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Mathematics in Population Biology

HORST R. THIEME

Mathematics In Population Biology Princeton Series In Theoretical And Computational Biology

Christian Düll,Piotr Gwiazda,Anna Marciniak-Czochra,Jakub Skrzeczkowski

Mathematics In Population Biology Princeton Series In Theoretical And Computational Biology:

Mathematics in Population Biology Horst R. Thieme,2018-06-05 The formulation analysis and re evaluation of mathematical models in population biology has become a valuable source of insight to mathematicians and biologists alike This book presents an overview and selected sample of these results and ideas organized by biological theme rather than mathematical concept with an emphasis on helping the reader develop appropriate modeling skills through use of well chosen and varied examples Part I starts with unstructured single species population models particularly in the framework of continuous time models then adding the most rudimentary stage structure with variable stage duration The theme of stage structure in an age dependent context is developed in Part II covering demographic concepts such as life expectation and variance of life length and their dynamic consequences In Part III the author considers the dynamic interplay of host and parasite populations i e the epidemics and endemics of infectious diseases The theme of stage structure continues here in the analysis of different stages of infection and of age structure that is instrumental in optimizing vaccination strategies Each section concludes with exercises some with solutions and suggestions for further study The level of mathematics is relatively modest a toolbox provides a summary of required results in differential equations integration and integral equations In addition a selection of Maple worksheets is provided The book provides an authoritative tour through a dazzling ensemble of topics and is both an ideal introduction to the subject and reference for researchers Proc. of the Fourth Brazilian Symp. on Mathematical and Computational Biology vol.2: First International Symposium on Mathematical and Computational Biology , **Proc. of the 2006 International Symposium on Mathematical and Computational Biology: BIOMAT 2006** , **Introduction to Mathematical Methods in Population Theory** Jacek Banasiak,2024-12-20 This textbook provides an introduction to the mathematical methods used to analyse deterministic models in life sciences including population dynamics epidemiology and ecology The book covers both discrete and continuous models The presentation emphasises the solvability of the equations appearing in the mathematical modelling of natural phenomena and in the absence of solutions the analysis of their relevant properties Of particular interest are methods that allow for determining the long term behaviour of solutions Thus the book covers a range of techniques from the classical Lyapunov theorems and positivity methods based on the Perron Frobenius theorem to the more modern monotone dynamical system approach The book offers a comprehensive presentation of the Lyapunov theory including the inverse Lyapunov theorems with applications to perturbed equations and Vidyasagar theorem Furthermore it provides a coherent presentation of the foundations of the theory of monotone dynamical systems with its applications to epidemiological models Another feature of the book is the derivation of the McKendrick von Foerster equation from the discrete Leslie model and the analysis of the long term behaviour of its solutions Designed for upper undergraduate courses and beyond this textbook is written for students and researchers looking to master the mathematics of the tools commonly used to analyse life science models It therefore goes

somewhat deeper into mathematics than typical books at this level but should be accessible to anyone with a good command of calculus with elements of real and complex analysis and linear algebra the necessary concepts are collected in the appendices *Dynamical Systems with Applications Using MATLAB®* Stephen Lynch,2025-09-09 This textbook now in its third edition provides a broad and accessible introduction to both continuous and discrete dynamical systems the theory of which is motivated by examples from a wide range of disciplines It emphasizes applications and simulation utilizing MATLAB Simulink the Image Processing Toolbox the Symbolic Math Toolbox and the Deep Learning Toolbox The text begins with a tutorial introduction to MATLAB that assumes no prior programming knowledge Discrete systems are covered in the first part after which the second part explores the study of continuous systems using delay ordinary and partial differential equations The third part considers chaos control and synchronization binary oscillator computing Simulink and the Deep Learning Toolbox A final chapter provides examination and coursework type MATLAB questions for use by instructors and students For the Third Edition all the material has been thoroughly updated in line with the most recent version of MATLAB R2025a New chapters have been added on artificial neural networks delay differential equations numerical methods for ordinary and partial differential equations and the Deep Learning Toolbox MATLAB program files Simulink model files and other materials are available to download from the author s website and through GitHub The hands on approach of Dynamical Systems with Applications using MATLAB has minimal prerequisites only requiring familiarity with ordinary differential equations It will appeal to advanced undergraduate and graduate students applied mathematicians engineers and researchers in a broad range of disciplines such as population dynamics biology chemistry computing economics nonlinear optics neural networks and physics Praise for the Second Edition This book is a valuable reference to the existing literature on dynamical systems especially for the remarkable collection of examples and applications selected from very different areas as well as for its treatment with MATLAB of these problems Fernando Casas zbMATH The vast compilation of applications makes this text a great resource for applied mathematicians engineers physicists and researchers Instructors will be pleased to find an aims and objectives section at the beginning of each chapter where the author outlines its content and provides student learning objectives Stanley R Huddy MAA Reviews *Dynamical Systems with Applications using Python* Stephen Lynch,2018-10-09 This textbook provides a broad introduction to continuous and discrete dynamical systems With its hands on approach the text leads the reader from basic theory to recently published research material in nonlinear ordinary differential equations nonlinear optics multifractals neural networks and binary oscillator computing Dynamical Systems with Applications Using Python takes advantage of Python s extensive visualization simulation and algorithmic tools to study those topics in nonlinear dynamical systems through numerical algorithms and generated diagrams After a tutorial introduction to Python the first part of the book deals with continuous systems using differential equations including both ordinary and delay differential equations The second part of the book deals with discrete dynamical systems and progresses

