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# Dynamical Systems in Population Biology

*Second Edition*



 Springer

# Dynamical Systems In Population Biology

**Saber Elaydi, Mustafa R. S.  
Kulenović, Senada Kalabušić**



## **Dynamical Systems In Population Biology:**

*Dynamical Systems in Population Biology* Xiao-Qiang Zhao, 2013-06-05 Population dynamics is an important subject in mathematical biology. A central problem is to study the long term behavior of modeling systems. Most of these systems are governed by various evolutionary equations such as difference, ordinary functional and partial differential equations (see e.g. [165, 142, 218, 119, 55]). As we know, interactive populations often live in a fluctuating environment. For example, physical environmental conditions such as temperature and humidity and the availability of food, water and other resources usually vary in time with seasonal or daily variations. Therefore, more realistic models should be nonautonomous systems. In particular, if the data in a model are periodic functions of time with commensurate period, a periodic system arises. If these periodic functions have different minimal periods, we get an almost periodic system. The existing reference books from the dynamical systems point of view mainly focus on autonomous biological systems. The book of Hess [106] is an excellent reference for periodic parabolic boundary value problems with applications to population dynamics. Since the publication of this book, there have been extensive investigations on periodic, asymptotically periodic, almost periodic and even general nonautonomous biological systems, which in turn have motivated further development of the theory of dynamical systems. In order to explain the dynamical systems approach to periodic population problems, let us consider as an illustration two species periodic competitive systems  $\frac{dU_i}{dt} = U_i(U_2 - U_1)$  (0 < U\_1 < U\_2 < 0).

*Dynamical Systems in Population Biology* Xiao-Qiang Zhao, 2017-04-11 This research monograph provides an introduction to the theory of nonautonomous semiflows with applications to population dynamics. It develops dynamical system approaches to various evolutionary equations such as difference, ordinary functional and partial differential equations and pays more attention to periodic and almost periodic phenomena. The presentation includes persistence theory, monotone dynamics, periodic and almost periodic semiflows, basic reproduction ratios, traveling waves and global analysis of prototypical population models in ecology and epidemiology. Research mathematicians working with nonlinear dynamics, particularly those interested in applications to biology, will find this book useful. It may also be used as a textbook or as supplementary reading for a graduate special topics course on the theory and applications of dynamical systems. Dr. Xiao-Qiang Zhao is a University Research Professor at Memorial University of Newfoundland, Canada. His main research interests involve applied dynamical systems, nonlinear differential equations and mathematical biology. He is the author of more than 100 papers and his research has played an important role in the development of the theory and applications of monotone dynamical systems, periodic and almost periodic semiflows, uniform persistence and basic reproduction ratios.

**Dynamical Systems and Population Persistence** Hal L. Smith, Horst R. Thieme, 2011 The mathematical theory of persistence answers questions such as which species in a mathematical model of interacting species will survive over the long term. It applies to infinite dimensional as well as to finite dimensional dynamical systems and to discrete time as well as to continuous time semiflows. This monograph provides a self-contained treatment of persistence.

theory that is accessible to graduate students The key results for deterministic autonomous systems are proved in full detail such as the acyclicity theorem and the tripartition of a global compact attractor Suitable conditions are given for persistence to imply strong persistence even for nonautonomous semiflows and time heterogeneous persistence results are developed using so called average Lyapunov functions Applications play a large role in the monograph from the beginning These include ODE models such as an SEIRS infectious disease in a meta population and discrete time nonlinear matrix models of demographic dynamics Entire chapters are devoted to infinite dimensional examples including an SI epidemic model with variable infectivity microbial growth in a tubular bioreactor and an age structured model of cells growing in a chemostat

Publisher's description **Dynamical Systems and Their Applications in Biology** Shigui Ruan, Gail Susan Kohl Wolkowicz, Jianhong Wu, 2003 This volume is based on the proceedings of the International Workshop on Dynamical Systems and their Applications in Biology held at the Canadian Coast Guard College on Cape Breton Island Nova Scotia Canada It presents a broad picture of the current research surrounding applications of dynamical systems in biology particularly in population biology The book contains 19 papers and includes articles on the qualitative and or numerical analysis of models involving ordinary partial functional and stochastic differential equations Applications include epidemiology population dynamics and physiology The material is suitable for graduate students and research mathematicians interested in ordinary differential equations and their applications in biology Also available by Ruan Wolkowicz and Wu is Differential Equations with Applications to Biology Volume 21 in the AMS series Fields Institute Communications

**Competition Models in Population Biology** Paul Waltman, 1983-01-01 This book uses fundamental ideas in dynamical systems to answer questions of a biologic nature in particular questions about the behavior of populations given a relatively few hypotheses about the nature of their growth and interaction The principal subject treated is that of coexistence under certain parameter ranges while asymptotic methods are used to show competitive exclusion in other parameter ranges Finally some problems in genetics are posed and analyzed as problems in nonlinear ordinary differential equations

