<u>Parallel Session</u>
Population Biology IV

HOW DOES HERD GATHERING INFLUENCE INTERACTING POPULATION DYNAMICS?

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Keywords: Predator-prey, Symbiosis, Competitive exclusion, Herd gathering, Tristability.

We present few models for two-populations interactions, incorporating possible population social behavior, expressed by their gathering together in herds or packs, [2]. Basically, populations interact through the individuals occupying the outermost positions in the herd, those that correspond to the perimeter (in 2D) or to the surface (in 3D) of the herd. Mathematically, the functional response can be modeled via a power function. A novel feature is discovered, population extinction in finite time, [2]. Herd shape influences population equilibrium levels, [1]. Competitive exclusion does not always hold, as tristability is discovered.

References

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THE EVOLUTION OF RHIZOME SYSTEM IN BAMBOOS UNDER SPATIAL HETEROGENEITIES

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Bamboos are clonal plants that undergo mass flowering followed by simultaneous death after a long-term period of rhizomatous vegetative growth. The time to flowering after germination depends on species and shows a geographic cline in which it is short in tropical region and becomes longer as we move to northward into temperate region. As another geographic tendency in bamboo, rhizome system is different between tropical and temperate region. The species in tropical region have short and thick rhizomes (called pachymorph), resulting in clumped spatial arrangement of ramets. On the other hand, species in temperate region have long and slender rhizomes (called leptomorph). As a result, individuals are spatially intermingled each other. How these types of rhizome emerged in the evolutionary history and how the geographic correlation between flowering interval and rhizome system has been formed remains elusive. In this talk, using spatially explicit mathematical model, we explore the evolution of rhizome system in heterogeneous environment. We demonstrate that the longer rhizome is adaptive in relatively homogeneous environment, and short rhizome can evolve only when spatial autocorrelation of the quality of environment is high. We also demonstrate that flowering interval affects the evolution of rhizome length, in which long rhizomes are favored when flowering interval is long.

RECONSIDERATION ABOUT AN OPTIMAL MANAGEMENT FOR THE MIGRATED SPECIES

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Keywords: Stock management, Fishery, Highly migrated species.

Migrated fish distributed all over the ocean in the world. Fishermen catch fish as food corresponding to their spatial pattern. This means the allocation of fisherman's effort. This is important issue in two meanings; one is that fisherman have possibility to catch everywhere and to try increasing catch, the other one is that fisherman also have option to take care of stock in each habitat (i.e. marine protected area, MPA or to manage fishing ground). Both points are trade-off. Recently, to catch the status of fishery, electronic searching system were developed. Ross et. al., [1] were assessed the efficiency of multiple electrofishing scenarios by comparing various strategies for the spatial and temporal allocation of sampling effort to improve a coastal fish community survey. After knowing the status, the stock management is required for the sustainable use of fish stock. Therefore, author will talk the optimal management strategy for highly migrated or migrated species. In this talk, the age and spatial structured model is applied. Firstly, fish stock is divided into two group, juvenile and adult, and three habitats are incorporated into the model. Secondly, more age group and habitats are incorporated into the one. For this study, we assume the management target, for example Maximum Sustainable Yield (MSY). However, in the case for the spatial management, the definition of the MSY is difficult. Therefore, in this talk, we define several types of the definition of the 'optimal' harvest: 1. the maximization of sum of catch for all fishing ground, 2. The maximization of catch in each fishing ground. This talk shows two characteristics: first is the population dynamics without the fishing. Second is the optimal catch strategy. At first, we assume the steady state of these situation, and give some knowledge about the dynamics of fish. After that, the catch effect to the system are analyzed. Finally, we evaluate the management strategy. As results, the strategy "maximization of sum of catch for all fishing ground" will maximize the total catch than the strategy "maximization of catch for all fishing ground" if the migration is abortive migration or unsatisfactory abortive migration. Therefore, to know the abortive or not migratory is important for the management. Furthermore, in our model, we recognize the importance of when and where the catch event happened during the migratory again.

References

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OPTIMAL EFFORT CONTROL FOR THE HARVESTING OF A POPULATION MODELED BY A PARABOLIC PDE

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Keywords: Optimal control, Population dynamics, Parabolic partial differential equations.

Targeting and removing invasive species from ecosystems can have important benefits; hence, invasive species management represents an important topics in nature conservation. In this respect, improving strategies for the control and eradication of invasive species is a relevant aspect of natural resource management. This task can be achieved using mathematical modelling and optimization. We describe the spatio-temporal dynamics of an invasive species by a parabolic PDE where the reaction term accounts for a logistic growth. In addition, a Holling-II type term takes into account the effort needed for harvesting management. We exploit optimal control theory to solve for optimal management, under the assumption that a budget constraint is implemented. We start from the weak formulation of the state equation, and we perform an analytical study of the model properties, including the well-posedness of the problem. We also perform some simulations on realistic problems. This allows us to determine the optimal space and time allocation of the resources.

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DISCRETE TIME MULTIREGIONAL STOCHASTIC MODELS WITH FAST MIGRATION: RE-SCALING SURVIVAL TO THE FAST SCALE

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Keywords: Time-scales, Environmental stochasticity, Multiregional models.

In this work we address the analysis of discrete time size structured populations spread into several spatial patches and subjected to environmental stochasticity, i.e., the environment the population lives in changes randomly in each time step. In general these models are analytically intractable, so in order to study them previous works [1] have made use of the fact that in many cases migration between the spatial sites is fast with respect to demography (maturation, survival, reproduction) of the population, which allows one to apply approximate reduction techniques to reduce the dimension of the system and, in several instances of interest, carry out the analysis of the reduced model. With this approach, in each time step of the model there is a large number of migration fast steps followed by a slow demographic event. However this assumption is questionable from a biological perspective since in real life individuals can die at any moment of the time step. In order to deal with this consideration we have changed the modelling approach and have re-scaled survival in order to take into account its effect on the fast scale as well, so that each fast step includes both the contribution of migration and of survival.

We first construct the slow-fast multiregional model for a population structured into q size classes and spread out into s sites living in a randomly varying environment, which results in a model with qs variables. Then we show how to carry out its reduction, the reduced model having only q variables corresponding to the total population with each size. Then we prove that the main parameters in these kind of stochastic models, the so called stochastic growth rate and the scaled logarithmic variance [2], can be related for the original and the reduced systems, so that the analysis of the reduced system allows us to ascertain the fate of the multiregional model. Then we go on to consider particular cases of the general setting in which the reduced system can be studied analytically, most notably the case in which the population has only one size class. We then concentrate of the comparing the effect of choosing the classic modeling approach [1] versus the one followed here on the persistence or extinction of the population.

References

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DERIVING SIMPLE PREDATOR-PREY MODELS FROM INDIVIDUAL BASED MODELS VIA SINGULAR PERTURBATION THEORY

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Keywords: Predator-prey model, Holling disc function, Singular perturbation theory, Tikhonov-Fenichel parameters.

The Rosenzweig-MacArthur system is a particular case of the Gause model. It is widely used to describe the behavior of predator-prey systems. In literature, its interaction terms in the differential equation are essentially derived from balancing predators time needed for handling and searching prey.

In this talk we present a different derivation of this model from first principles: We first establish a stochastic individual based model using simple mass action kinetics. The large volume limit leads to a three-dimensional (polynomial) ODE system. Subsequently we obtain the Rosenzweig-MacArthur system by a singular perturbation reduction for certain small parameters. Moreover, the systematic investigation of all two-dimensional reductions of the three-dimensional ODE system leads to other notable two-dimensional predator-prey systems, too.