to the study of both continuous and discrete systems in contexts like chaos control and synchronization neural networks and binary oscillator computing These later sections are useful reference material for undergraduate student projects The book is rounded off with example coursework to challenge students programming abilities and Python based exam questions This book will appeal to advanced undergraduate and graduate students applied mathematicians engineers and researchers in a range of disciplines such as biology chemistry computing economics and physics Since it provides a survey of dynamical systems a familiarity with linear algebra real and complex analysis calculus and ordinary differential equations is necessary and knowledge of a programming language like C or Java is beneficial but not essential **The Basic Approach to Age-Structured Population Dynamics** Mimmo Iannelli,Fabio Milner,2017-08-27 This book provides an introduction to age structured population modeling which emphasizes the connection between mathematical theory and underlying biological assumptions Through the rigorous development of the linear theory and the nonlinear theory alongside numerics the authors explore classical equations that describe the dynamics of certain ecological systems Modeling aspects are discussed to show how relevant problems in the fields of demography ecology and epidemiology can be formulated and treated within the theory In particular the book presents extensions of age structured modeling to the spread of diseases and epidemics while also addressing the issue of regularity of solutions the asymptotic behavior of solutions and numerical approximation With sections on transmission models non autonomous models and global dynamics this book fills a gap in the literature on theoretical population dynamics The Basic Approach to Age Structured Population Dynamics will appeal to graduate students and researchers in mathematical biology epidemiology and demography who are interested in the systematic presentation of relevant models and mathematical methods **Dynamical Systems with Applications using Mathematica®** Stephen Lynch,2007-09-20 This book provides an introduction to the theory of dynamical systems with the aid of the Mathematica computer algebra system It is written for both senior undergraduates and graduate students The rst part of the book deals with c tinuous systems using ordinary differential equations Chapters 1 10 the second part is devoted to the study of discrete dynamical systems Chapters 11 15 and Chapters 16 and 17 deal with both continuous and discrete systems It should be pointedoutthatdynamicalsystemstheoryisnotlimitedtothesetopicsbutalso compassespartialdifferentialequations integralandintegrodifferentialequations stochastic systems and time delay systems for instance References 1 4 given at the end of the Preface provide more information for the interested reader The author has gone for breadth of coverage rather than ne detail and theorems with proofs are kept at a minimum The material is not clouded by functional analytic and group theoretical de nitions and so is intelligible to readers with a general mathematical background Some of the topics covered are scarcely covered el where Most of the material in Chapters 9 10 14 16 and 17 is at a postgraduate levelandhasbeenin uencedbytheauthor sownresearchinterests Thereismore theory in these chapters than in the rest of the book since it is not easily accessed anywhere else It has been found that these chapters are especially useful as ref ence material for senior