**Dynamical Systems and Their Applications in Biology** Shigui Ruan, Gail Susan Kohl Wolkowicz, Jianhong Wu, Fields Institute for Research in Mathematical Sciences, 2003-01-01 This volume is based on the proceedings of the International Workshop on Dynamical Systems and their Applications in Biology held at the Canadian Coast Guard College on Cape Breton Island Nova Scotia Canada It presents a broad picture of the current research surrounding applications of dynamical systems in biology particularly in population biology The book contains 19 papers and includes articles on the qualitative and or numerical analysis of models involving ordinary partial functional and stochastic differential equations Applications include epidemiology population dynamics and physiology The material is suitable for graduate students and research mathematicians interested in ordinary differential equations and their applications in biology Also available by Ruan Wolkowicz and Wu is Differential Equations with Applications to Biology Volume 21 in the AMS series Fields Institute

Communications      Population Dynamics: Algebraic And Probabilistic Approach Utkir A Rozikov, 2020-04-22 A population is a summation of all the organisms of the same group or species which live in a particular geographical area and have the capability of interbreeding The main mathematical problem for a given population is to carefully examine the evolution time dependent dynamics of the population The mathematical methods used in the study of this problem are based on probability theory stochastic processes dynamical systems nonlinear differential and difference equations and non associative algebras A state of a population is a distribution of probabilities of the different types of organisms in every generation Type partition is called differentiation for example sex differentiation which defines a bisexual population This book systematically describes the recently developed theory of bisexual population and mainly contains results obtained since 2010 The book presents algebraic and probabilistic approaches in the theory of population dynamics It also includes several dynamical systems of biological models such as dynamics generated by Markov processes of cubic stochastic matrices dynamics of sex linked population dynamical systems generated by a gonosomal evolution operator dynamical system and an evolution algebra of mosquito population and ocean ecosystems The main aim of this book is to facilitate the reader s in depth understanding by giving a systematic review of the theory of population dynamics which has wide applications in biology mathematics medicine and physics      *Dynamical Systems for Biological Modeling* Fred Brauer, Christopher Kribs, 2015-12-23 Dynamical Systems for Biological Modeling An Introduction prepares both biology and mathematics students with the understanding and techniques necessary to undertake basic modeling of biological systems It achieves this through the development and analysis of dynamical systems The approach emphasizes qualitative ideas rather than explicit computa      *Dynamical Systems for Biological Modeling* Fred Brauer, Christopher Kribs, 2015-12-23 Dynamical Systems for Biological Modeling An Introduction prepares both biology and mathematics students with the understanding and techniques necessary to undertake basic modeling of biological systems It achieves this through the development and analysis of dynamical systems The approach emphasizes qualitative ideas rather than explicit computa      Dynamical Systems Lamberto Cesari, Jack K. Hale, Joseph P. LaSalle, 2014-05-10 Dynamical Systems An International Symposium Volume 1 contains the proceedings of the International Symposium on Dynamical Systems held at Brown University in Providence Rhode Island on August 12 16 1974 The symposium provided a forum for reviewing the theory of dynamical systems in relation to ordinary and functional differential equations as well as the influence of this approach and the techniques of ordinary differential equations on research concerning certain types of partial differential equations and evolutionary equations in general Comprised of 29 chapters this volume begins with an introduction to some aspects of the qualitative theory of differential equations followed by a discussion on the Lefschetz fixed point formula Nonlinear oscillations in the frame of alternative methods are then examined along with topology and nonlinear boundary value problems Subsequent chapters focus on bifurcation theory evolution governed by accretive operators topological dynamics and its relation to integral equations and non autonomous

systems and non controllability of linear time invariant systems using multiple one dimensional linear delay feedbacks The book concludes with a description of sufficient conditions for a relaxed optimal control problem This monograph will be of interest to students and practitioners in the field of applied mathematics

**Applied Nonautonomous and Random Dynamical Systems** Tomás Caraballo,Xiaoying Han,2017-01-31 This book offers an introduction to the theory of non autonomous and stochastic dynamical systems with a focus on the importance of the theory in the Applied Sciences It starts by discussing the basic concepts from the theory of autonomous dynamical systems which are easier to understand and can be used as the motivation for the non autonomous and stochastic situations The book subsequently establishes a framework for non autonomous dynamical systems and in particular describes the various approaches currently available for analysing the long term behaviour of non autonomous problems Here the major focus is on the novel theory of pullback attractors which is still under development In turn the third part represents the main body of the book introducing the theory of random dynamical systems and random attractors and revealing how it may be a suitable candidate for handling realistic models with stochasticity A discussion of future research directions serves to round out the coverage

