Population models with discrete or continuous trait spaces: Competitive exclusion or coexistence?

Competitive interactions between organisms play a significant role in structuring ecological communities. The questions of when do competing species coexist and when do they exclude each other have long intrigued both ecologists and mathematicians. In 1932, Gause formulated the well-known Competitive Exclusion Principle, which states that two species competing for the same resources cannot coexist if other ecological factors are constant. Experiments and mathematical models, beginning with the Lotka-Volterra model, have been used to support or violate this tenet. In this talk recent population models in which individuals are distributed over a phenotypical trait space (discrete or continuous) and compete with one another will be discussed. Conditions under which competitive exclusion occurs and conditions under which coexistence is possible are presented. In particular, it shown that when competition efficiencies of different species are similar, competitive exclusion occurs and the winner is the one with an invasion reproduction number larger than one. It is also shown that when competition efficiencies are different then coexistence and bi-stability are possible outcomes. Then, a measure-valued modeling approach will be presented. This approach has the advantage of combining models with discrete or continuous trait spaces under one formulation. The long-time behavior of solutions of this measure-valued model is discussed. It is shown that for the case where individuals of one trait produce individuals of the same trait (pure selection), the solution of the dynamical system converges to a Dirac measure centered at the fittest trait class, i.e., competitive exclusion is the outcome where the fittest trait outcompetes all others. It is also shown that when the trait space is discrete, the model with small mutation has a locally asymptotically stable equilibrium that attracts all initial conditions that are positive at the fittest strategy. In this case coexistence between different traits is possible.

Biography of Azmy S. Ackleh

Dr. Azmy S. Ackleh is the Dean of the College of Sciences and the Devon Endowed Professor of Mathematics at the University of Louisiana at Lafayette. Ackleh received his Ph.D. from the University of Tennessee at Knoxville in 1993. He then joined the Center of Research in Scientific Computation at North Carolina State University as a postdoctoral fellow until 1995 where he became an Assistant Professor of Mathematics at the University of Louisiana at Lafayette and rose through the ranks to become a Full Professor of Mathematics in 2003. In 2007 he received the University Distinguished Professor award and was selected to become the R.P. Authement Eminent Scholar and Endowed Chair in Computational Mathematics. From 2011-2013 he served as the Head of the Department of Mathematics at the University of Louisiana at Lafayette and has been serving as the Dean of the College of Science since 2013.

Ackleh's research is in the areas of Mathematical Biology with particular emphasis on population ecology and epidemiology. He is interested in the development of continuous and discrete models to describe the dynamics of populations and in using mathematical tools to understand the short-term and long-term behavior of solutions to these models. Particular applications that he has worked on include selection-mutation models, amphibian dynamics, the competitive interaction between blue and yellow irises, and the impact of oil spills on marine mammals in the Gulf of Mexico. He published more than 130 peer-reviewed articles and served as the PI or Co-PI on more than $8M in external research funding. He mentored 3 postdocs and served as the major advisor for 15 Ph.D. students.