undergraduate project work The theory in other chapters of the book is dealt with more comprehensively in other texts some of which may be found in the references section of the corresponding chapter **Stability and Boundary Stabilization of 1-D Hyperbolic Systems** Georges Bastin,Jean-Michel Coron,2016-07-26 This monograph explores the modeling of conservation and balance laws of one dimensional hyperbolic systems using partial differential equations It presents typical examples of hyperbolic systems for a wide range of physical engineering applications allowing readers to understand the concepts in whichever setting is most familiar to them With these examples it also illustrates how control boundary conditions may be defined for the most commonly used control devices The authors begin with the simple case of systems of two linear conservation laws and then consider the stability of systems under more general boundary conditions that may be differential nonlinear or switching They then extend their discussion to the case of nonlinear conservation laws and demonstrate the use of Lyapunov functions in this type of analysis Systems of balance laws are considered next starting with the linear variety before they move on to more general cases of nonlinear ones They go on to show how the problem of boundary stabilization of systems of two balance laws by both full state and dynamic output feedback in observer controller form is solved by using a backstepping method in which the gains of the feedback laws are solutions of an associated system of linear hyperbolic PDEs The final chapter presents a case study on the control of navigable rivers to emphasize the main technological features that may occur in real live applications of boundary feedback control Stability and Boundary Stabilization of 1 D Hyperbolic Systems will be of interest to graduate students and researchers in applied mathematics and control engineering The wide range of applications it discusses will help it to have as broad an appeal within these groups as possible *Spaces of Measures and their Applications to Structured Population Models* Christian Düll,Piotr Gwiazda,Anna Marciniak-Czochra,Jakub Skrzeczkowski,2021-10-07 Structured population models are transport type equations often applied to describe evolution of heterogeneous populations of biological cells animals or humans including phenomena such as crowd dynamics or pedestrian flows This book introduces the mathematical underpinnings of these applications providing a comprehensive analytical framework for structured population models in spaces of Radon measures The unified approach allows for the study of transport processes on structures that are not vector spaces such as traffic flow on graphs and enables the analysis of the numerical algorithms used in applications Presenting a coherent account of over a decade of research in the area the text includes appendices outlining the necessary background material and discusses current trends in the theory enabling graduate students to jump quickly into research **Active Particles, Volume 4** José Antonio Carrillo,Eitan Tadmor,2024-12-12 This edited volume collects nine surveys that present the state of the art in modeling qualitative analysis and simulation of active particles focusing on specific applications in the natural sciences As in the preceding Active Particles volumes it blends diverse applications that demonstrate the interdisciplinary nature of the subject and the various mathematical tools available Contributions were selected with the aim of covering a variety of viewpoints from modeling the

interactions in collective dynamics of animals and in population dynamics through neural networks semi supervised learning and Monte Carlo methods in optimization to kinetic and continuum theories with applications to aggregations and birth and death processes Mathematicians and other members of the scientific community interested in active matter and its many applications will find this volume to be a timely authoritative and valuable resource *An Introduction to Game-Theoretic Modelling: Third Edition* Mike Mesterton-Gibbons,2019-07-05 This book introduces game theory and its applications from an applied mathematician s perspective systematically developing tools and concepts for game theoretic modelling in the life and social sciences Filled with down to earth examples of strategic behavior in humans and other animals the book presents a unified account of the central ideas of both classical and evolutionary game theory Unlike many books on game theory which focus on mathematical and recreational aspects of the subject this book emphasizes using games to answer questions of current scientific interest In the present third edition the author has added substantial new material on evolutionarily stable strategies and their use in behavioral ecology The only prerequisites are calculus and some exposure to matrix algebra probability and differential equations **Journal of the Korean Mathematical Society** ,2009 **Differential Equations and Population Dynamics I** Arnaud Ducrot,Quentin Griette,Zhihua Liu,Pierre Magal,2022-06-20 This book presents the basic theoretical concepts of dynamical systems with applications in population dynamics Existence uniqueness and stability of solutions global attractors bifurcations center manifold and normal form theories are discussed with cutting edge applications including a Holling s predator prey model with handling and searching predators and projecting the epidemic forward with varying level of public health interventions for COVID 19 As an interdisciplinary text this book aims at bridging the gap between mathematics biology and medicine by integrating relevant concepts from these subject areas making it self sufficient for the reader It will be a valuable resource to graduate and advance undergraduate students for interdisciplinary research in the area of mathematics and population dynamics Stochastic Epidemic Models with Inference Tom Britton,Etienne Pardoux,2019-11-30 Focussing on stochastic models for the spread of infectious diseases in a human population this book is the outcome of a two week ICPAM CIMPA school on Stochastic models of epidemics which took place in Ziguinchor Senegal December 5 16 2015 The text is divided into four parts each based on one of the courses given at the school homogeneous models Tom Britton and Etienne Pardoux two level mixing models David Sirl and Frank Ball epidemics on graphs Viet Chi Tran and statistics for epidemic models Catherine Lar do The CIMPA school was aimed at PhD students and Post Docs in the mathematical sciences Parts or all of this book can be used as the basis for traditional or individual reading courses on the topic For this reason examples and exercises some with solutions are provided throughout