Dynamical Models in Biology Miklós Farkas,2001-06-15 Dynamic Models in Biology offers an introduction to modern mathematical biology This book provides a short introduction to modern mathematical methods in modeling dynamical phenomena and treats the broad topics of population dynamics epidemiology evolution immunology morphogenesis and pattern formation Primarily employing differential equations the author presents accessible descriptions of difficult mathematical models Recent mathematical results are included but the author s presentation gives intuitive meaning to all the main formulae Besides mathematicians who want to get acquainted with this relatively new field of applications this book is useful for physicians biologists agricultural engineers and environmentalists Key Topics Include Chaotic dynamics of populations The spread of sexually transmitted diseases Problems of the origin of life Models of immunology Formation of animal hide patterns The intuitive meaning of mathematical formulae explained with many figures Applying new mathematical results in modeling biological phenomena Miklos Farkas is a professor at Budapest University of Technology where he has researched and instructed mathematics for over thirty years He has taught at universities in the former Soviet Union Canada Australia Venezuela Nigeria India and Columbia Prof Farkas received the 1999 Bolyai Award of the Hungarian Academy of Science and the 2001 Albert Szentgyorgyi Award of the Hungarian Ministry of Education A down to earth introduction to the growing field of modern mathematical biology Also includes appendices which provide background material that goes beyond advanced calculus and linear algebra

**Mathematics for Ecology and Environmental Sciences** Yasuhiro Takeuchi,Yoh Iwasa,Kazunori Sato,2007-01-19 Dynamical systems theory in mathematical biology has attracted much attention from many scientific directions The purpose of this volume is to discuss the many rich and interesting properties of dynamical systems that appear in ecology and environmental sciences The main topics include population dynamics with dispersal nonlinear

discrete population dynamics structured population models mathematical models in evolutionary ecology stochastic spatial models in ecology game dynamics and the chemostat model Each chapter will serve to introduce students and scholars to the state of the art in an exciting area to present important new results and to inspire future contributions to mathematical modeling in ecology and environmental sciences

**Advances in Discrete Dynamical Systems, Difference Equations and Applications** Saber Elaydi, Mustafa R. S. Kulenović, Senada Kalabušić, 2023-03-25 This book comprises selected papers of the 26th International Conference on Difference Equations and Applications ICDEA 2021 held virtually at the University of Sarajevo Bosnia and Herzegovina in July 2021 The book includes the latest and significant research and achievements in difference equations discrete dynamical systems and their applications in various scientific disciplines The book is interesting for Ph D students and researchers who want to keep up to date with the latest research developments and achievements in difference equations discrete dynamical systems and their applications the real world problems

**Robust Engineering Designs of Partial Differential Systems and Their Applications** Bor-Sen Chen, 2021-12-22 Most systems in science engineering and biology are of partial differential systems PDSs modeled by partial differential equations Many books about partial differential equations have been written by mathematicians and mainly address some fundamental mathematic backgrounds and discuss some mathematic properties of partial differential equations Only a few books on PDSs have been written by engineers however these books have focused mainly on the theoretical stabilization analysis of PDSs especially mechanical systems This book investigates both robust stabilization control design and robust filter design and reference tracking control design in mechanical signal processing and control systems to fill a gap in the study of PDSs Robust Engineering Designs of Partial Differential Systems and Their Applications offers some fundamental background in the first two chapters The rest of the chapters focus on a specific design topic with a corresponding deep investigation into robust H filtering stabilization or tracking design for more complex and practical PDSs under stochastic fluctuation and external disturbance This book is aimed at engineers and scientists and addresses the gap between the theoretical stabilization results of PDSs in academic and practical engineering designs more focused on the robust H filtering stabilization and tracking control problems of linear and nonlinear PDSs under intrinsic random fluctuation and external disturbance in industrial applications Part I provides backgrounds on PDSs such as Galerkin s and finite difference methods to approximate PDSs and a fuzzy method to approximate nonlinear PDSs Part II examines robust H filter designs for the robust state estimation of linear and nonlinear stochastic PDSs And Part III treats robust H stabilization and tracking control designs of linear and nonlinear PDSs Every chapter focuses on an engineering design topic with both theoretical design analysis and practical design examples

**An Introduction to Dynamical Systems for Biological Modeling** Fred Brauer, Christopher Kribs-Zaleta, 2014-10 Taking more of a qualitative rather than computational approach this text presents the techniques required to undertake basic modelling of biological systems through the development and analysis of dynamical systems It

includes many different types of applications from population biology and epidemiology

**Discrete and Continuous Dynamical Systems**, 2006

**Current Trends in Dynamical Systems in Biology and Natural Sciences** Maira Aguiar, Carlos Braumann, Bob W. Kooi, Andrea Pugliese, Nico Stollenwerk, Ezio Venturino, 2020-05-06 This book disseminates the latest results and envisages new challenges in the application of mathematics to various practical situations in biology epidemiology and ecology It comprises a collection of the main results presented at the Ninth Edition of the International Workshop Dynamical Systems Applied to Biology and Natural Sciences DSABNS held from 7 to 9 February 2018 at the Department of Mathematics University of Turin Italy While the principal focus is ecology and epidemiology the coverage extends even to waste recycling and a genetic application The topics covered in the 12 peer reviewed contributions involve such diverse mathematical tools as ordinary and partial differential equations delay equations stochastic equations control and sensitivity analysis The book is intended to help both in disseminating the latest results and in envisaging new challenges in the application of mathematics to various practical situations in biology epidemiology and ecology

Nonlinear Dynamic Systems in Behavioral Psychology Jon Koerner, 1993

**Complex Systems**, 1997

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