolution of populations of competing species with a repulsive effect between individuals. For these strongly coupled nonlinear systems, a question as basic as the existence of solutions appears to be extremely complex. We introduce an approach based on the most recent extensions of duality lemmas and on entropy methods. We prove the existence of weak solutions in a general setting of reaction-cross diffusion systems, as well as some qualitative properties of the solutions.

Organizers

Quentin Griette, IMAG (lead organizer)
Léo Girardin, UPMC, LJLL
Álvaro Mateos González, UMPA, INRIA