Title and abstracts for talks on December 16, 2021

Robert Stephen Cantrell (Miami)

Title: On The Evolution Of Slow Dispersal In Multispecies Communities

Abstract: For any $N \geq 2$, we show that there are choices of diffusion rates $\{d_i\}_{i=1}^N$, such that for N competing species which are ecologically identical and have distinct diffusion rates, the slowest disperser is able to competitively exclude the remainder of the species. In fact, the choices of such diffusion rates are open in the Hausdorff topology. Our result provides some evidence in the affirmative direction regarding the conjecture by Dockery et al. in 1998. The main tools include Morse decomposition of the semiflow and the theory of normalized Floquet principal bundle for linear parabolic equations. A critical step in the proof is to establish the smooth dependence of the Floquet bundle on diffusion rate and other coefficients, which may be of independent interest. This is joint work with King-Yeung Lam.

Louis Wai Tong Fan (Indiana)

Title: Probability of extinction in expanding populations

Abstract: In spatial population genetics, it is important to understand the probability of extinction in multi-species interactions. For example, the probability of non-coexistence for two species is the probability of extinction of either type. In this talk, based on stochastic reaction-diffusion equations, I will discuss about the dynamics and the genealogies of expanding populations such as growing bacterial colonies, cancer tumor evolution and human migration. I will talk about the probability of extinction and some recent work on travelling waves for the Fisher-KPP equation on metric trees.

Yun Kang (Arizona State)

Title: Recruitment Dynamics of Social Insect Colonies

Abstract: Recruitment plays a vital role in the ecological and evolutionary successes of social insect colonies. In this project, we formulate a four-compartment model and its simplified version to explore how we should model the recruitment dynamics of workers in social insect colonies properly. Our four-compartment model has the components of the unalarmed patrollers-P, the alarmed patrollers-A, the alarmed recruiters-R, and the available workers-W, while its simplified version has three components where we combine the unalarmed patrollers and the alarmed patrollers into the patrollers. The classes of P, A, R compete for new recruitments with each other and they are interchangeable with each other. We perform complete mathematical and bifurcation analyses on both the full system and its simplified system. We have many interesting findings, including that (i) the simplified three-compartment system has only simple equilibrium dynamics, i.e., no periodic and chaotic dynamics; (ii) the four-compartment system has very complex dynamics; for example, it can have up to three subcritical Hopf bifurcations, two supercritical Hopf bifurcations, two limit point bifurcations, and a fold bifurcation of the limit cycle. Those important results provide theoretical guidance for modeling and studying recruitment dynamics of social insect colonies: It is critical to have proper compartments for biological systems as the number of compartments could lead to totally different dynamics, and hence affect policy-making. The ongoing work is to include spatial component to the current approach.

Junping Shi (College of William & Mary)

Title: The effect of time delay on diffusive Lotka-Volterra competition models

Abstract: First we show that in a diffusive Lotka-Volterra competition model with stage structure and maturation time delay, a complete classification of the global asymptotic behavior can be achieved for the weak competition case. In particular, no oscillatory dynamics is possible, and under otherwise same conditions, the species with shorter maturation time prevails. Secondly we show in a diffusive Lotka-Volterra competition model with memory-based cross-diffusion with a time-delay, spatially inhomogeneous time-periodic patterns can be generated through Hopf bifurcations, and the species may coexist in an oscillatory fashion.

Bo Zhang (Oklahoma State)

Title: Movement alters carrying capacity and coexistence in heterogeneous environments

Abstract: Movement alters carrying capacity and coexistence in heterogeneous environments A large body of theory predicts that populations dispersing in heterogeneous environments reach higher total size than if non-diffusing, and, paradoxically, higher size than in a corresponding homogeneous environment. However, this theory and its assumptions have not been rigorously tested. We first extended previous theory to include exploitable resources, proving qualitatively novel results, which we tested experimentally using spatially dispersing laboratory populations of yeast. Consistent with previous theory, we predicted and experimentally observed that spatial dispersal increased total equilibrium population abundance in heterogeneous environments. Refuting previous theory, however, this work discovered that homogeneously distributed resources support higher total carrying capacity than heterogeneously distributed resources, even with species dispersal. Recently, we extend our previous work to multiple interacting species to understand their coexistence. Mathematical analysis of models of competition between two identical species moving at different rates of symmetric diffusion in heterogeneous environments show that the slower mover excludes the faster one. The models have not been tested empirically and lack inclusions of a component of directed movement toward favorable areas. To address these gaps, we extended previous theory by explicitly including exploitable resource dynamics and directed movement. We tested the mathematical results experimentally using laboratory populations of the nematode worm, Caenorhabditis elegans. Our results not only support the previous theory that the species diffusing at a slower rate prevails in heterogeneous environments but also reveal that moderate levels of a directed movement component on top of the diffusive movement allow species to coexist. Our results broaden the theory of species coexistence in heterogeneous space and provide empirical confirmation of the mathematical predictions.

Rachidi Salako (U. Nevada, Las Vegas)

Title: Competition-Exclusion of pathogens in a diffusive multi-strain epidemic model

Abstract: We study the dynamics of classical solutions of a diffusive multi-strain epidemic model in spatially heterogeneous environments. Sufficient conditions are provided to guarantee the extinction of some strains of the disease when their basic reproduction numbers are bigger than one. Special interest is devoted to the scenario where all transmission rates are uniformly proportional. In which case a complete dynamics of classical solutions of a two species competition system will be studied.

Chris Klausmeier (Kellogg's Biological Station, Michigan State)

Title: Towards a Unified Framework for Metacommunity Ecology

Abstract: Metacommunity ecology extends the metapopulation concept to provide a theoretical framework for understanding multi-species interactions in spatially subdivided landscapes. Despite the widespread interest in metacommunity ecology, the theory is currently loosely organized into disjunct paradigms such as species sorting, patch dynamics, mass effects, and neutral theory. Reconciling these diverse models in a unified framework requires inclusion of three fundamental ecological processes: selection (niche-based processes), ecological drift (stochasticity), and dispersal. In this talk I will present a competitive Lotka-Volterra metacommunity model that includes all of these processes. First we look at open systems, where immigrants come from a mainland source population. Then we look at true metacommunities, where immigrants come from other patches in the landscape. Using efficient numerical techniques to calculate equilibria and invasion criteria, we determine how the regional outcome of competition depends on local interactions, dispersal, and local population size. Finally, we conclude with prospects for future theoretical development. This joint work with Thomas Koffel, Brian Lerch, Akshata Rudrapatna.