Theories of Population Variation in Genes and Genomes Freddy Bugge Christiansen,2014-11-23 This textbook provides an authoritative introduction to both classical and coalescent approaches to population genetics Written for graduate students and advanced undergraduates by one of the world s leading authorities in the field the book focuses on the theoretical

background of population genetics while emphasizing the close interplay between theory and empiricism Traditional topics such as genetic and phenotypic variation mutation migration and linkage are covered and advanced by contemporary coalescent theory which describes the genealogy of genes in a population ultimately connecting them to a single common ancestor Effects of selection particularly genomic effects are discussed with reference to molecular genetic variation The book is designed for students of population genetics bioinformatics evolutionary biology molecular evolution and theoretical biology as well as biologists molecular biologists breeders biomathematicians and biostatisticians Contains up to date treatment of key areas in classical and modern theoretical population genetics Provides in depth coverage of coalescent theory Discusses genomic effects of selection Gives examples from empirical population genetics Incorporates figures diagrams and boxed features throughout Includes end of chapter exercises Speaks to a wide range of students in biology bioinformatics and biostatistics **Dynamical Systems with Applications using MapleTM** Stephen Lynch,2009-12-23 Since the rst edition of this book was published in 2001 the algebraic computa TM tion package Maple has evolved from Maple V into Maple 13 Accordingly the second edition has been thoroughly updated and new material has been added In this edition there are many more applications examples and exercises all with solutions and new chapters on neural networks and simulation have been added Thereare alsonewsectionsonperturbationmethods normalforms Gr bnerbases and chaos synchronization This book provides an introduction to the theory of dynamical systems with the aid of the Maple algebraic manipulation package It is written for both senior undergraduates and graduate students The rst part of the book deals with c tinuous systems using ordinary differential equations Chapters 1 10 the second part is devoted to the study of discrete dynamical systems Chapters 11 15 and Chapters 16 18 deal with both continuous and discrete systems Chapter 19 lists examination type questions used by the author over many years one set to be used in a computer laboratory with access to Maple and the other set to be used without access to Maple Chapter 20 lists answers to all of the exercises given in the book It should be pointed out that dynamical systems theory is not l ited to these topics but also encompasses partial differential equations integral and integro differential equations stochastic systems and time delay systems for instance References 1 5 given at the end of the Preface provide more inf mation for the interested reader *A Primer on Population Dynamics Modeling* Hiromi Seno,2022-11-16 This textbook provides an introduction to the mathematical models of population dynamics in mathematical biology The focus of this book is on the biological meaning translation of mathematical structures in mathematical models rather than simply explaining mathematical details and literacies to analyze a model In some recent usages of the mathematical model simply with computer numerical calculations the model includes some inappropriate mathematical structure concerning the reasonability of modeling for the biological problem under investigation For students and researchers who study or use mathematical models it is important and helpful to understand what mathematical setup could be regarded as reasonable for the model with respect to the relation between the biological factors involved in the

assumptions and the mathematical structure of the model Topics covered in this book are modeling with geometric progression density effect in population dynamics deriving continuous time models from discrete time models basic modeling for birth death stochastic processes continuous time models modeling interspecific reaction for the continuous time population dynamics model competition and prey predator dynamics modeling for population dynamics with a heterogeneous structure of population qualitative analysis on the discrete time dynamical system necessary knowledge about fundamental mathematical theories to understand the dynamical nature of continuous time models The book includes popular topics in ecology and mathematical biology as well as classic theoretical topics By understanding the biological meaning of modeling for simple models readers will be able to derive a specific mathematical model for a biological problem by reasonable modeling The contents of this book is made accessible for readers without strong Mathematical background **An Introduction to Undergraduate Research in Computational and Mathematical Biology** Hannah Callender Highlander,Alex Capaldi,Carrie Diaz Eaton,2020-02-17 Speaking directly to the growing importance of research experience in undergraduate mathematics programs this volume offers suggestions for undergraduate appropriate research projects in mathematical and computational biology for students and their faculty mentors The aim of each chapter is twofold for faculty to alleviate the challenges of identifying accessible topics and advising students through the research process for students to provide sufficient background additional references and context to excite students in these areas and to enable them to successfully undertake these problems in their research Some of the topics discussed include Oscillatory behaviors present in real world applications from seasonal outbreaks of childhood diseases to action potentials in neurons Simulating bacterial growth competition and resistance with agent based models and laboratory experiments Network structure and the dynamics of biological systems Using neural networks to identify bird species from birdsong samples Modeling fluid flow induced by the motion of pulmonary cilia Aimed at undergraduate mathematics faculty and advanced undergraduate students this unique guide will be a valuable resource for generating fruitful research collaborations between students and faculty

Discrete and Continuous Dynamical Systems ,2007

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