

Universitext

Jacques Istas

**Mathematical
Modeling
for the
Life Sciences**

 Springer

Jacques Istas
Département IMSS BSHM
Université Pierre Mendès-France
38000 Grenoble
France
e-mail: jacques.istas@umpf-grenoble.fr

Based on the French edition “Introduction aux Modélisations Mathématiques pour les Sciences du Vivant”, Mathématiques et Applications, Vol. 34, Springer-Verlag 2000

Mathematics Subject Classification (2000): 92B05

Library of Congress Control Number: 2005926252

ISBN-10 3-540-25305-X Springer Berlin Heidelberg New York
ISBN-13 978-3-540-25305-1 Springer Berlin Heidelberg New York

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilm or in any other way, and storage in data banks. Duplication of this publication or parts thereof is permitted only under the provisions of the German Copyright Law of September 9, 1965, in its current version, and permission for use must always be obtained from Springer. Violations are liable for prosecution under the German Copyright Law.

Springer is a part of Springer Science+Business Media
springeronline.com
© Springer-Verlag Berlin Heidelberg 2005
Printed in Germany

The use of general descriptive names, registered names, trademarks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

Cover design: Erich Kirchner, Heidelberg
Typesetting by the author using a Springer \LaTeX macro package

Printed on acid-free paper 41/sz - 5 4 3 2 1 0

Contents

1	General introduction	1
1.1	Preface	1
1.2	Structure of the book	2
1.3	Acknowledgments	5
2	Continuous-time dynamical systems	7
2.1	Introduction	7
2.2	Historical demographical models	9
2.3	Pest control: the spruce budworm	15
2.4	Interactions in biological systems	18
2.5	Reaction-diffusion equations	26
2.6	Bibliography	35
2.7	Exercises	36
3	Discrete-time dynamical systems	45
3.1	Introduction	45
3.2	Delay models	46
3.3	Discrete logistic model	49
3.4	<i>Tribolium</i> dynamics	53
3.5	Bibliography	56
3.6	Exercises	56
4	Game theory and evolution	59
4.1	Introduction	59
4.2	Games, strategies and equilibria	60
4.3	Hawks and doves	62
4.4	Bibliography	65
4.5	Exercises	65

5	Markov chains and diffusions	67
5.1	Introduction	67
5.2	Definitions and first properties	68
5.3	Subset classification.....	72
5.4	Genetical drift	73
5.5	Invariant measure	75
5.6	Continuous-time.....	78
5.7	The domestication of pearl millet	83
5.8	Bibliography	88
5.9	Exercises	88
6	Random arborescent models	93
6.1	Introduction	93
6.2	Temporal branching processes	94
6.3	Polymerase Chain Reaction	104
6.4	Percolation	105
6.5	Spatial branching processes	107
6.6	The colonization of Europe by oaks	110
6.7	Bibliography	112
6.8	Exercises	113
7	Statistics	119
7.1	Introduction	119
7.2	Maximum Likelihood Estimate	120
7.3	Localization of QTL	122
7.4	Asymptotical study of the likelihood	124
7.5	The weevil life	128
7.6	Bibliography	133
7.7	Exercises	134
A	Appendices	141
A.1	Ordinary differential equations	141
A.2	Evolution equations.....	148
A.3	Probability	151
A.4	Statistics	153
	References	157
	Index	163